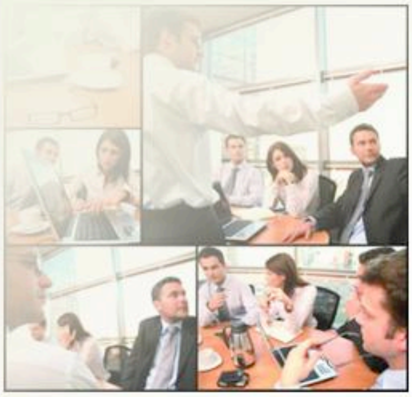
Saudi Arabia's National Innovation Ecosystem:



Proposed Framework and Initiatives

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مدينة الملك عبدالعزيز للعلوم والتقنية KACST

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Al-Aghar Group

Contents

Background and Purpose

The Kingdom's Vision for Science, Technology, and Innovation

The Kingdom of Saudi Arabia has established a goal of diversifying its economy beyond reliance on natural resources and toward development of knowledge-based industries. In light of the close connection between economic growth and technological change and innovation, advancement of and support for science, technology, and innovation in the Kingdom are central to achieving this goal. Accordingly, the Kingdom has initiated far-reaching efforts to establish and strengthen institutions, policies, and incentives that contribute to an innovation-driven economy.

The Kingdom's vision for science-, technology- and innovation-based (STI-based) development is to join the advanced knowledge-based economies with highly competitive innovation ecosystems by 2025. In the immediate term (through 2010), the Kingdom intends to establish the infrastructure of people, equipment, policies, and institutions necessary to provide the foundation for growth. In the medium- and longer-terms, the Kingdom aspires to raise its levels of science and technological investment to become one of the leaders in the region and in Asia. Accomplishing these goals will require increasing engagement of the Kingdom's population in science and technology fields, improved effectiveness of the Kingdom's science and technology institutions, and broader changes in attitudes and capacity related to entrepreneurship, collaboration, and orientation toward markets. In recognition of the fundamental challenges facing – and opportunities related to – the Kingdom's transformation toward an innovation-driven economy, key stakeholders have devised and begun to implement critical policies, plans, and programs, as outlined below.

The Kingdom's Plan for a Comprehensive NIE Development Framework

At center stage of efforts to articulate the Kingdom's aspirations are the National Science and Technology Plan (NSTP) and related Strategic Technology Plans. The "Comprehensive, Long-Term National Science and Technology Plan," which spans 2001 to 2020, was developed by the King Abdulaziz City for Science and Technology (KACST) in accordance with its founding charter and in cooperation with the Ministry of Economy and Planning. Approved in July 2002 by the Council of Ministers, the plan dedicates particular attention to development of human capital, infrastructure, and institutional foundations for science, technology and innovation; the plan also identifies eleven technologies or areas of technology application that are strategically important to the Kingdom. Initiatives that are critical to achieving the nation's transition into a diversified, knowledge-based economy are being conducted by the Ministry of Economy and Planning, Ministry of Education, Ministry of Higher Education, Ministry of Commerce and Industry, Ministry of Communications and Information Technology, Saudi Arabian General Investment Authority, King Abdullah University for Science and Technology, King Abdulaziz and His Companions Foundation for Giftedness and Creativity, and the Royal Commission of Jubail and Yanbu.

The National Innovation Ecosystem (NIE) project is an ambitious initiative proposed by KACST with the aim of delineating a framework that will enable Saudi Arabia to leapfrog towards a knowledge economy. A joint effort between KACST, the Al-Aghar Group, and a number of leading representatives from the public, private and academic sectors, the NIE project aspires to articulate a clear, collaborative framework for innovation at the national level. The NIE framework will enable all relevant stakeholders to align their organization-level innovation plans with the activities of other participants in the ecosystem, identify important leverage points in plan execution, and enable greater collaboration, coordination, and achievement of organizational and national goals. By catalyzing flows of knowledge, technology, and information across all stakeholders, the NIE framework will provide the missing link between the various plans, policies, and programs initiated by major constituents in the Kingdom.

A series of conceptual and analytical steps have been undertaken since inception of the NIE project in late 2007. As part of this initial work, the NIE's vision and mission have been articulated, as described below.

The **vision** for Saudi Arabia's NIE is:

> *"To be a global innovation hub and a sustainable source of innovative solutions."*

The **mission** for Saudi Arabia's NIE is:

> *"To build a Saudi NIE with effective institutions, adequate resources and appropriate infrastructure, whilst enriching the culture of innovation and business environment that facilitate productive interactions among all constituents within Saudi Arabia and with relevant global partners, to produce world-class, competitive solutions for social well being."*

Purpose of this Report

In this report, SRI builds on and further delineates the conceptual and analytical bases on which the Saudi NIE will be established. In addition, using the proposed framework, SRI delineates numerous initiatives targeted at addressing key areas of the innovation system that must be further developed for the Kingdom to reach its overall goals. In short, the report serves two three purposes:

- It proposes a framework detailing the elements of an NIE tailored to encompass the realm of activities needed for the Kingdom to reach its goals. The proposed NIE framework is informed by review of both theoretical constructs and practical experience in countries with highly successful NIE structures.
- The report compares the components of the proposed NIE framework to the elements of the NSTP. The purpose of the comparison is to assess gaps and

complementarities between the two and, thereby, to develop understanding of the ways in which currently ongoing NSTP activities can be coordinated with and incorporated into the broader NIE framework.

- It describes approximately seventy targeted initiatives that directly support the NIE in a manner that is consistent with the overall framework, Saudi Arabia's current level of development, and with effective practices from countries with highly developed innovation ecosystems. In addition, these initiatives are intended to address gaps identified between the NIE framework and activities initiated under NSTP to date. These initiatives formed the core of KACST's submission to the Ministry of Economy and Planning for the next five-year national development plan.

This report, Volume 1, covers the first two of the three components. The third component, the initiatives proposed for the next five-year development plan, are presented in Volume 2 of this report. The Volume 1 report contains an overview of NIE frameworks, the proposed framework for Saudi Arabia, the comparison of the NIE framework to the National Science and Technology Plan, and, in the Appendix, detailed case studies of other countries' national innovation ecosystems.

Overview of National Innovation Ecosystems (NIE) Frameworks

As countries have engaged in dedicated efforts to strengthen their capacity for innovation-based economic growth, various theoretical frameworks have been created to guide policy-makers in pursuit of such goals. In parallel, individual nations have devised tailored NIE structures designed to address the major challenges related to STI-oriented development; these practical applications of NIE frameworks often exhibit iterative or radical changes that illustrate how an NIE framework evolves to meet needs over time. This section describes both forms of NIE frameworks – theoretical constructs and practical applications – in order to form a foundation for defining a system that is appropriate for Saudi Arabia.

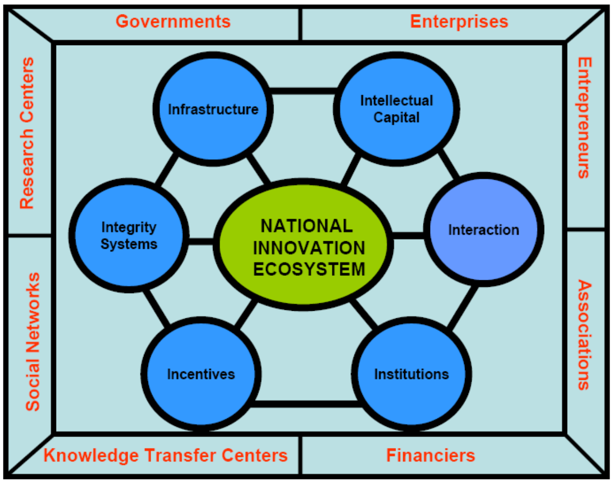
Theoretical Constructs for National Innovation Ecosystems

Four frameworks for NIE ecosystems are outlined in this section. Two – the 7i framework and SRI's framework for knowledge-based industries – are comprehensive systems oriented towards countries that are at the early stages of entering innovation-based economic development. In contrast, the other two – the open innovation framework and Australia's recently announced plan – assume more advanced levels of innovation and thereby illustrate the next-generation challenges that Saudi Arabian policymakers now have the opportunity to plan for and incorporate into the Kingdom's NIE framework.

7i Framework

The 7i framework, developed by Drs. Mahendhiran Nair and Mudiarasan Kuppusamy, illustrates factors that contribute to national innovative capacity. In this framework, seven elements that facilitate movement up the innovation value chain. The 7i's are:

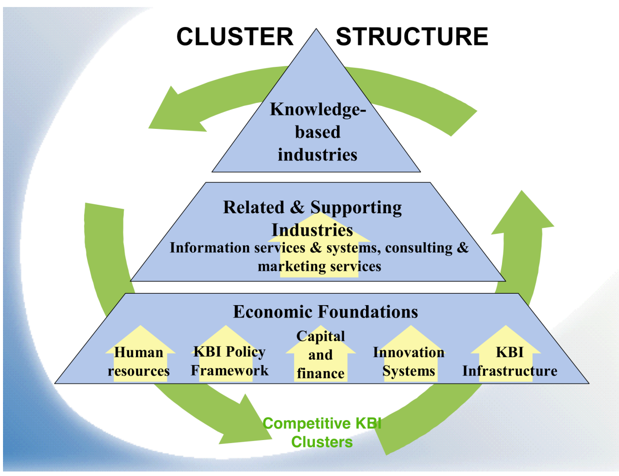
- **Infrastructure**, encompassing both physical and digital infrastructure, which enables a country's connectivity to the global economy;
- **Intellectual capital**, defined as including education and skill levels as well as the types of graduates produced through the education and training system, which together determine whether the local workforce satisfies requirements for innovation;
- **Interaction**, which covers myriad global and strategic partnerships, such as those between companies, and between universities and companies, among others;
- **Integrity**, denoting the strength, effectiveness, impact, comprehensiveness, and transparency of national governance systems;
- **Incentives**, including fiscal and non-fiscal tools to foster creativity and entrepreneurship; and
- **Institutions**, signifying the importance of organizations responsible for efficient, effective functions affecting the economy.



The 7i framework is depicted as a set of factors surrounded by various organizations, including government, enterprises, entrepreneurs, associations, financiers, knowledge transfer centers, social networks, and research centers. By placing the 7i's of the NIE at the center of these organizations, interaction, connection and feedback loops are implied but not explicit.

SRI Framework for Knowledge-based Industries

SRI International developed the SRI framework for knowledge-based industries (KBIs) to explain how and why KBIs have flourished (or failed to flourish) in different circumstances as well as to highlight policy and programmatic interventions that can stimulate KBI development. An extension of SRI's industry cluster model, the framework comprises three areas – economic foundations, related and supporting industries, and knowledge-based industries. The pillars of the economic foundations equate to the key elements of an NIE framework, with economic foundations supporting development of related industries and ultimately KBIs. Relationships and feedback loops among the three "levels" of the pyramid are implied but not explicitly



denoted. The five foundational elements are:

- **Human resources**, representing availability of workers that are skilled, adaptable, and educated in subjects appropriate for innovation-related roles;
- **Policy framework**, denoting governance structures for accountability, stability and innovation incentives;
- **Capital and finance**, including access to and the reliability of the financial systems generally as well as specialized types of funding necessary for entrepreneurship and invention;
- **Innovation systems**, comprising the availability of resources for scientific and technological pursuits, the quality and quantity of outputs related to such research, and translation of new ideas into products, processes or services with commercial potential; and
- **Infrastructure**, signifying the need for specialized, advanced physical and digital capacity to support innovation.

Open Innovation Framework

Developed by DeJong, Vanhaverbeke, Kalvet and Chebrough,[1] the open innovation framework focuses on the activities of enterprises, rather than those of government, in supporting innovation. The open innovation framework focuses on behavioral elements that are internal to the enterprise, while noting three elements that are external to the enterprise but critical to firms' innovation-related activities. The components that are internal to the enterprise include:

- **Networking**, which fills specific knowledge needs within a firm and may lead to partnerships;
- **Collaboration**, which encompasses R&D alliances that a firm may initiative to share costs and risks, joint business-university projects, and expanded, global knowledge bases, including users;
- **Corporate entrepreneurship**, including efforts related to corporate venturing, intrapreneurship and spinoffs;
- **Intellectual property (IP) management**, defined as efforts ranging from active use or licensing of internal IP as well as active pursuit of external IP; and
- **Performance of R&D**, described as fundamental to strengthen a firm's internal innovation performance and to maintain its capacity to absorb and apply knowledge generated outside the firm.

The elements that are external to the enterprise – but critical to its success in innovative activities – include:

- The **stock of basic knowledge** in the country, focusing mainly on the production of basic, early-stage research and its dissemination throughout society;
- The existence of a **highly-educated, mobile workforce**, which helps enterprises to share tacit knowledge, maintain capacity to absorb new information and ideas, and enhance linkages between the firm and other organizations; and
- **Access to finance**, including the availability of different types of capital (equity, debt, etc.) and for different stages of development.

[1] See, for example, DeJong, Vanhaverbeke, Kalvet and Chel
Cases, July 2008, http://www.openinnovation.eu/download,
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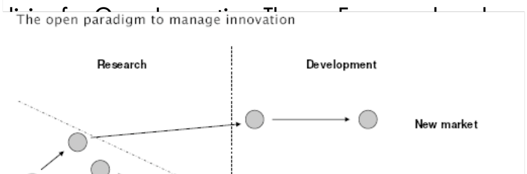

The open innovation framework, depicted in the following diagram, emphasized linkages (including connections with users or customers), networks, attitudes, mobility and R&D or technology diffusion. In part because the framework concentrates on enterprises, it assumes that typical public responsibilities – governance, infrastructure, and institutions, for example – exist and are sufficient, albeit certain external elements are emphasized, as noted above.

Selected Country Frameworks – Australia

Several countries with advanced innovation systems have embarked recently upon efforts to re-tune and update their NIE frameworks. Detailed lessons learned from three such countries, Finland, Korea, and Singapore, are provided in the next section, Lessons Learned from NIE Practices in Selected Countries. This section outlines the emerging NIE practices of Australia, which is in the midst of a significant restructuring of its NIE. These NIE elements represent refinements and enhancements to an existing NIE; thus many predecessor activities and conditions are assumed to already be in place, such as governance systems, general infrastructure, general education and workforce skills, etc. Nonetheless the themes underpinning Australia's new and still developing NIE framework provide insight into key issues that have affected the country's NIE implementation. The main elements include:

- **Encouragement of business innovation** through promotion of supportive government policies, development of enterprise capacity, and evaluation of best practices;
- **Continuing investments in infrastructure**, mainly emphasizing public funding for large-scale, landmark facilities and development of mechanisms to maximize the effectiveness and use of existing infrastructure;
- **Strengthening of skills**, particularly those viewed as critical for a strong innovation environment, such as: teamwork, problem-solving, and communications skills; ability to prioritize and manage innovation; and fluency in various languages needed to enhance global competitiveness;
- **Reforms to the regulatory environment**, with a dedication to shifting from prescriptive rules toward an outcomes-based, collaboration-enhancing approach to regulations;
- **Promotion of connections and collaborations** of all types, such as industry-science (including services-science), international (research centers, companies, governments, and markets), and inter-governmental (within Australia); and
- **Changes in culture**, to develop an Australia that encourages risk-taking (including accepting mistakes and failures), values creativity, and rewards enterprise.

Comparative Analysis

The following table provides a visual depiction of elements shared by two or more of the four innovation frameworks. Five NIE elements are clearly identifiable as fundamental, meaning that they need to be in place as a basic condition for an NIE's successful operation. In the Australian framework, which represents a more advanced level of NIE development, some of these foundational elements are not cited specifically, since they are assumed to exist. Similarly, as depicted by their inclusion the Australian and open innovation frameworks, three emerging elements are identifiable, namely: networks, interaction and collaboration; societal attitudes, culture, and values; and orientation toward customers or users, the marketplace, and the world. These findings regarding foundational and emerging elements of NIE frameworks, combined with the lessons from NIE practices in Finland, Korea, and Singapore (described in the next section) have important implications for Saudi Arabia's NIE, implications that are drawn out in the proposed NIE framework.

Element	Innovation Framework			
	7i	SRI	OI	Australia
Human Resources	♦	♦	♦	♦
Infrastructure				
Digital & Physical	♦	♦		
Institutions/Facilities				♦
Governance (including incentives)	♦	♦		♦
Innovation Systems		♦	♦	
Finance		♦	♦	
Networks, Interaction, Collaboration	♦		♦	♦
Societal Attitudes, Culture and Values			♦	♦
Outward Orientation (market, customer, global)			♦	♦

Lessons Learned from NIE Practices in Selected Countries

As a central element of Saudi Arabia's efforts to define its NIE framework, SRI prepared detailed case studies that synthesize experiences of other NIEs for which structured plans were designed and implemented. In order to pinpoint appropriate cases, SRI identified and then applied key criteria for selecting case study targets. The criteria included the country's innovation performance; the impetus for establishing a national innovation framework; and the nature and dynamics of the country's innovation governance structure.[2] Based on these criteria, SRI recommended (and KACST concurred) that the case studies focus on Finland, Korea, and Singapore. Summaries of each country's experiences and key findings related to the proposed framework for the Kingdom's NIE are presented below. Details of each case, including many practical examples of implementation practices, are provided in the Appendix.

Finland

In recent years, the transformation of Finland's economy has proceeded in three main phases. In the post-war period, the country industrialized rapidly, primarily "on the back of heavy investments in export-oriented heavy industries including paper and pulp, basic metals, and chemicals."[3] Following economic collapse in autumn 1990, "it became clear that the Finnish economy and society required major structural changes,"[4] and by the mid-1990s, the government and the private sector, operating in consensus, turned toward technology and innovation as the core driver of economic growth strategy. In addition, the government embarked upon efforts to increase its own efficiency and competitiveness. These efforts have yielded impressive results, with Finland often referred to as an "innovation leader." The country's innovation performance[5] is well above that of the EU27[6] average and all other countries, and its ranking combines strong innovation performance with moderate rates of growth on many innovation indicators. The following summary of Finland's NIE structure and experiences (as well as the complete case study contained in the Appendix) provides insight into the policies behind the country's innovation performance.

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[2] Details regarding the process and analysis leading to selection of the case study targets are available in "National Innovation Ecosystem Project: Rationale for Selection of Target Cases," February 20, 2009, prepared by SRI International for KACST.

[3] Schienstock, Gerd and Timo Hämäläinen, "Transformation of the Finish innovation system: a network approach," Sitra Report Series 7, 2001, p. 33.

[4] Schienstock, Gerd and Timo Hämäläinen, op. cit., p. 34.

[5] The development in innovation performance has been calculated for each country and for the EU27 as a block using data over a five-year period. This calculation is based on absolute changes in the indicators, as opposed to previous EIS reports where trends were calculated relative to the EU average. Further details of the methodology used can be viewed at: Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT) (2009) European Innovation Scoreboard 2008: Comparative Analysis of Innovation Performance, January, p. 49, http://www.proinno-europe.eu/EIS2008/website/docs/EIS_2008_Final_report.pdf.

[6] EU27 comprises the twenty-seven member states of the European Union.

NIE Structure and Collaboration Mechanisms

In 2008, the Finnish Government decided to develop a new National Innovation Strategy and a related Action Plan. The new strategy is guided by five strategic goals:

- Increase *cooperation between all government entities* working on policies that impact innovation performance;
- Further promote *open and cooperative innovation models* to better involve consumers, customers and other firms in product development;
- Encourage *creativity, entrepreneurship and innovation-based productivity* in all sectors of the economy;
- Enhance the *research capacity* of universities, polytechnics and research institutes and further strengthen the linkages between universities, research institutes and the private sector; and
- Enhance *international mobility* among students and researchers, to ensure more linkages and mutual learning opportunities.

To realize the new goals, significant structural changes to the NIE also have been enacted. Most notably, the Cabinet Committee on Economic Policy will be expanded into the Cabinet Committee on Economic and Innovation Policy, which will act as a forum for the strategic management and coordination of innovation-related reforms. Moreover, a new Research and Innovation Council has already been established to monitor and review broad-based innovation policies. The Council, which is chaired by the Prime Minister, advises the Council of State and its Ministries in matters concerning research, technology, innovation and their utilization and evaluation. Supported by a small secretariat, the Council is responsible for the strategic development and coordination of Finnish science and technology policy as well as of the national innovation system as a whole. The Council, comprised of representatives from seven national ministries and ten other expert members from different stakeholder groups, is the highest level of the Finnish NIE (not including Parliament, to which all government entities report).

The second level consists of the ministries. The key ministries with respect to research policy are the Ministry of Education and the Ministry of Employment and the Economy. The third level is the level at which research priorities are determined, funding decisions made (except for the allocations between different ministries), and cooperation efforts facilitated consists of the R&D funding agencies. The third level consists of the Academy of Finland, the Finnish Innovation Fund (Sitra), and Tekes. The Academy of Finland funds basic research through competitive grants. Sitra, the Finnish Innovation Fund, is an independent public fund which, under the supervision of the Finnish Parliament, promotes innovation through a series of research programs. The majority of Tekes' funds are allocated to R&D projects carried out by companies, though Tekes is also a large financier of university research. At the fourth level are local level organizations that conduct research, including universities, public research institutes, private research organizations and business enterprises.

Key Findings and Implications for Saudi Arabia

Four important lessons from Finland's NIE structure and experience provide particular insight for formulation of the Kingdom's NIE, as outlined below.

Establishment of a Clearly Defined Institutional Framework

Finland created a clearly defined institutional framework for NIE development at the national government level, with a single government entity positioned as the lead national agency with responsibility for policy development, enforcement, and implementation oversight, across government ministries and at the sub-national level In the context of this institutional framework, Finland's NIE also has benefited substantially from support for continuity of purpose through senior leadership of the Government and executive levels, regardless of political party and for almost 30 years. Moreover, Finland's Research and Innovation Council is staffed with recognized innovation experts with the resources and political authority to drive national innovation at the national and sub-national level, which is an important lesson for development of the Kingdom's NIE framework. In addition, the country has developed a range of national level institutions to manage and guide specific components of the NIE, while simultaneously establishing a range of institutional coordinating mechanisms that bring together and enforce coherency among what otherwise could become piecemeal activities under the innovation banner. Finally, Finland's NIE framework was not permitted to be stagnant: instead it is reviewed and evaluated with the assistance of international experts on a triennial basis. For the Kingdom, adopting such an approach may assist in leading to informed recommendations for NIE course corrections and continuous improvement.

Appreciation and Support for Sector- and Region-based Specialization

Finland sought early on to embed sub-national institutions and business clusters as a foundation of national innovation. It put in place national and local level systems to support municipal and regional industry sector specialization as a driver for business development and knowledge transfer. Within Finland, at the national, regional and city level, there is an appreciation that regions and cities, enterprises and universities, have a place in the national innovation ecosystem, have, using regional and local economic, scientific and industrial advantage, the potential to position themselves as entrepreneurial and innovation friendly environments. A cluster-based approach to innovation, which encouraged numerous interactions and knowledge and technology transfers among small start-up companies and larger firms, service providers, research institutes, and universities, was pursued, and policies to encourage a business-driven approach for the transition to a knowledge-based economy were enacted. In short, national mechanisms to foster such regional, local, and cluster competitiveness are strongly advanced and supported.

Outward Focus with Intent to Change Attitudes and Expand Networks

Today, as in previous years, Finland's NIE and the development of a revised national innovation strategy are driven by an appreciation of global forces shaping and impacting Finland. As competition for enterprise activities and production processes increases, Finland recognizes the need to embed entrepreneurialism and risk taking in society, and promoting innovations and enhancing national and regional competitiveness have become core goals of national policy. As part of such policies, the country has undertaken a comprehensive review of education and university policies, resulting in specific mechanisms to foster university-based inter-disciplinary activities that embed an inter-cultural innovation and learning society. In addition, Finland has actively sought partnerships with the world's leading centers of innovation, and the nature and locations of such partnership continue to expand. For Saudi Arabia, the dedication of Finland, an advanced economy but one with a relatively small population on the peripheral north of Europe, to expanding periodically its internal and external outreach and societal development efforts is noteworthy.

Attention to Monitoring and Assessment of Progress

The role of innovation metrics in informing the rate of progress of Finland's NIE has been substantial, and the country has benefited from the extensive availability of relevant national and international metrics. The comparative lack of such innovation metrics in the Kingdom indicates a need to initiate a national policy and program to facilitate the development of such a system.

Korea

Korea has achieved one of the fastest rates of economic development in the world, and many scholars have taken note of the country's dramatic development process. In 40 years, the country has transformed from a mostly agrarian society to a developed member of the global knowledge economy. Korea's commitment to technology innovation continues to the present day, maintaining a target research and development (R&D) expenditure of 5% of GDP. In fact, the evolution of Korea's National Innovation Ecosystem (NIE) has been characterized as a game of "technology catch up," comprised of three main stages – factor-driven (1960s and 1970s), investment-driven (late 1970s to 1990s), and innovation-driven (1990s to present). The summary below focuses on Korea's more recent NIE experiences, while the case study in the Appendix provides broader and more detailed information.

NIE Structure and Collaboration Mechanisms

In 2005, the Korean government implemented a major overhaul of the country's NIE, prompted by a desire to remove inefficiencies from the country's innovation governance. The restructuring gave the National Science and Technology Council (NSTC) – itself formed in 1998 to calm infighting taking place between ministries that were frequently quarrelling over the boundaries of their jurisdictions and overlapping research interests – a stronger role as coordinator of innovation and research policies. To act as the secretariat of the NSTC, the Office of Science, Technology Innovation

(OSTI) was also newly established. It has the responsibility supervising, coordinating, and evaluating S&T related policies (including policies dealing with industrialization, financing, regional innovation, human resource development). OSTI also coordinates and allocates the entire government R&D budget. As an exclusive support agency for OSTI, the Korea Institute of Science & Technology Evaluation and Planning (KISTEP) plays a key role in planning national S&T strategies, setting priorities for the coordination and allocation of R&D budgets, evaluating and analyzing national R&D programs, and capitalizing R&D knowledge. KISTEP manages a nationwide database of research projects, so they are able to evaluate which new research priorities align with the projects that different R&D performers are currently pursuing.

The 2005 reforms also sought to shrink the size of Korea's national government by merging institutions across the board. The former Ministry of Science and Technology (MoST) merged with the Ministry of Education to create a new Ministry of Education, Science, and Technology. For private sector governance, the Ministry of Commerce, Industry & the Economy (MOCIE) merged with elements of the Ministry of Information and Communications, Technology, and the Ministry of Finance and Economy. Korean planners expect that, with one unified ministry to coordinate research efforts, the GRIs will cooperate with universities more after this merger. Korea's Research Councils (which operated under MoST, interpreted S&T initiatives, and determined which R&D projects to pursue through the Government Research Institutes, or GRIs) were reorganized, relocated under different ministries or closed.

Other agencies involved in Korea's NIE include the Korea Science and Engineering Foundation (KOSEF), founded in 1977 and serving as the country's main funding agency for basic science and engineering research; and the Korea Industrial Technology Association (KOITA), established in 1979 to strengthen the innovative capabilities of Korean companies, mainly through support of industrial research and development, provision of assistance to corporate R&D centers throughout the country, and collection and dissemination of industry R&D statistics; and the Korean Technology Transfer Center (KTTC), created in 2000 to promote technology transfer and commercialization through review of salable technology, estimation of commercial viability, and identification of potential licensees or partners with whom researchers can work.

Key Findings and Implications for Saudi Arabia

Four key lessons from Korea's NIE-related economic development experience are particularly pertinent for the Kingdom's NIE, as described below.

Inadequate Coordination and Collaboration

Korea's 2005 reforms to its NIE framework are intended to address (among other goals) persistent coordination and collaboration problems. These challenges center upon the lack of interaction between government researchers and the private sector and on inter-governmental in-fighting and fragmentation and duplication of efforts. Regarding the first issue, Korea's NIE advisory agencies are dominated by academics, and many analysts point to this underrepresentation of industry in government as a cause for the weak links between industry and public R&D in Korea. To address inter-governmental coordination issues, Korea has merged institutions with similar agendas, but for the most part, has not eliminated organizations. The difficulties in instilling cooperation across Korean ministries emphasizes the importance that the Kingdom's NIE leaders must place while putting into place operational mechanisms for coordination.

Reducing the Number of Institutions over Time

A major complaint that prompted the 2005 restructuring of Korea's NIE Korea's Government Research Institutes. These criticisms of the GRIs include the charges that the GRIs: engaged in unhealthy competition for research grants; conducted research projects that tended to overlap with both universities and other GRIs.; lacked a customer-service orientation; and lacked technology transfer offices. Each of these issues points to a problem inherent in the scale and number of the institutes that operate in Korea: at one point, Korea's NIE counted 100 GRIs and 444 national research labs. It is not efficient for 100 medium-sized GRI labs to each have their own customer service and technology transfer officers. Nor is it efficient for each GRI to keep track of what 99 other GRIs are pursuing to identify possible conflicts or opportunities for collaboration. Korea restructured its NIE in 2005 and attempted to address the problems listed above by consolidating ministries and other oversight organizations. One can imagine that consolidating the GRIs themselves would have alleviated some of the country's coordination woes. An important implication for Saudi Arabia is that focusing its resources carefully and building concentrated centers of excellence, rather than diffusing efforts across many organizations, may generate returns related not only to research output but also to effective operation and coordination of the national innovation ecosystem.

Stakeholder Involvement

A key element of Korea's NIE is Technology Forecasting activities, most recently performed by KISTEP. While use of forecasting methods are not unique to Korea, they are worthy of mention here because of the strong commitment that Korea has made to the forecasting process as a means for policy guidance. Essentially, the technology forecasting activities give all of the stakeholders in Korea's NIS an opportunity to voice their concerns through panels and surveys. The forecasting process also promotes interaction between stakeholders in the NIE, which could promote collaboration and, in turn, innovation. However, this interaction only occurs every five years or so, when the forecasting activities are conducted, and, given the difficulties Korea has experienced in instilling inter-institutional collaboration, much more could be done to include industry and government opinions in the country's NIE management. For Saudi Arabia, a central lesson from the Korean NIE experience, therefore, is to initiate, early on, activities and mechanisms (such as the technology forecasting exercise) that foster public-private connections on a regular basis.

Accountability for Research Funds

During the evolution of its NIE, Korea made several changes to hold researchers more accountable for the research money that they accepted from ministries. The first big change came in 1995 when Korea's shifted from a "lump sum" funding system to a project-based system (PBS). This change is described above in the "Pillar: Governance" section. The change meant that researchers had to bill their man hours to specific projects, as a consulting firm would, in order to justify their research grant spending. In the aggregate, the PBS system held researchers more accountable to their timelines and caused them to spend their research dollars more efficiently[7].

Korea had problems when the Ministry of Science and Technology (MoST) was performing both the allocation of research funds and the evaluation of the programs on which those funds were spent. After MoST had helped to design and fund research programs, it was difficult for the Ministry to turn around and cut unsuccessful programs. Cutting unsuccessful programs seemed (to some) to be an admission of bad judgment that begged the question, "Why were these unsuccessful programs selected in the first place?" MoST desired a reputation of sound judgment so, ironically, the ministry cut few of their unsuccessful programs. After KISTEP was formed in 2001, the government separated the allocation and evaluation functions: MoST retained the allocation and KISTEP took over the analysis and evaluation of S&T-related projects. According to several reports on the evolution of Korea's NIE, this separation of duties helped Korea to trim their less productive projects and to improve researchers' accountability for their work. The lessons for Saudi Arabia from these experiences are two-fold: incentives for individual researchers must be aligned with national priorities and goals; and NIE leadership must have the will and authority to restructure or eliminate programs that are not working well.

Educating for Industries' Needs

As Korea's NIE developed, the government shifted its education priorities in anticipation of its workforce needs. In the 1960s, the government focused on providing universal primary and secondary education to create a workforce that had the basic literacy and mathematical skills necessary for the light manufacturing that Korea pursued in that timeframe. In the 1970s, the focus shifted to vocational training to provide the trade skills that were necessary for the growing heavy and chemical industries. Higher education expanded in the 1990s to provide a white collar workforce capable of advanced research. In short, rather than front-loading their workforce with white-collar professionals, Korea built their workforce from the bottom up to meet the labor needs of their aggressive industrialization. The country has also

[7] Hong, Y. S. (2005), *Evolution of the Korean National Innovation System and Technological Capability Building*, Korea's Science & Technology Policy Institute (STEPI).

made lifelong learning programs available to keep its workforce up to date with new tools and techniques, though it has yet to respond effectively to criticisms that the educational system is too homogeneous and focused on rote memorization rather than learning. The key lesson for the Kingdom is that a balanced approach to human capital development, involving the full spectrum of education and training levels, is necessary for innovation-based growth.

Singapore

When Singapore became an independent nation in 1965, it had an underdeveloped agrarian economy. Owing largely to targeted government policies over the past four decades, the country has built a world class knowledge economy and joined the ranks of the developed world.[8] The current structure of the country's National Innovation Ecosystem (NIE) and the key findings and implications of Singapore's experience for Saudi Arabia are summarized below; details are provided in the Appendix.

NIE Structure and Collaboration Mechanisms

Throughout its history, the Singaporean government has taken a flexible approach to planning that does not depend on a rigid time frame but instead focused on achievement of results. Apart from the initial five year plan (1960-64), the government did not produce any more five year economic plans. This flexibility has allowed it to tweak its interventions in response to both local and global conditions and to expand successful interventions and to terminate initiatives that are not working. An example of this flexibility came in the early 1970s, when Singapore attained full employment and was beginning to face labor shortages. The government modified its economic strategy and its investment promotion efforts, moving away from labor-intensive manufacturing industries and focusing instead on upgrading its labor force. In designing its NIE, the government incorporated the same flexible approach to policy planning.

Singapore's NIE is directed by a small number of institutions, each having a large amount of responsibility. At the highest level of the NIE, the Prime Minister's office solicits advice from a council (the RIEC) representing government, industry, and academia. The Prime Minister uses this advice to articulate priorities for the NIE and these priorities are acted upon by the National Research Foundation (NRF) and the Ministry for Trade and Industry (MTI). In pursuit of the national priorities, these organizations delegate responsibilities to sub-organizations; the NRF has sub-programs and the MTI has statutory boards, such as the Agency for Science, Technology and Research (A*STAR), Exploit Technologies (the commercialization arm of A*STAR), the Economic Development Board (EDB), and the Standards, Productivity and Innovation Board (SPRING).

A key mechanism that Singapore uses to build inter-institutional consensus is one that can be termed "cross-pollination". Cross-pollination involves executives from innovation

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[8] For example, Singapore's GDP per capita (in 2009 US dollars) has risen from $427 (1960) to $37,597 (2008).

institutions participating in the direction of other boards outside of their sphere of influence. For example, an academic institution may tap the government and industry sectors to form its advisory panels. Some examples of cross-pollination in the Singaporean NIE include: (1) the 13-member A*STAR board of directors counts four members from academia, four members from industry, and five members from government careers; (2) the Directors of the Economic Development Board count ten industry and four government representatives; and (3) the National Research Foundation's board of directors has six members from government, nine members from industry, and one academic.

In addition to collaboration at the organizational level, Singapore also encourages interaction among researchers from different institutions. For example, A*STAR's Biomedical Research Council works in close partnership with the Singapore Economic Development Board's (EDB) Biomedical Sciences Group and Bio*One Capital, to develop Singapore's biomedical sciences cluster. The mechanisms for these partnerships include A*STAR's joint grants that require collaboration between research institutes (i.e., a grant may be issued that requires participants from both the Singapore Bioimaging Consortium and the Singapore Immunology Network). Joint grants such as these help researchers to identify synergies, develop lasting relationships, and build innovation networks.

Key Findings and Implications for Saudi Arabia

Four key lessons from Singapore's NIE-related economic development experience are particularly pertinent for the Kingdom's NIE, as described below.

Flexibility

Singapore's economic development policies were largely successful because the system they set up was flexible: it allowed the government to be responsive to global conditions. Policy makers were not confined to a rigid blueprint, nor were they overly committed at any time to a few specific technologies. The government was also keen on program evaluation and was not afraid to restructure or cancel ineffective programs. The lesson for Saudi Arabia is that policymakers should incorporate flexibility in designing the Kingdom's NIE.

Promotion of Foreign Investment

The key to Singapore's success in promoting foreign investment has been providing more hospitable conditions than its competitors. In addition to assets such as an economically and politically stable investment and an English-speaking, hard-working population, Singapore offered potential investors benefits that were, on average, better than its competitors.[9] The vast majority of Saudi Arabia's foreign investment comes from overseas oil companies that locate within the Kingdom's borders because their extraction operations must be proximate to the resources with which they work. Knowledge-based companies, however, are typically more mobile and do not need to

[9] For example, in the early 1980s, Singapore guaranteed foreign countries 100% ownership of their investments and, by establishing overseas offices of the EDB, drew attention to such policies.

locate near natural resources, with the implication that the Kingdom's investment promotion efforts will face intense competition from developing countries. Accordingly, in addition to offering tax breaks and development incentives to investors, the Kingdom will need to define carefully the aspects of its economy that are attractive to foreign enterprise.

Investment in All Levels of Education

Early in its development process, the Singaporean government realized that, to attract foreign investment, the country had to provide a competent workforce to meet industry's labor needs. To that end, the government began investing heavily in primary and secondary education. As industry's labor needs progressed from competent to semi-skilled to skilled labor, so did Singapore's investments shift toward vocational training and higher education. The country's National Technology Plans 1990-2010 called for investments in worker re-training as domestic production moved from traditional manufacturing sectors to high technology and service industries.

In sum, Singapore has been dedicated to providing a workforce that meets the needs of its economic base, whether that base requires manual or skilled labor. The government's education policies have anticipated labor needs several years in advance, but have also been adaptive in the face of changing local conditions. The implication for Saudi Arabia is that, rather than focusing solely on producing white collar, university-trained professionals, the Kingdom should devote energy to developing a cadre of vocationally trained workers and to creating a responsive infrastructure for re-training and supplementation of skills over the course of workers' lifetimes.

Broadening of NIE Scope over Time

The Singaporean government first began developing their innovation system in 1990, with the formation of A*STAR (then called the National Science and Technology Board). The initial mission of A*STAR was very narrow: it was created to promote science and technology. But as Singapore's knowledge resources and R&D investments grew over time, the government broadened the scope of its NIE. New councils and statutory boards such REIC and SPRING were established in due course, and research parks were eventually created to capitalize on the knowledge base that the country was building. Institutions that did not function well were restructured or closed.

The important takeaway here is that Singapore did not try to build a full scale NIE overnight. Because their NIE developed gradually, the institutions within the NIE had time to assume and explore their responsibilities before they were forced to interface with other newly created institutions. The Singaporean government also had time to evaluate and tweak new institutions and to see which initiatives worked and which ones did not. The sequential evolution of Singapore's NIE had several benefits for the country: it helped to minimize turf wars between institutions and to reduce inefficiencies in the country's innovation policy.

Use of Numerous, Concrete Cooperation and Consensus-building Mechanisms

Singapore has put in place numerous mechanisms to encourage cooperation across the multiple institutions involved in its NIE. At the highest level, the Research, Innovation and Enterprise Council (which is responsible for national strategy) is comprised of members representing government, industry, and academia. The council's secretariat – the National Research Foundation – holds primary responsibility for coordinating the research of different agencies to ensure coherency and effectiveness. In addition, the boards overseeing almost all of Singapore's NIE institutions represent examples of cross-pollination, involving government, academia, and the private sector, thereby promoting inter-institutional interaction and coordination. At the operational levels, Singapore's institutions also endeavor to promote collaboration, avoid inefficiencies, and reduce turf battles. Examples of such efforts include:

- A*STAR's issuance of grant solicitations requiring joint research projects (i.e., those that entail collaboration between two or more research organizations);
- The requirement that researchers submitting a grant proposal to an institution in the NIE certify that they do not have a similar proposal pending at another institution;
- Grant review panels that are seeded with representatives from many NIE institutions; and
- Co-chairmanship of the executive committees of Singapore's national strategic programs by two separate ministries.

Development of an NIE Framework for Saudi Arabia

Guiding Principle and Key Parameters

The guiding principle that shapes the development of the NIE framework for Saudi Arabia is this: the NIE framework must not only be suitable for and responsive to the Kingdom's current level of development but also be forward-looking and ambitious in order to enable the nation to leapfrog across development stages. In light of this guiding principle, two parameters shape the content of the NIE:

- Fundamental foundational elements – infrastructure, education, etc. – must be included in Saudi Arabia's NIE because the Kingdom is still in the process of building its capacity for innovation. In addition, sub-elements of the basic NIE components must be denoted explicitly so that targeted interventions are developed and sufficient investment is allocated.
- Emerging components from the NIEs of other countries – such as networks, attitudes, etc. – must also be included so that the Kingdom's NIE reflects learning from global experience and supports leapfrogging of development stages.

The proposed NIE framework described below has been developed based on this key principle and these central parameters.

Proposed NIE Framework

The NIE framework proposed for Saudi Arabia is comprised of six "pillars." These pillars encompass the combination of essential foundational components (on which continuing attention must be devoted to attain world standards) and more ambitious elements (with which countries with more advanced NIEs are now grappling). The six pillars include:

- Infrastructure
- Human capital
- Governance
- Innovative capacity

Interaction and Synergies between Human Capital and Innovative Capacity Development in Korea

Korea's educational system was expanded in tandem with the labor needs at various stages of the country's innovation ecosystem development. During the 1950s/1960s, when Korea's economy focused on subsistence farming and light manufacturing, the country began to provide universal primary and secondary education so that the industry workforce was at least literate. During the 1960s, labor-intensive light manufacturing industries grew, leading to establishment of vocational high schools for craft skills training. In the 1970s, Korea set up junior vocational colleges to train technicians for chemical and heavy industries. To train the white collar workers and R&D personnel, Korea further expanded its higher education system in the 1980s, with another expansion in the 1990s to ensure an ample supply of workers for the country's growing R&D programs.

- Networks and attitudes
- Finance and capital

Each of the six NIE pillars is composed of several sub-components that further define important areas in which substantial effort must be exerted in order to create a hospitable environment for innovation in the Kingdom. It is important to note that, as in a building, the pillars of the NIE framework are dependent on each other: the strength or weakness of one pillar necessarily affects the overall strength of the system. In addition, changes or improvements in one pillar often result in ripple effects on the other pillars. The following box provides an example of the complementary nature of strengthening efforts across pillars, in this case supporting Korea's infrastructure as well as its innovative capacity; many of the other examples highlighted in boxes through this section also "cross" or support two or more pillars. In short, the pillars "work together" to support the innovation ecosystem, and therefore constant interaction amongst entities related to individual pillars is imperative for successful functioning of the NIE. The following sections describe the nature of each pillar and sub-components.

Infrastructure

Basic and advanced infrastructure is necessary for innovation to become rooted and thrive in a country. All innovation ecosystem frameworks refer to the importance of infrastructure in some respect: for NIEs serving more advanced countries, the types of infrastructure may be more complex, while for those with nascent knowledge economies, building essential infrastructure may assume a greater role in the NIE framework. The adjacent box provides examples of the kinds of infrastructure in which Singapore has invested. The three major infrastructure sub-components that are necessary to build the Kingdom's NIE are:

Examples of Major infrastructure Investments in Singapore

Singapore invested heavily in infrastructure, initially to establish a business environment suitable for foreign investment and later to create "nodes" for knowledge-based activities. Examples of these infrastructure investments include:

- 1961: Construction of the nation's first industrial estate – the 17,000-acre Jurong industrial Estate – begins; two years later, it houses 23 factories.
- 1980: Singapore Science Park is established to bring R&D to the country; by 2007, the park has approximately 175 IT and electronics tenants, with 350 total tenants.
- 2003: Biopolis, a massive, $290 million biomedical research facility, is completed.

- **Physical infrastructure**, which refers to the quantity and quality of the Kingdom's physical "grid," including roads, railways, air transportation facilities, ports, electricity, water, and local suppliers of such utilities.
- **Digital infrastructure,** which encompasses access to, investments in, reach of, and usage of digital tools including internet (especially broadband), computers, and telecommunications.
- **Institutional infrastructure**, which involves public investments in a variety of establishments (including research institutes, science/technology parks, business incubators, and pilot plants) as well as advanced facilities (such as clean rooms, wet labs, dry labs, and other specialized equipment and machinery) within such establishments that is required for many types of science- and technology-based innovation.

Human Capital

A tenet of innovation-based economic growth is that such development requires a more knowledgeable, skilled, and flexible workforce than for economies based on, for example, natural resources extraction, agriculture, or manufacturing. Accordingly, a readily available base of sufficiently skilled workers is central to the NIE concept, as are the building blocks that prepare individuals to assume work functions. For Saudi Arabia's NIE framework, three components of human capital are critical:

- **Education**, which encompasses:
  - Overall expenditures and quality of educational investments;
  - Access to, enrollment in, attainment levels of, expenditures on, and quality of primary, secondary and tertiary education, including education related to science, technology, engineering and mathematics (STEM), management/ business administration, and entrepreneurship; and

Finland's Aalto University

To achieve national ambitions to create a university that experiments in inter-disciplinary activities and to develop an inter-cultural innovation and learning society, Finland will establish Aalto University, scheduled to open in January 2010. Formed through the merger of the Helsinki School of Economics, the University of Art and Design Helsinki and the Helsinki University of Technology, Aalto University is intended to provide a unique and "integrated seedbed for innovation." As the flagship project in a national shake-up of higher education, the university is intended to set and improve framework conditions conducive to knowledge creation, human resources and entrepreneurial behavior, and will establish a new set of standards for innovative learning and for how knowledge is created and developed.

  - Access to, types of, and participation in vocational education and training, whether school-based, transitional, continuing education, or work-based programs and including apprenticeships and other types of on-the-job training.
- **Workforce quality and composition**, which refers to:
  - Overall investments made by firms/institutions in training for their workers;
  - The numbers and proportion of employment of highly skilled workers (e.g., researchers, R&D personnel, workers in medium-/high-tech manufacturing, engineers, PhDs, etc.); and
  - The mobility of workers (especially highly skilled workers) into and out of the Kingdom as well as between jobs within the country.
- **Specialized training for researchers and scientists**, which denotes dedicated efforts to raise the quality and quantity of highly-skilled and -specialized science- and technology-focused researchers and to engage R&D personnel in translating their research outputs into marketable products or services.

Governance

Governance refers to the policies, administration, and organization of an entity, in this the report referring to a nation, the Kingdom of Saudi Arabia. Governance is critical to the operations of an innovation ecosystem since it determines what policies are pursued, what functions are assumed or left unattended, and, in many circumstances, how different parts of the system interact with other parts. As a result, the laws, policies, and practices established and executed by public agencies greatly affect a society's capacity for successful innovation. To reflect this importance, four sub-components are included in the NIE's governance pillar, namely:

- **Laws, regulations and incentives,** including:
  - The efficiency, reach, and burden of the overall legal and regulatory system (e.g., regarding ICT, customs, auditing/reporting, environment, taxes, labor, anti-monopoly, non-tariff barriers, etc.);
  - R&D-related support policies (e.g., tax subsidies);
  - Intellectual property protection (e.g., copyright, trademark, industrial design, patent, trade secrets, electronic transactions); and
  - Standards and accreditation criteria and approval processes for institutions, professional or technical qualifications, products, and services;
- **Economic policies,** which refers to policies affecting the overall macroeconomic environment in the country (e.g., GDP, productivity, debt, deficit/surplus, savings, and inflation);
- **Trade and investment policies,** which denotes policies related to trade barriers, trade intensity, exports, attractiveness to foreign direct investment (FDI), foreign ownership, and breadth of international markets);
- **Accountability and transparency practices,** which focuses on professional management and effectiveness of enterprises (public and private), the voice of citizens in public matters, corruption, judicial independence, and public trust in government and politicians, as well as related issues such as political stability, reliability of law enforcement, and business costs of crime and violence.

Singapore's Efficiency, Accessibility, and Transparency in Government Initiatives

The government of Singapore was one of the first nations in the world to implement an e-Government system. Singapore's e-Government initiative began in 1980 with the Civil Service Computerization Program, which sought to improve government efficiency by automating work functions and reducing paperwork. The effort continued in 2000 with three multi-year action plans, administered by the Infocomm Development Authority of Singapore:

- The first e-Government Action Plan (2000-03) established the governments "eCitizen" portal, where citizens can interact online with the Government on a vast range of matters 24 hours a day, seven days a week. Individual agencies construct their online tools with centrally developed "building blocks" (such as payment or messaging options) to minimize development time.
- The second e-Government Action Plan, launched in 2003 with a US$0.76 billion investment, focuses on making all government services that can be placed online available via the internet and directing public agencies to work together on e-services integration.
- The latest e-Government plan, launched in 2006, is a US$1.3 billion initiative to actively engage citizens in the policy-making process and further improve e-Government efficiency.

Innovative Capacity

Innovative capacity refers to the systems available to support the transformation of a broad range of new ideas into marketable products, processes or services. As such, this pillar focuses on entrepreneurship of all types. Two sub-components compose the innovative capacity pillar:

- **Business dynamism,** which denotes the levels of entrepreneurship, startups, types

Examples of Korea's Innovative Capacity Investments

Up until the early 1990s, the Korean government did not pay much attention to developing new enterprises. Since that time, however, numerous programs have been established to support business development. A sample of these initiatives includes:

of intra-enterprise innovation, enterprise competitiveness, and extent of business involvement in medium- and high-technology sectors; and

- **Nature and levels of innovative capacity,** which captures the types and levels of research output, the mechanisms for and extent of technology transfer and diffusion, the degree to which research is commercialized, and firm-level innovation (such as sales, products, processes, and services that are new-to-market, new-to-firm, or new-to-world).

Networks and Attitudes

The networks and attitudes pillar emphasizes the importance of a culture that encourages risk-taking, values creativity, and rewards entrepreneurship as well as an environment in which people who demonstrate such characteristics are able to connect readily with each other and to the resources they need to move forward with their ideas. The networks and attitudes pillar consists of three sub-components:

> **Finland's FinNode Innovation Center Program**
>
> Finland has actively sought partnerships with the world's leading centers of innovation. Bilateral cooperation with countries outside Europe is set to increase, particularly with countries demonstrating leading technological advances and emerging economies.
>
> The international FinNode innovation centers, which have been set up in China, the United States, Russia and Japan, represent a new kind of partnership model: FinNode Centers are joint initiatives established by Tekes, Finpro, VTT, Sitra, and the Academy of Finland. FinNode's services are organized to complement Finland's national innovation programs.

- **Collaboration and linkages,** which refers to the myriad ways in which public institutions, universities, and private enterprises interact with each other in innovation-related activities;
- **Market and customer orientation,** which embodies the extent to which enterprises respond to market signals and drive market trends using deep knowledge of customers' behavior, preferences, and challenges;
- **Openness to change and new ideas,** which encompasses public attitudes toward change as well as government use and promotion of innovation tools.

Finance and Capital

Public and private sector investment in R&D and entrepreneurship are critical to development of a robust innovation ecosystem, as is an overall financial and capital markets system that is stable, sound, and provides the variety of funding vehicles needed by entrepreneurs. The finance and capital pillar involves four sub-components:

- **Financial and capital markets**, which gauges the soundness of the financial system and access to various types of funding (such as loans, equity investment, and risk capital);
- **Public R&D funding**, which involves the sources, levels, and nature of government expenditures on R&D;
- **Private R&D expenditures**, which denotes the sources, levels and nature of businesses' investment in R&D; and
- **Other funding**, which refers to capital investments that are not specifically R&D-related but that nonetheless support innovation in the broad context.

Venture Capital in Finland: The Important Role of Public Support

The government of Finland has taken an active role in fostering a Finnish venture capital (VC) sector. For example, following a fact-finding mission to Silicon Valley in 1986, Sitra was established to make direct investments in Finnish companies. In 1988, the European Private Equity and Venture Capital Association was invited to organize a seminar in Finland, and in the same year Finland's largest commercial bank launched the first national VC fund. In 1993, a Government Committee recommended a series of new guidelines for VC policy that included the broadening of investment rules for pension funds and the creation of subsidized management fees of VC funds. In short, the government has taken a series of deliberate steps to expand the types of finance available to Finnish businesses.

Comparison of the NIE Framework to the National Science and Technology Plan

Overview of Differences in Scope and Purpose

It is now generally understood that science and technology are important elements of innovation, but that not all innovation is based in science and technology. Instead, innovations may be product-related or process-related, may be fundamentally technological or based in business models or organizational structures, or may be either disruptive or incremental in nature. Moreover, innovation is a non-linear process entailing complex interactions among a multitude of supporting policies and organizations, including but not limited to entities conducting R&D. Regardless of the type of innovation, innovations improve value to the consumer, producer, or society at large.

A society's capacity for innovation – and consequently its ability to establish the basis for sustained economic growth – depends to a large extent on the strengths of and interactions among the many institutions involved in innovation and on the effectiveness of innovation-related policies, with such institutions and policies including but not limited to those related to science and technology. The term used in this report – national innovation ecosystem – has been adopted widely to reflect the scope of support and the complexity of the organizational and policy environment necessary to support science-, technology- and innovation-based growth.

The distinction that science and technology are a significant element of innovation but do not serve as the basis for all types of innovation is central to defining the major differences between the scope and purpose of the Saudi National Science and Technology Plan and the scope and purpose of the National Innovation Ecosystem framework described in this report.[10] Developed to address Royal Decree No. (8/m) to "propose a national policy for the development of science and technology and to devise the strategy and plans necessary to implement them," the NSTP is true to its scope and purpose, namely: design approaches and mechanisms to support science and technology. Innovation is indeed included in the NSTP, but mainly as a supporting element for developing science and technology rather than a standalone component.

In contrast, the scope and purpose of the NIE project is broader: its mission specifically notes the involvement of "all constituents in Saudi Arabia," not only those focused on science and technology. Accordingly, the NIE framework is inherently broader than the NSTP, since it encompasses innovation of all types, whether science-, technology or R&D-based or not. Because it has a broader scope, the NIE also has broader functions and audiences. In terms of functions, for example, the NIE focuses greater attention on, e.g., entrepreneurship, collaborative processes, and networks, among others. In terms of audiences, the NIE includes the government, universities and research institutions (like the NSTP) but also has a strong focus on the private sector and society as a whole; moreover, the NIE emphasizes interactions among the various constituents as a critical component of the innovative process.

The following table summarizes the direct correspondence between the NIE pillars and the NSTP strategic bases. As indicated, in many cases, the NIE pillars encompass aspects of several NSTP strategic bases. Two strategic bases are not applicable to the NIE framework, in one case because the NIE itself is envisioned as a cohesive, comprehensive, coordinated system and in the other because the NIE targets innovation broadly, rather than development of specific sectors.

Drawing from the table on the next page, the following section details key areas in which the NIE framework extends into areas that are not addressed or are not covered comprehensively in the NSTP.

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[10] Our comparison of the NSTP is derived from a close examination of pp. 33-41 of the English translation of the National Long-Term Comprehensive Plan for Science and Technology. Pages 33-41 describe the ten "strategic bases" and the policies/programs under each of the 10 strategic bases. The comparison contained in this section of SRI's report assumes that the reader is familiar with the National Science and Technology Plan and, thus, does not summarize or otherwise describe the plan. Readers unfamiliar with the plan may wish to refer to www.kacst.edu.sa/aboutkacst/STNP/pages/STNP.aspx.

Comparison of the National Science and Technology Plan (NSTP) and Proposed National Innovation Ecosystem (NIE) Framework	
Pillars of the NIE	**Strategic Bases of the NSTP**
Pillar 1: Infrastructure	**Second:** Activating education and training roles and improving their efficiency in quantity and in quality, in a way that complies with the needs of the desired scientific and technical advancement, and laying emphasis on the scientific and international new technical developments and their challenges. **Third:** Preparing the means and ways that can promote, develop and coordinate the scientific research and technology development national capabilities, and ensuring that they meet and integrate into the needs of society and the requirements of sustainable development. **Tenth:** Making the scientific and technical information available and facilitating all of the ways of access to it, within the framework of the Kingdom's goals and conditions.
Pillar 2: Human Capital	**Second:** Activating education and training roles and improving their efficiency in quantity and in quality, in a way that complies with the needs of the desired scientific and technical advancement, and laying emphasis on the scientific and international new technical developments and their challenges. **Third:** Preparing the means and ways that can promote, develop and coordinate the scientific research and technology development national capabilities, and ensuring that they meet and integrate into the needs of society and the requirements of sustainable development.
Pillar 3: Governance	**Sixth:** Continuing technology transfer, settlement and cultivation to improve the productivity, and the enhancement of the competitiveness of the productive and services sectors. **Eighth:** Developing the regulations that govern the performance of the national system for science, technology and innovation, and improving the efficiency of organization and management in the scientific and technical institutions to cope up with the current and future requirements of the comprehensive and sustainable development.
Pillar 4: Innovative Capacity	**Third:** Preparing the means and ways that can promote, develop and coordinate the scientific research and technology development national capabilities, and ensuring that they meet and integrate into the needs of society and the requirements of sustainable development. **Sixth:** Continuing technology transfer, settlement and cultivation to improve the productivity, and the enhancement of the competitiveness of the productive and services sectors. **Seventh:** Supporting, fostering and encouraging the national human capabilities, so as to have the ability to create and innovate.
Pillar 5: Networks and Attitudes	**Seventh:** Supporting, fostering and encouraging the national human capabilities, so as to have the ability to create and innovate. **Ninth:** Developing the different aspects of scientific and technical cooperation in the Gulf, Arab, Islamic, and international levels, focusing on the cooperation with the advanced countries and institutions in the scientific and technological fields in which the Kingdom seeks to achieve superiority.
Pillar 6: Capital and Finance	**Fifth:** Promoting, developing and diversifying the financial support sources for the activities of the national system for science, technology, and innovation, in a way that guarantees performing its tasks properly.
n/a	**First:** Adopting a comprehensive vision in developing the system of science, technology and innovation that leads to the collaboration among system components, the coordination of its plans, and closing its ties and interaction with the economic, social and cultural activities.
n/a	**Fourth:** Adopting main trends for scientific research and technical development that can satisfy the priorities of comprehensive national security and sustainable development requirements.

DISTINGUISHING CHARACTERISTICS OF THE NIE COMPARED TO THE NSTP

This section of the report accentuates the elements of the NIE that are significant extensions of or substantial additions to the NSTP's strategic bases and related policies. In other words, this section does not cover the many areas of the NIE and NSTP that are comparable or similar. Instead, it highlights the specific differences between the NIE framework and NSTP, categorizing the differences according to the six NIE pillars.

Infrastructure

As defined in the NIE framework, the infrastructure pillar encompasses two key components that are not addressed explicitly in the NSTP. Within the infrastructure pillar, the two distinguishing elements are:

- **Quality and quantity of physical infrastructure**, such as roads, railroads, electricity, and other parts of the tangible grid that underpins economic and innovative activity. Notwithstanding the advances that the Kingdom has achieved in this area, additional strengthening is needed to bring the country's physical setting to world-class levels and thus facilitate innovation. For example, parts of the Kingdom still experience disruptions in electricity, a phenomenon that impedes productivity in many types of companies and institutions. Accordingly, physical infrastructure is included in the proposed NIE framework.

- **Institutional infrastructure**, including:
  - ***Public investments in core facilities*** such as laboratories, pilot plants, clean rooms, etc., as well as equipment for such facilities and development of mechanisms so that researchers affiliated with a wide range of institutions (public and private) can access this highly specialized and expensive infrastructure. Much effort has already taken place in Saudi Arabia to establish research centers and institutions, but typically these facilities have not contained specialized laboratories or equipment. The recent announcement of an Intel-KACST nano-manufacturing R&D center[11] provides an indication of awareness of the need for specialized facilities; however, sustained, substantial investment is this area is important.
  - ***"Soft" institutional infrastructure***, such as professional societies, industry associations, and other groups that provide networking, professional development, information exchange, collaboration, and other opportunities that are a key part of the fabric of an innovation ecosystem. In general, such organizations have not played a major role in science-, technology-, and innovation-oriented development in the Kingdom, and increasing the reach and effectiveness of societies and associations will contribute significantly to the development of Saudi Arabia's NIE.

[11] www.semiconductor.net/article/CA6655150.html?nid=3663.

Human Capital

Contained in the proposed NIE framework are six important education- and training-related elements that distinguish the NIE compared to the NSTP. These human capital issues include:

- **Primary and secondary education** is an important building block to attainment at the tertiary level as well as to initiation of youth's interest in science, technology and innovation. As a result, it is very important to bolster STI capacity at the primary and secondary levels as part of an NIE.
- **Transition activities between education and the workforce** are often necessary, regardless of the stage of economic development, to translate the knowledge gained in schools to the skills needed in the workplace. Because much of STI-oriented development requires individuals with greater capacity than, for example, agriculture- or manufacturing-based development, tailored efforts to ease the transition to work form part of many NIEs.
- **Vocational and continuing education** helps to link education closely to industry needs, as well as to provide the full range of skilled technicians, laboratory managers, and other skilled support staff for STI-oriented enterprises. Accordingly, development of strong vocational and continuing education institutions and offering is critical in an NIE.
- **Engagement of the private sector in training** is another mechanism to ensure that the skills learned in schools are appropriate for industry's requirements. Through an NIE, the private sector is typically engaged to provide input to, directly offer, or sponsor job-related training.
- **Migration and employee turnover** is a concern in nations that have an insufficient supply of talented workers in STI fields, because "brain drain" and loss of key employees to other countries or institutions (including competitors) can significantly impede efforts to develop a vibrant NIE.
- **Education and training of researchers and scientists** is an important element of an NIE in order to build a solid base of competence and excellence in science and technology fields.

Governance

The NIEs of advanced countries (such as Australia or Finland) may not include this pillar, since strong governance structures are assumed to have been already developed. In the case of Saudi Arabia (and many other countries embarking upon or in the midst of transition to a knowledge-based economy), governance remains a "work in progress" that must continue to be built through NIE-related efforts. The central additions of the proposed NIE framework compared to the NSTP are:

- **Full range of legal and regulatory policies and incentives,** not only those related to science and technology, but also including more fundamental laws and regulations.
- **Standards and accreditation criteria and approval processes** are essential for high quality, free and open competition, ability of government (and private enterprises applying for certifications) to move quickly, and to facilitate many other functions that are important to an NIE.
- **Transparency and accountability,** especially by the public sector, is critical so that entrepreneurs and investors (and citizens in general) are confident that their

activities will be free from unwarranted interference. As a result, NIEs typically include a strong component of transparency and accountability measures and activities.

- **Stability and related risks** relate to the degree to which government provides a predictable environment for business growth; in the absence of such reliability, potential innovators may proceed cautiously (or not at all), thereby hindering overall growth.
- **Economy and trade**, meaning the basic foundation of economic and trade policies, forms the backbone of overall efforts to advance an economy, including initiatives within an NIE framework.

Innovative Capacity

The innovative capacity pillar represents an area in which the NIE has a significantly broader scope than the NSTP. As delineated in the NIE framework innovative capacity covers all types of innovation, not solely those related to science and technology. Two elements of this pillar stand out as prominent differentiators:

- **Entrepreneurship** is emphasized across all segments of the economy (not just S&T-based fields); because of the importance of promoting entrepreneurship, a large array of initiatives in this area is a tenet of NIE frameworks.
- **"Soft" elements of technology transfer and diffusion** involve the relationships and market/customer connections that are necessary for the tangible "results" of scientific research to be translated into commercially successful products or services. In other words, developing the formal mechanics of technology transfer is necessary but must be accompanied by dedicated attention to building capacity and market knowledge.

Networks and Attitudes

Like the innovation and capacity pillar, the networks and attitudes pillar of the NIE encompasses components that generally extend beyond the scope of the NSTP. Five main areas of the networks and attitudes pillar are particularly notable, namely:

- **Social receptivity to innovation** receives dedicated focus of attention under the NIE because, if society at large does not value or reward innovators of all types (not solely those that initiative scientific or technological advances) – even if a given innovation is not successful – it will be extremely difficult to encourage individuals to embark upon this path.
- **Public sector use of innovation tools** is important because government can "model" the openness to change and new ideas that encourages creativity, problem-solving and, ultimately, innovation.
- **Cooperation and collaboration among Saudi institutions** (as well as with the regional and international organizations referenced in the NSTP) is critical to develop in-county centers of excellence, promote knowledge-sharing, and maximize returns to public and private investment in R&D.
- **Myriad linkages and relationships** support innovation of all types, and innovation today is often thought of as a collaborative, team-based process, rather than an act of individual genius. Accordingly, while it is important to support creative individuals (as described in the NSTP), it is as or more important to devote

attention to building connectedness amongst individuals and groups involved in science, technology and innovation efforts.
- **Market and customer orientation** is an underlying principle without which innovation cannot flourish. Understanding what the market is not providing and users want is a key differentiator between an invention and an innovation. Without this understanding, the "discovery" remains unused; with this understanding, it is possible to develop a product, process, or service with commercial potential.

Finance and Capital

Funding for risky, innovative ventures with longer time horizons than the private sector alone is typically unwilling to assume is a central element of the innovation ecosystems of most advanced economies. Within the finance and capital pillar, two distinguishing elements are contained:

- **Funding for all types of enterprises**, not just those related to science and technology, is needed for innovation to flourish. Accordingly, the NIE encompasses the wide variety of financing vehicles, mechanisms, and types that are useful for enterprises in all sectors.
- **Private R&D expenditures** must be galvanized for a country to transition to a knowledge-based economy. In many NIE frameworks, therefore, mechanisms to encourage private spending on R&D (including public sector incentives) are common.

Appendix: Case Studies of Three National Innovation Ecosystems

FINLAND'S NATIONAL INNOVATION ECOSYSTEM (NIE)

Introduction

Summary of Innovation Performance

Using as an indicator the European Innovation Scoreboard (EIS)[12], which provides a comparative assessment of the innovation performance of European Union (EU) Member States under the EU Lisbon Strategy[13], Finland is identified as an "innovation leader", with innovation performance[14] well above that of the EU27[15] average and all other countries. Finland's ranking combines strong innovation performance with moderate rates of growth on many innovation indicators.

The Global Innovation Index (GII)[16], developed by the INSEAD Business School, France, as a formal model to help rank the extent to which individual nations and regions are responding to the challenge of innovation, ranks Finland 13th out of 130 countries. This report identifies that Finland has put most of the ingredients of a futuristic networked society in place by focusing on innovation, education and information technology. Unlike the rest of Europe, it scores highly on human capacity and on institutions and policies. Finland was the first country in the world to conceive of the idea of a national innovation system to feed into policy formulation. Leadership for national innovation emanates from the highest level of Finnish government. Finland's current rate of investment in research and development (R&D), at 3.5% of gross domestic product (GDP), is one of the highest in the world,[17] and a target of 4% of GDP has been set to be reached by 2011.[18]

As will be described in this case, Finland's innovation performance can be attributed to:

- The high standard of Finland's education system;
- National investments made in research and development;
- Strong network and scope of regional universities;

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[12] INNO-Metrics European Innovation Scoreboard, www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=5&parentID=51.

[13] See Innovation and the Lisbon Strategy: http://europa.eu/scadplus/leg/en/lvb/n26021.htm

[14] The development in innovation performance has been calculated for each country and for the EU27 as a block using data over a five-year period. This calculation is based on absolute changes in the indicators, as opposed to previous EIS reports where trends were calculated relative to the EU average. Further details of the methodology used can be viewed at: Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT) (2009) *European Innovation Scoreboard 2008: Comparative Analysis of Innovation Performance*, January, p. 49.

[15] EU27 comprises the twenty-seven member states of the European Union.

[16] The GII is intended to serve not only as a means for determining a particular country's relative response capacity, but also to provide a clearer picture of a country's strengths and deficiencies in regard to innovation-related policies and practices. Response-readiness is linked to a country's ability to adopt and benefit from leading technologies, increased human capacities, organizational and operational developments, and enhanced institutional performance.

[17] INSEAD (2009) *Global Innovation Index 2008-2009*, Fontainebleau, France, p. 16.

[18] Tekes (2008), "Finland Unveils New Innovation Strategy," *Science|Business*, www.tekes.fi/tekes/esittely/Science_Business_Tekes.pdf.

- Technology centers as a platform for interaction;
- Catalytic role of the Centers of Expertise Program (described later in this case);
- Specialization of expertise between regions;
- A national focus on world class knowledge;
- The operational development of public-private partnerships;
- The existence of the European Union's Structural Funds, which have supported innovation; and,
- Long-span networking (e.g. Multipolis Model).

Impetus Behind and Stages of the NIE

In recent years, the transformation of Finland's economy has proceeded in three main phases. In the post-war period, the country industrialized rapidly, primarily "on the back of heavy investments in export-oriented heavy industries including paper and pulp, basic metals, and chemicals."[19] Following economic collapse in autumn 1990, "it became clear that the Finnish economy and society required major structural changes,"[20] and by the mid-1990s, the government and the private sector, operating in consensus, turned toward technology and innovation as the core driver of economic growth strategy. In addition, the government embarked upon efforts to increase its own efficiency and competitiveness. Since then, "having a strong engineering orientation, the Finnish value-adding strategy was primarily based on technological innovation."[21] Beginning in 2009, Finland's NIE again entered a period of change, based on a 2008 review of the innovation policy system.

A number of policy drivers have served to foster Finland's NIE during these different stages of development. Public policies implemented during the 1980s, 1990s, and throughout the current decade have played a significant role in reinforcing Finland's innovative capacity by creating the requisite framework conditions for national and sub-national innovation. For example, from the late 1980s, a nationwide network of technology parks and centers of expertise were established.[22] In addition, important investments in R&D, together with the establishment of an effective network of public agencies supporting public and private R&D, were initiated. A cluster-based approach to innovation, which encouraged numerous interactions and knowledge and technology transfers among small start-up companies and larger firms, service providers, research institutes and universities, was pursued.

Effective education policies fostered a skilled workforce and facilitated the absorption of new technologies into production processes. Significantly, these policies generated an important pool of researchers and engineers needed for the development of the country's telecom equipment industry, a key industry sector that considerably

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[19] Schienstock, Gerd and Timo Hämäläinen, "Transformation of the Finish innovation system: a network approach," Sitra Report Series 7, 2001, p. 33.

[20] Schienstock, Gerd and Timo Hämäläinen, op. cit., p. 34.

[21] Schienstock, Gerd and Timo Hämäläinen, op. cit., p. 37.

[22] Australian Business Foundation (2005) *National Innovation Systems: Finland, Sweden & Australia Compared: Learnings for Australia*, November, p. 8, www.abfoundation.com.au/research_project_files/4/NISRoosShortPaper22Nov05.pdf.

underpinned the development of Finland's transformation to an innovation economy, its NIE, and subsequent status as an innovation leader.

The early liberalization and deregulation of Finland's telecommunications market resulted in a competitive market structure with numerous local and foreign operators. This generated incentives for the introduction of technological innovations. The Finnish government's role in the early development of the mobile telecommunications industry (through the development of the NMT and GSM standards) enabled Nokia and other Finnish industry players to benefit from 'first mover advantages' globally.[23] Accordingly, Finland's transformation to a knowledge-based economy and its strengthened national innovative capacity has, to a large extent, been a business-driven process.

Moreover, to actively foster NIE evolution, Finland has put in place, and actively pursued, a cooperation model that brings together the government, companies and universities. Since the mid-1980s, the Finnish government has been heavily investing in R&D with the active participation of industry and universities and with the establishment of focused innovation-supporting institutions. Founded in 1983, a key instrument in Finland's NIE institutional framework is the Funding Agency for Technology and Innovation (Tekes)[24]. Tekes is a Finnish state fund with a considerable annual budget, reaching €512 million in 2007.[25] Starting in the mid-1990s, research and innovation in the country has been based on a "triple-helix model", which involves universities as producers of knowledge, industry as a user of that knowledge, and the government as the guarantor of long-term sustainability for research programs.

Within Finland's university system, there are some 10,000 professors and researchers working with mainstream budgets, with another 10,000 individuals working with the external funding. Institutionally, there are thirty two science parks and technology centers within the Finnish Science Park Association (TEKEL).[26] At the national level, the Finnish Science Park Association works in close collaboration with national ministries. Regionally, science parks operate at the interface between industry and universities. The country's science parks are at the heart of Finland's excellence in science and innovation. Finland has been successful in ensuring that platforms (such as science

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[23] See for example, Ali-Yrkkö, J. and Hermans, R. (2004) Nokia: A Giant in the Finnish Innovation System, in Schienstock G. (ed.) *Embracing the Knowledge Economy: The Dynamic Transformation of the Finnish Innovation System*, pp. 106-127. MA, Edward Elgar.

[24] Funding Agency for Technology and Innovation, www.tekes.fi/eng.

[25] ERAWATCH, http://cordis.europa.eu/erawatch/index.cfm?fuseaction=org.document&uuid=7D87CBAB-CCA0-11D1-88A0A8E6455E588B

[26] TEKEL Presentation (2009) TEKEL Finnish Science Park Association: Homes for Innovation, January, www.tekel.fi/@Bin/95588266/TEKEL_Jan2009.pdf.

parks) for cooperation in research and innovation exist, and that such platforms are visible and have the required marketing and targeted image-building.[27]

Education has been, and continues to be, a key foundation of Finland's NIE. In the OECD's recent Program for International Student Assessment surveys (PISA 2003 and 2006), Finland was ranked as the highest-performing country in terms of learning skills among 15 year-olds in mathematics, science, and reading literacy. Basic, secondary and tertiary education is publicly funded and free of charge, and the social security system in Finland exerts a strong incentive for young people to remain in continuing post secondary education. Between 1993 and 1998, the total intake of students in universities nearly doubled, while in polytechnics, student numbers almost tripled.[28] Finland has established, and invested in, a number of technical universities and public research institutes, such as the Helsinki University of Technology and the Technical Research Centre of Finland.

In 2008, the Finnish Government decided to develop a new National Innovation Strategy and a related Action Plan.[29] The new strategy aims to be a broad-based strategy that enables the adoption of a *systemic and comprehensive approach* to innovation policy that triggers demand-driven (user-oriented) innovation. Key strategic goals that will underpin Finland's future national innovation strategy, and that will likely impact Finland's future NIE, include the following:

- Increase *cooperation between all government entities* working on policies that impact innovation performance. The Cabinet Committee on Economic Policy will, for example, be expanded into the Cabinet Committee on Economic and Innovation Policy, which will act as a forum for the strategic management and coordination of innovation-related reforms. A new Research and Innovation Council has already been established to monitor and review broad-based innovation policies. The use of innovative products and processes will also be promoted throughout Finland's public sector agencies.

- Further promote *open and cooperative innovation models* to better involve consumers, customers and other firms in product development. Strategic partnership and cooperation frameworks with other innovation networks will be reinforced. European innovation networks and programs will be better leveraged, and regional innovation centers (hubs of expertise) will be established to attract new skills, businesses and venture finance globally. A key aim will be to establish Finland as a pioneering environment for innovation.

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[27] N. Tapani Saarinen (2008) Co-operation Key to Finland's Innovation Excellence, Wednesday 30 January, www.euractiv.com/en/science/saarinen-operation-key-finland-innovation-excellence/article-169953.

[28] Lesser, C. (2008) Case Study No. 1: Market Openness, Trade Liberalisation and Innovation Capacity in the Finnish Telecom Equipment Industry, Working Party of the Trade Committee Trade and Innovation Project, Organisation for Economic Cooperation and Development, Trade Policy Working Paper No. 73 TAD/TC/WP(2008)6/PART2/A/FINAL, 29 July, p. 22, www.oecd.org/dataoecd/5/53/41076976.pdf.

[29] See: National Innovation Strategy proposal, www.innovaatiostrategia.fi/en/overview.

- Encourage *creativity, entrepreneurship and innovation-based productivity* in all sectors of the economy, for example, through the establishment of a consolidated public entity that will coordinate the delivery of business and financial services to entrepreneurs and innovative growth companies. Reforms in the educational system will ensure that it nurtures entrepreneurship, creativity and innovation. Additional continuous learning and training opportunities for adults will be provided. All proposed public policy reforms will be systematically reviewed to assess their likely impact on entrepreneurship and innovation.

- Enhance the *research capacity* of universities, polytechnics and research institutes and further strengthen the linkages between universities, research institutes and the private sector, to make Finland an internationally competitive environment for R&D.

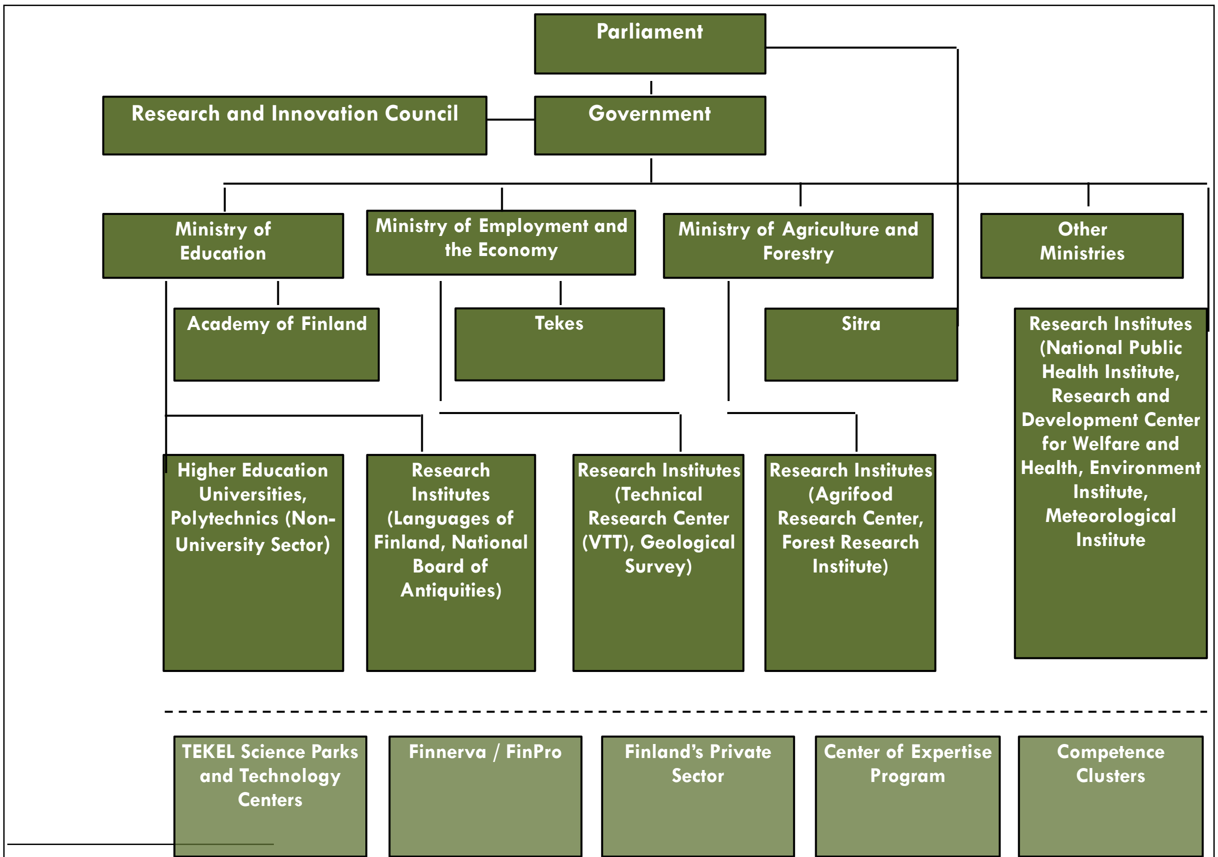
- Enhance *international mobility* among students and researchers, to ensure more linkages and mutual learning opportunities.

National-Level NIE Structure and Collaboration Mechanisms

Organizational Structure of Finland's NIE

The organizational structure of Finland's NIE consists of four, and arguably five, operational levels. The highest level of governance resides with Parliament and the National government. The structure is depicted in the following diagram.

Organizational Structure of the Finnish Innovation and Research System[30]



[30] As of 19/01/2009, adapted from, http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=35&countryCode=FI&parentID=34.

Government is supported in matters related to research, technology and innovation policy by the newly established, high-level advisory body, the Research and Innovation Council. The council comprises seven national ministries and ten other expert members from different stakeholder groups that advise on strategic development and coordination of Finnish science and technology policy, as well as of the national innovation system as a whole.[31]

The second level consists of the ministries. The key ministries with respect to research policy are the Ministry of Education and the Ministry of Employment and the Economy. While there is a sectoral division of labor between science and technology policy, over the past few years, cooperation has increased significantly between these two ministries in issues related to science and innovation. This is partly as a result of their similar and joint objectives to promote research funding using government budgets, for which their close participation in the Research and Innovation Council has provided a good platform.

The third level consists of the R&D funding agencies, the Academy of Finland, the Finnish Innovation Fund (Sitra), and Tekes. The Academy of Finland funds basic research through competitive grants. Sitra, the Finnish Innovation Fund, is an independent public fund which, under the supervision of the Finnish Parliament, promotes innovation through a series of research programs. Sitra is involved in various ways in drawing up the country's new national innovation strategy, and the analysis and reform ambitions of the Finnish innovation system are overarching themes in a number of Sitra's projects.[32] While the majority of Tekes' funds are allocated to R&D projects carried out by companies, Tekes is also a large financier of university research. This is the level at which research priorities are determined, funding decisions made (except for the allocations between different ministries), and cooperation efforts facilitated.

At the fourth level are local level organizations that conduct research. These include universities, public research institutes, private research organizations and business enterprises. The Finnish research system is heavily decentralized, and there are 20 universities. There are 26 polytechnics, of which six are managed by local government authorities, seven by municipal education consortia and thirteen by private organizations. There are also 18 state run research institutes.[33]

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[31] Full membership at www.minedu.fi/OPM/Tiede/tutkimus-_ja_innovaationeuvosto/kokoonpano/neuvosto.html?lang=en.

[32] Sitra (2009) *Board Report and Financial Statements 2008*, Sitra, the Finnish Innovation Fund Electronic Publication, p.7, www.sitra.fi/en/Publications/annualreports/annual.htm.

[33] Finnish Science and Technology Information Service, State Research Institutes, Budgetary research funding and overall research expenditure in state research institutes 2009, www.research.fi/en/research_environments/state_research_institutes.

Finland's NIE framework is further supported a range of international, sub-national, regional and municipal level institutions that are considerable contributors to, and drivers of, national innovation and Finland's NIE. These include the private sector, science parks and technology centers, Finnerva[34], centers of expertise, competence clusters, regional and municipal governments, and others.

Key Institutions and their Roles

Finland's NIE is underpinned by a range of institutions. The roles of key institutions are described below.

The *Research and Innovation Council*[35], which was formerly the Science and Technology Policy Council, became operational on January 1, 2009. The Council, which is chaired by the Prime Minister, advises the Council of State and its Ministries in matters concerning research, technology, innovation and their utilization and evaluation. Supported by a small secretariat, the Council is responsible for the strategic development and coordination of Finnish science and technology policy as well as of the national innovation system as a whole.

The *National Technology Agency* (Tekes) is the principal source of public funding for applied technological research and industrial R&D (through grants and loans). Operating under the Ministry of Employment and the Economy, it contributes to the competitiveness of Finnish industry and service sectors (including the ICT and mobile telephony sector) by promoting research and application in the field of technological development. Tekes prepares, funds, and coordinates national technology programs and funds applied technical research and risk-carrying R&D ventures. It also contributes to the preparation of national technology policy. Of note is that foreign companies located in Finland are eligible for the same Tekes funding and services as Finnish companies.

The *Academy of Finland*, which operates under the authority of the Ministry of Education, is the prime funding agency for basic research in Finland. The Academy primarily seeks to advance scientific research and its application, support international scientific cooperation, serve as an expert body in science policy issues, and allocate funding to research and other advancement of science. Approximately 15% of all government research funding is channeled through the Academy.

The *Finnish National Fund for Research and Development* (Sitra) is an independent public foundation under the supervision of the Finnish Parliament. Its activities are designed to promote the economic prosperity of the Finnish people, and Sitra focuses its operations on program level activities. The methods used include research and training, innovative projects, business development, and corporate funding. Sitra's activities are financed

[34] Finnerva is a specialized financing company offering financing services to promote the domestic operations of Finnish businesses and to further exports and internationalisation of enterprises.

[35] Research and Innovation Council, www.minedu.fi/OPM/Tiede/tutkimus-_ja_innovaationeuvosto/?lang=en.

by the yield from its own endowment capital and the return on its venture-capital investments.

The *Technical Research Centre of Finland* (VTT)[36] is an applied research center that develops applied technology solutions for businesses, and participates in national and international research programs and collaborative networks. Operating as a non-profit research organization under the domain of the Ministry of Employment and the Economy, VTT is one of the largest multi-technological applied research organizations in Northern Europe, with a range of research and technology programs.[37]

The *Finnish Science Park Association* (TEKEL) represents, at the national and international level, the membership interests of the thirty-two science parks and technology centers located in university towns throughout Finland. These science parks and technology centers aim to facilitate exchanges between academic institutions and businesses. In 2007, these science parks housed approximately 2,400 companies with more than 44,000 employees.[38]

While not generally considered to be a central part of Finland's NIE, *Finnvera,* a specialist financing company owned by the Finnish state and which provides services to supplement the Finnish financial market, is actively engaged in supporting new enterprise development in the technology sector. Finnvera's task is to promote the development of enterprise, regions and the exports of Finnish companies. Finnvera carries out this task by improving the range and versatility of financing options available to enterprises through loans, guarantees and export credits.

Process Used to Build Inter-Institutional Consensus and Agreement

At the national, sub-national, and indeed international level, Finland has engineered, and continues to engineer, the formation of "thick" institutional structures that support national efforts to integrate innovation at the economic, competitiveness and policy and implementation levels. Finland's NIE is very much centered on a process that builds consensus and agreement through various inter-institutional mechanisms and initiatives. As described elsewhere in this case study, strong leadership from the Prime Minister, the fostering of inter-ministry collaboration through institutions such as the Research and Innovation Council and Sitra, and 'bottom-up' cross-sectoral and cross-institutional collaboration among agencies including TEKEL, science parks, universities, regional and municipal governments, national ministries, and the private sector, are a fundamental underpinning of Finland's NIE. Examples of building inter-institutional consensus and agreement are referenced throughout this case study.

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[36] VTT Technical Research Centre of Finland, www.vtt.fi/?lang=en.

[37] VTT research and technology programs include: Applied materials; bio- and chemical processes; energy; industrial systems management; information and communication technologies; micro-technologies and electronics; services and the built environment; and business and innovation research.

[38] TEKEL (2008) Brochure, www.tekel.fi/@Bin/95039029/TEKEL_2007_webesite08.pdf.

Mechanisms and Approaches Used for Effective Collaboration

A number of mechanisms have been put in place to foster effective collaboration and networking across Finland's NIE. Cross-institutional governance frameworks and working groups have been created to facilitate inter-institutional consensus and common understanding. A range of key national and internationally respected individuals sit on the Boards of various NIE institutions. The Research and Innovation Council (RIC), and the former Science and Technology Policy Council that RIC replaced, have both had a considerable role in positively affecting the networking and collaboration capacity in Finland's NIE. As a good practice case example in building NIE cooperation and consensus, the RIC brings together a range of key national innovation champions in a single council format to advance and guide NIE activities.

Chaired by the Prime Minister, the RIC comprises a range of key individuals. Deputy chairs include the Minister of Education and Science and the Minister of Economic Affairs. Ministerial members include the Minister of Finance, Minister of Agriculture and Forestry, Minister of Labor, Minister of Health and Social Services, and Minister of Culture and Sport. Members appointed by the Government include the President and CEO of the Nokia Corporation, Director General of the Technical Research Centre of Finland VTT), Chief Executive of the European Science Foundation, President of the Academy of Finland, Chief Executive of Finnzymes Ltd., Manager of the Central Organization of Finnish Trade Unions, the Director General of Tekes, Rector of the Central Ostrobothnia University of Applied Sciences, a Professor at the Helsinki University of Technology, and rector of the University of Turku.

In addition, various national R&D support programs, especially those conducted by Tekes, have frequently put networking as a main goal. Similarly, the regional Centers of Expertise program has also been exemplary in this respect.

Nature of Collaboration on Different NIE Functions

The nature of collaboration on different NIE functions is determined by the function being addressed. At the academic and researcher level, universities have traditionally established public-private partnerships with local, regional and national businesses to diffuse academic experience and gain industry insights on engineering, technology and other related fields. TEKEL, as well as Finland's science parks, are engaged in local, regional and national partnerships with universities, government ministries, businesses, and regional and municipal governments, to foster entrepreneurship, employment, regional development, and competitiveness. Such partnerships extend from formal agreements between stakeholders to informal level activities for local level development. A range of staff exchanges and secondments are available at various NIE institutions throughout the country to facilitate inter-disciplinary knowledge and experience between NIE sectors.

Academic staff at the TAMK University of Applied Sciences in Tampere can, for example, participate in staff exchange programs both to share their skills and knowledge, and to carry out teaching in other higher education institutions. The period of staff exchange may range from one week to one semester. TAMK University of Applied Sciences is a member of the Forum Nokia Innovation Network, a dedicated cluster of selected Forum Nokia PRO University members that research, develop and deploy innovative mobile solutions together with developer companies, and other related industry players. The international network focuses on applied research, proof of concept development, real world testing, rapid prototyping, and mobile systems and applications training and education.

Sub-National, Regional and International Linkages

Roles of Key Institutions in Delivering the NIE

In extending the reach of Finland's NIE to the sub-national level, a range of funding, programmatic and sector specific mechanisms have been established to foster innovation regionally and locally. A program that has fostered, and which will continue to foster, Finland's NIE framework at the regional level is the Ministry of Employment and the Economy Innovation Department Center of Expertise Program (CEP).[39] Initially established in 1994, and expanded in 1999 and 2003, the CEP is a fixed term governmental initiative that currently operates between 2007 and 2013 to deliver the Government's framework for improving regional competitiveness in accordance with national and European policies.

Focusing regional resources and activities on development areas of key national importance and pursuing a cluster-based model, the primary objective of the program is to bring together scattered expertise and research resources for the creation of more influential systems, and increase regional specialization and strengthen cooperation between Centers of Expertise (see the following table for additional detail about the key clusters and related target visions). The program involves thirteen national competence clusters of expertise and twenty-one regional Centers of Expertise. Coordinated nationally by a secretariat and advised by a multi-disciplinary Committee appointed by the Government, the secretariat and committee are supported by experts from the Ministry of the Employment and the Economy, the Ministry of Education, and Tekes. At the national level, CEP aims to:

- Generate new innovations, products, services, businesses and jobs based on top-level expertise;
- Support specialization and division of tasks between regions to form internationally competitive Centers of Expertise; and,
- Increase the capacity of regional innovation environments to attract internationally active businesses, investment and top professionals.

Ministry of Employment and the Economy, Center of Expertise Program (2007-2013) Competence Clusters and Vision Statement	
Competence Cluster	Target Vision

[39] Centre of Expertise Program, www.oske.net/en.

Ministry of Employment and the Economy, Center of Expertise Program (2007-2013) Competence Clusters and Vision Statement	
Cleantech	The environmental technology sector has become a new pillar of Finland, and the Finnish Cleantech Cluster has met the global customer demands within the environmental field. The constantly improving level of research and development supports the generation of new innovations and pioneer export enterprises in addition to attracting new competence-based investments into Finland.
Digibusiness	Making digital content competence into a world-class product and service business.
Energy Technology	The Finnish energy technology competence cluster has reached a strong position in the internationally growing areas of energy technology. This growth is sped up by industry-based research, development, and education environments.
Food Development	In 2013, Finland is the leading producer of wholesome, health-promoting and safe food in Europe.
Forest Industry Future	Finland in 2013 has a successful, competitive and sustainable operating forest cluster, whose ability to utilize the best available expertise and to commercialize innovations has become more effective especially in small and medium-sized enterprises.
HealthBIO	In 2013 Finland is an internationally attractive, leading-edge centre for bioscience and technology, producing competitive business significant from the point of view of the national economy and regional development. The five centres of expertise in the cluster form a highly performing cooperation network for Finnish and international businesses and research institutions operating in the field.
Health and Well-being	The health and well-being business has become a rapidly growing and internationalizing field in Finland. This is evident through growth in business activities, development in the structures and services of health care and an improvement in the well-being of citizens.
Intelligent Machines	Finland is one of the world's leading concentrations of expertise in researching, developing, commercializing and utilizing intelligent machines.
Living Business	The production and implementation of living solutions has shifted towards user-oriented production and operating models, which has reinforced the position of Finnish companies in the international market.
Maritime	Finland has the most efficient and productive maritime cluster in the world, and its innovative products and services succeed in the markets despite keen competition. By 2013 the maritime cluster program has promoted in particular the opportunities for the SME sector to grow and to offer its know-how and products in the global operating environment. The enterprises in the maritime cluster are attractive employers and, together with universities, research institutions and public sector actors, they create and further develop innovative products, processes, services and types of operation.
Nanotechnology	During the program period, Finland has evolved into one of the most integral European centres of nano- and micro-technology, as well as the applied research on new materials based on nano- and micro-technology and the business operations utilizing it.
Tourism and Experience Management	In 2020, Finland will be a top tourism destination in Europe providing easy access and premium-quality year-round services. The tourism offer is based on unspoiled natural landscapes and unique Finnish culture. In this way, the Finnish tourism industry will be able to build sustainable destinations and provide meaningful experiences for both business and pleasure.
Ubiquitous Computing	The vision of the Ubiquitous Computing Cluster is that by the end of the program season in 2013, Finland will be the know-how leader in the development, commercialization and capitalization of embedded intelligence in human-centered, distributed, mobile and constructed environments.

Source: CEP Competence Clusters, www.oske.net/en/contact_information/competence_clusters.

The role of regions and urban areas as drivers of sub-national innovation development is recognized under a complementary program that is being implemented by the national Ministry of Interior's Department for Development of Regions and Public Administration. The Regional Center Program (RCP)[40] is a government program implemented in accordance with the Regional Development Act of 2001. Its objective is the establishment of a network of regional centers covering every region and province for the development of the strengths, specialization and cooperation of urban regions. RCP network development themes are innovative action, prosperity, education and culture. During the RCP programming period 2007-2010, key foci include:

[40] Regional Center Program, www.intermin.fi/intermin/hankkeet/aky/home.nsf/pages/indexeng.

- Company oriented development and implementation of business and specialization strategies;
- Strengthening of the urban region expertise base especially in fields of specialization;
- Development of an attractive operating and innovation environment;
- Generating new modes of operation for innovative activity; and,
- Public and private sector partnership on various administrative levels.

At the regional level, Tekes' services can be accessed at a network of fifteen regional Employment and Economic Development Centers[41] located throughout Finland. Similarly, the range of Technical Research Center (VTT) services and research and technology expertise are available through VTT staff based locally in ten locations throughout Finland.

Approaches and Roles for Supporting International Linkages

The main drivers to creating international linkages in Finland's NIE are many. These include Finland's membership of the EU, its peripheral location in northern Europe, the collapse of the Soviet Union in the 1990s and the associated collapse in bilateral trade, the subsequent scale and speed with which Finnish companies have internationalized, and its relatively small population and home market. Accordingly, Finland has, by necessity, adopted an outward looking approach to innovation and development. The majority, if not all, of Finland's NIE institutions and programs have some element of international linkage. Indeed, as a fundamental component of building Finland's NIE networks for industry and knowledge transfer, international networking has deliberately featured as a component of Finland's NIE development.

As a member of the EU and one that is engaged in a number of EU-funded R&D and innovation programs, Finland must (and does) participate in such coordination. Entry criteria to many EU-funded programs requires EU-wide dissemination and linkages with other EU program recipients. In many cases, such programs are cross-national in nature, requiring working partnership and collaboration with similarly focused teams in other EU member states.

To foster international linkages between Tekes and international governments and NIE institutions, Tekes operates through a number of overseas offices in Europe, China, Japan and United States. Co-located at Finnish embassies in Brussels, Washington, DC, Beijing and Tokyo, and at Consulates-General in Silicon Valley and Shanghai, Tekes' international staff has responsibility for specific institutional development with companies and research institutes, and specific themes such as cleantech, venture capital, foresight, international business development, healthcare and well-being, and biotechnology. Tekes' international staff seek to foster international R&D cooperation in the areas of academic research cooperation, licensing, investment funding and corporate R&D partnerships.

[41] www.te-keskus.fi/Public/?PresLanId=2&area=7580&lang=2.

Roles of International Associations and Knowledge Networks

Finland's membership in the European Union is perhaps the most significant of mechanisms in informing the development of Finland's NIE and providing access to international associations and knowledge networks. Several of Finland's regions have been engaged with the Innovating Regions in Europe network,[42] a network created by the European Commission in the mid-1990s. With a stated aim of "facilitating exchange of experience and good practice among European regions" through the "development and implementation of regional innovation strategies,"[43] four of Finland's regions have prepared a regional innovation strategy and benefited from international learning. Two regions were similarly engaged in the development of regional innovation and technology transfer strategies (RIITS).[44]

Finnish research organizations and companies have been successful in competing for projects in the EU's research and innovation programs, with Finland being a net recipient of EU R&D funding.[45] The country is actively active in several new EU initiatives concerning EU and EU neighboring country research and innovation policy, in areas such as intensifying cooperation between national R&D programs and promoting European research through the European Research Area[46], the European Research Council[47], the EU's Seventh Framework Program (FP7)[48] and the Competitiveness and Innovation Framework Program.[49]

A Finnish Secretariat for EU R&D, with offices in Helsinki and Brussels, communicates EU framework program funding opportunities and EU policy issues to all Finnish stakeholders in companies, universities, research institutes, governmental agencies and municipalities. The secretariat provides general information and advice on the Seventh Framework Program for research and technological development (FP7), which is the European Union´s main instrument for funding research over the period 2007 to 2013. Established through a partnership between TEKES, the Academy of Finland and the Finnish science and technology information service, the secretariat coordinates the Finnish national contact system and monitors the EU project landscape and Finnish participation.

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[42] www.innovating-regions.org/network.

[43] www.innovating-regions.org/network/presentation/index.cfm.

[44] RITTS were aimed at supporting local and regional governments and/or development organizations for the analysis of innovation, technology transfer and RTD infrastructures, in view of the development of more efficient innovation support and promotion policies.

[45] Government of Finland (2009), *Government's Communication on Finland's National Innovation Strategy to the Parliament*, p. 13.

[46] European Research Area, http://ec.europa.eu/research/era/index_en.html.

[47] European Research Council, http://erc.europa.eu/index.cfm.

[48] Seventh Framework Program (FP7), http://cordis.europa.eu/fp7/understand_en.html.

[49] Competitiveness and Innovation Framework Program, http://ec.europa.eu/cip/index_en.htm.

Finland has actively sought partnerships with the world's leading centres of innovation. Bilateral cooperation with countries outside Europe is set to increase, particularly with countries demonstrating leading technological advances and emerging economies. The international FinNode innovation centres, which have been set up in China, the United States, Russia and Japan, represent a new kind of partnership model, and an investigation into establishing an innovation centre in India is underway.[50] FinNode Centers are joint initiatives established by Tekes, Finpro, VTT, Sitra, and the Academy of Finland, and FinNode's services are organized to complement Finland's national innovation programs.

Responsiveness to Local Conditions

Experience Simultaneously Building Capacity and Cooperation

The approach that Finland has pursued in the development and structuring of its NIE is innovative in itself, enabling Finland to build capacity and cooperation in a number of ways. As detailed in this case study, itt has created a number of NIE focused institutions that have a reach from the national to local level, through their structuring, inter-institutional governance and operational focus.

Undoubtedly, Finland has learned considerably from its engagement with the EU on transnational EU projects. Finland's NIE leadership has been able to witness comparative systems and approaches, and determine relative progress though benchmarking activities and international fora, of the need to reinvigorate and renew existing institutional and program level approaches to innovation. Having sought and developed extensive international linkages early on in its NIE journey, Finland has been able to identify optimal global approaches to building NIE capacity and cooperation. Pursuing a system in which industry and government have been heavily engaged and aligned, has similarly led to capacity building and cooperation across and within sectors for NIE development. Having actively fostered the "triple-helix model since the mid-1990s, capacity building and cooperation, in essence, have been a considerable foundation of Finland's NIE.

Experience Building on Institutional Strengths and Programs

Through a candid assessment of Finland's limitations in translating world class R&D efforts to product development, Finland has demonstrated a capacity to build and refocus institutional efforts and programs to reinvigorate national and sub-national efforts for innovation.

The recent renaming and rededication of the Science and Technology Policy Council to the Research and Innovation Council in January 2009, with a more focused innovation remit, demonstrates a willingness to renew existing institutions to strengthen the NIE. Key changes to the RIC mean that the new body will also deal with tasks relating to the comprehensive monitoring and promotion of innovation policy. Membership criteria of

[50] Ibid. p. 13.

the council have been changed so that expertise in broad innovation policy will be taken into account, there will be fewer quota-based memberships, and existing subcommittees dealing with science policy and technology policy will be replaced by a science and education subcommittee and a technology and innovation subcommittee. Furthermore, the council's secretariat will be strengthened.

As detailed in the section at the end of this case study entitled Key NIE Initiatives, Finland is putting in place a number of significant programs and initiatives that build upon institutional strengths and advance the scope and reach of Finland's NIE. These include a new national innovation strategy, Strategic Centers of Excellence, a new university that facilitates inter-cultural innovation and learning, and a new public sector initiative that aims to foster high-technology development based on the 'triple helix' model of cooperation in the peripheral North of Finland.

Experience Fostering Growth and Enterprise Development

Private sector growth and enterprise development are key drivers underpinning Finland's NIE. At the national level, there is an acceptance that Finland has not been particularly effective in translating substantial NIE investments into commercial products. In part a driver of the international evaluation of Finland's NIE currently taking place, there is widespread appreciation for the need to improve the process of bringing innovations into the market and turning them into competitive products at global level. The formula for an effective innovation policy is more than just promoting research and development projects, but translating such R&D into growth and enterprise development.

Finland's NIE has had a broad range of institutions and programs in place to foster growth and enterprise development. The former Ministry of Trade and Industry, through its oversight of Tekes and Sitra, made strategic-level investments in companies in the 1980s and 1990s to foster enterprise growth and innovation. In the 1980s, it is estimated that over 25% of Nokia's R&D was financed by Tekes, and between 1995 and 2000, Nokia received €1.7bn of public sector funding.

Another significant development has been the emergence in Finland of a market for venture capital (VC), a development greatly affected by public sector decisions. The Finnish government took an active role in fostering a Finnish VC sector. Following a fact-finding visit to Silicon Valley in 1986, Sitra was established with a role of making direct investments in Finnish companies. In 1988, the European Private Equity and Venture Capital Association was invited to organize a seminar in Finland, and in the same year Finland's largest commercial bank launched the first national VC fund. The Finnish Venturing Association was established in 1990, and in 1993, a Government Committee recommended a series of new guidelines for VC policy that included the broadening of investment rules for pension funds and the creation of subsidized management fees of VC funds.

Finnvera plc, the State-owned financing company and Finland's official Export Credit Agency, acts as an intermediary between the European Union's financing programs and Finnish SMEs. Finnvera's main tasks are to promote and develop particularly SME operations as well as firm-level internationalization and export operations, by offering financing services.

Through its membership of the European Union, Finnish SMEs are able to access the services of the Enterprise Europe Network in Finland (FINCIP). Comprising a number of key national and sub-national level NIE institutions including the Ministry of Employment and the Economy, the Employment and Economic Development Center for Southwestern Finland, Helsinki Region Chamber of Commerce, the Finnish Science Park Association, Technopolis Ventures Oy, Turku Science Park Ltd, and a number of SME business services providers, FINCIP provides support and advice to Finland's businesses to identify and maximise EU opportunities for SME and business-to-business development. FINCIP links Finland's SMEs and enterprises to the EU's Competitiveness and Innovation Framework Programme (CIP). Operating from 2007 to 2013 under the renewed Lisbon strategy for growth and jobs, CIP has a budget of approximately €3.6 billion. CIP comprises an Entrepreneurship and Innovation Programme (EIP) that aims to improve the conditions for innovation, such as exchanges of best practices between EU member states and actions to improve, encourage and promote innovation in enterprises. EIP supports actions fostering sector-specific innovation, clusters, public-private innovation partnerships and the application of innovation management.

Other institutions that actively seek to facilitate growth and enterprise development for Finnish innovation include Enterprise Finland, Finpro, the Foundation for Finnish Inventions, the National Board of Patents and Registration, the Finnish Industry Investment, the Employment and Economic Development Centers (TE Centers) and the Finnish Tax Administration.

Finland's NIE: Identifying Goals and Measuring Progress

In seeking to maintain and improve its standing as an innovation leader, Finland has identified a number of strategic and specific targets and goals. Finland also makes use of a range of national and international level mechanisms and instruments to measure progress at the NIE framework, institutional and implementation level.

Within Government, and at the thematic and institutional level, few NIE quantitative targets have been established with which to measure progress and drive strategy and implementation development (one notable target is, however, the goal of R&D funding of 4% of GDP by 2011). Finland does however make use of nationally and internationally driven systems of quantitative measurement, and both the Government and NIE institutions make considerable use of quantitative targets, if not having such targets themselves.

In assessing the actions, structure, and future operations and direction of the entire NIE, the Ministry of Employment and the Economy issued a contract notice in August 2008 to initiate an international evaluation of Finland's National Innovation System. To be coordinated by the Research Institute of the Finnish Economy[51], this work will be completed in September 2009. The objectives of the evaluation are fourfold:

Finnish National Innovation System International Evaluation Objectives
To form an outside view of major drivers of change in the system, as well as to evaluate how well they are addressed in innovation policy.
To identify ways of addressing the current and future challenges.
To point out needs for institutional and policy adjustments and reforms.
To draw conclusions and recommendations for the policy governance and steering.

Between 2004 and 2006, Statistics Finland, which operates administratively under the Ministry of Finance but is independently responsible for its activities, services and statistics, undertook a survey on innovation activity among Finland's enterprises.[52] Measuring product, process, organizational and marketing innovations across thirty-five categories, the final report, published in 2008, provides a national benchmark to inform the Government on enterprise level innovation and needs.

Through its membership of the European Union, Finland is automatically included in the data collection activities of the European Commission's Eurostat[53] agency. Eurostat regularly provides a wide range of EU-wide data sets and analysis tools on the themes of science, technology and innovation, R&D industrial investment, and information society. Similarly, the European Innovation Scorecard (EIS), which Finland uses to measure innovation standing and progress, provides a comparative assessment of the innovation performance of EU Member States under the EU Lisbon Strategy using 29 indicators.[54] EIS annually benchmarks the innovation performance of Finland (and all EU member states) drawing on statistics from a variety of EU sources.

The Nordic Innovation Center[55], which was created under the Nordic Council of Ministers and on whose Board a representative of Tekes sits, has recently funded a program entitled *Policy Relevant Nordic Innovation Indicators* which is assessing a mechanism for producing comparable statistics on stocks and flows of human resources for science and technology across the Nordic region.

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[51] Research Institute of the Finnish Economy, http://www.etla.fi/eng/index.php.

[52] See Statistics Finland (2008), *Innovation 2006: Innovation Survey Final Report*, www.tilastokeskus.fi/til/inn/2006/inn_2006_2008-12-12_en.pdf.

[53] Eurostat (http://epp.eurostat.cec.eu.int), the Statistical Office of the European Communities, is tasked with providing the European Union with statistics at a European level that enable comparisons between countries and regions.

[54] See: European Innovation Scoreboard EIS 2008, www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=437&parentID=51.

[55] Nordic Innovation Center, www.nordicinnovation.net.

As a member country of the Organization for Economic and Cooperation and Development (OECD), Finland's progress is regularly reviewed through the OECD's STI Outlook[56], which alternates every year with the OECD Science, Technology and Industry Scoreboard, which provides a comprehensive picture of the country's performance in science, technology and innovation.

Key NIE Initiatives

PILLARS: Innovative Capacity and Governance

Development of a New National Innovation Strategy

Perhaps the most significant initiative taking place in Finland's NIE is the process of preparation for a new national innovation strategy that facilitates the development and renewal of competence-based competitiveness of industry, the national economy, and the regions. As stated, "the basic choices of the national innovation strategy will steer the operations and development of the [national] innovation environment in Finland."[57]

While Finland has been successful in advancing innovation in some sectors of the economy, it is generally accepted that investment in R&D and in technology has failed to produce sufficient results as measured by indicators such as the number of high growth businesses, active entrepreneurship, or successful venture capital investment. Generally referred to as Finland's paradox,[58] Finnish success in international comparisons evaluating competitiveness and the development of the information society has been on the decline in recent years.

In preparing a new strategy, the practical preparation of the strategic work was undertaken by the Ministry of Employment and the Economy. The strategy was prepared on a transparent basis, involving the extensive consultation of specialists, stakeholders and citizens. Eleven workshops, focusing on the key challenges of innovation policy, were held in the autumn of 2007, with approximately 800 specialists providing input. A steering group, chaired by the President of Sitra, was appointed for the preparation of the innovation strategy. This steering group submitted its proposal for a national innovation strategy to the Ministry of Employment and the Economy in June 2008, and a formal response from Government to the Finnish Parliament was submitted in March 2009.[59]

Within the proposed strategy, a number of steps are proposed. First, steps are being taken to strengthen the financial and administrative autonomy of universities. The

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[56] The OECD STI Outlook reviews key trends in science, technology and innovation in OECD countries and a number of major non-member economies including Brazil, Chile, China, Israel, Russia and South Africa.

[57] Proposal for Finland's National Innovation Strategy (no date), no page.

[58] Sitra (2005), *Making Finland a Leading Country in innovation: Final Report of the Competitive Innovation Environment Development Program*, p. 6, www.eib.org/attachments/general/events/forum_2005_article1_en.pdf.

[59] Government of Finland (2009), *Government's Communication on Finland's National Innovation Strategy to the Parliament*, www.tem.fi/files/21010/National_Innovation_Strategy_March_2009.pdf.

review of the existing Universities Act will provide universities with better opportunities to apply modern human resources policies, improve the quality and effectiveness of teaching and research, and strengthen creative and innovative research and learning environments. Universities with a higher degree of independence will be able to succeed internationally.

Enhancing international activities and encouraging closer dialogue with other stakeholders in society will also help to diversify university finances. Research training will be transformed in order to facilitate a more systematic approach to training in both research schools and other organizations. In addition to subject areas, expertise produced by research training will include key skills required in working life. Universities will implement a four-tier research career model (detailed in the following table), which will increase transparency and facilitate career planning. A similar task-based system in other research institutions and the private sector, along with a broader interpretation of achieving work merits, will encourage mobility between sectors.

Implementation of the Four-stage Research Career Model

Strengthening Finland's Researcher Training and Research Careers (2007-2011) Ministry of Education's Reform Program for the Four Stage Career Model: Overview	
The Four-stage Research Career Model Description	
First Stage	Usually consists of young researchers working on their doctoral dissertation
Second Stage	Career phase of researchers who have recently completed their doctorate
Third Stage	Independent research and education professionals capable of academic leadership
Fourth Stage	Professorship
Reform Program Key Points	
• Support and facilitate greater transferability between universities and other institutions (research institutes, private sector, civil service) by, e.g., readjusting the method of evaluating qualifications acquired by researchers outside of their academic work. • Provides businesses and research institutes with methods for examining the structure of their own system of permanent positions. • Recommendation that the Ministry of Education considers the level of implementation of the four-stage research career system by universities when determining university funding • Adopt 'management by results' procedures between research institutes and ministries. • In the near future, the promotion of research careers will be a more important aspect in the activities of public research financing and trust funds. • Post-doctoral international mobility to and from Finland must be increased, for example, by unifying regulations at the European level and by adopting a plan of action by which social security and advancing in one's career is not negatively affected by periods abroad. • Make the four-stage research career model more transparent, more predictable and a more egalitarian research career path that promotes innovation and strengthens Finland NIE.	

PILLAR: Governance

Intellectual Property Rights (IPR): A New National Strategy

In strengthening Finland's NIE, and as part of the process of devising a new national innovation strategy, the Government of Finland, through the Ministry of Employment and the Economy and Ministry of Education, established an IPR steering group in 2007. Tasked with drawing up a national IPR strategy with a specific focus on small- and medium-sized enterprises, the 18 steering members, representing government administration and funding departments, entrepreneurs, industry, media, universities, IPR management and businesses, were invited to identify an improved systemic approach to intellectual and industrial property rights, awareness, utilization based on national need and international development and global trends. Based on background work undertaken by the Steering Group, the two line Ministries produced a report in January 2009 that will serve as the basis for the Government to build the IPR Strategy. On 26 March 2009 the Finnish Government published the guideline decision on a National IPR Strategy.[60]

PILLAR: Innovative Capacity

Strategic Centers of Excellence (SHOK)

First identified in 2004 as a potential mechanism to create a limited number of clusters of competence of high international quality in Finland, preparations for the establishment of Strategic Centers of Excellence for science, technology and innovation (SHOK) were initiated in 2006 following guidelines issued by the then Science and Technology Policy Council. Intended to strengthen key areas of research and innovation in terms of strategic competencies required by the business sector, while increasing the dialog between cutting-edge research, five such Centers have been established since 2007 in the thematic areas of forestry, information and communication industry and services, metal products and mechanical engineering, energy and the environment and the built environment. A proposal for a sixth SHOK called the Strategic Center for Health and Well-being has recently been approved by the Ministry of Employment and the Economy. Based on partnerships between businesses and the public sector and on long-term commitments by all stakeholders, Center's are initiated, managed and financed by partners.

PILLAR: Human Capital

Aalto University

As part of an attempt to strengthen the education pillar of Finland's NIE, a major initiative of the new innovation strategy is the establishment of a new university. Aalto University61 forms part of national ambitions to create a university that experiments in inter-disciplinary activities and which has the ambition to create a new type of inter-cultural innovation and learning society. It is intended that the effort will improve the framework conditions conducive to knowledge creation, human resources and entrepreneurial behavior, and will establish a new set of standards for innovative learning and for how knowledge is created and developed.

Aalto University, which is scheduled to formally open in January 2010, is being created through the merger of the Helsinki School of Economics, the University of Art and Design Helsinki and the Helsinki University of Technology. This three-way merger is intended to create a unique and "integrated seedbed for innovation."[62] The new institution, Aalto University, will offer joint courses in late 2009 and will be open fully

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[60] The National IPR Strategy is not currently available in English.

[61] www.aaltoyliopisto.info/en.

[62] Green M. (2009) Merger with innovation at its heart, *Financial Times*, March 29, www.ft.com/cms/s/2/5399caa8-1aeb-11de-8aa3-0000779fd2ac.html.

at the beginning of 2010 as the flagship project in a national shake-up of higher education. The government, academics and Finland's business community, which is strongly represented on Aalto's board, are hoping to capitalize on the country's record in industrial and product design to create an internationally competitive, business-focused institution that takes inter-disciplinary working to a level not seen anywhere else in the world. A goal for Aalto University is to be one of the leading institutions in the world in terms of research and education in its own specialized disciplines by 2020.

PILLAR: Innovative Capacity

Multipolis Initiative

The Multipolis Initiative[63] is a public sector initiative that aims to foster high-technology development based on the 'triple helix' model of cooperation in the peripheral North of Finland.[64] The initiative seeks to advance the links between technology enterprises in Northern Finland with higher education and research institutes to achieve product innovations in a number of sectors.[65]Multipolis is managed as an innovation cooperation network encompassing nineteen 'polises', or centers of expertise. Measures have been taken to extend the Multipolis operation to Northern Sweden and Northern Norway.

Key Findings and Implications for Saudi Arabia

A range of factors underpinning the development and direction of Finland's NIE provide valuable insights on the approach to establishing and developing Saudi Arabia's NIE. These factors are described below.

Establishment of a Clearly Defined Institutional Framework

Finland created a clearly defined institutional framework for NIE development at the national government level, with a single government entity positioned as the lead national agency with responsibility for policy development, enforcement, and implementation oversight, across government ministries and at the sub-national level In the context of this institutional framework, Finland's NIE also has benefited substantially from support for continuity of purpose through senior leadership of the Government and executive levels, regardless of political party and for almost 30 years. Moreover, Finland's Research and Innovation Council is staffed with recognized innovation experts with the resources and political authority to drive national innovation at the national and sub-national level, which is an important lesson for development of the Kingdom's NIE framework. In addition, the country has developed a range of national level institutions to manage and guide specific components of the NIE, while simultaneously establishing a range of institutional coordinating mechanisms that bring together and

[63] Multipolis, www.multipolis.com.

[64] Kainuu, Central Ostrobothnia, Lapland, Northern Ostrobothnia, and Northern Savo.

[65] For example, electronics, information and telecommunications technology, environmental technology, environmental technology, microelectronics, radar engineering, development of measurement methods, wood product sector. For sector information on each of the nineteen Polis within the Mulipolis network, see www.multipolis.com/index.php?185.

enforce coherency among what otherwise could become piecemeal activities under the innovation banner. Finally, Finland's NIE framework was not permitted to be stagnant: instead it is reviewed and evaluated with the assistance of international experts on a triennial basis. For the Kingdom, adopting such an approach may assist in leading to informed recommendations for NIE course corrections and continuous improvement.

Appreciation and Support for Sector- and Region-based Specialization

Finland sought early on to embed sub-national institutions and business clusters as a foundation of national innovation. It put in place national and local level systems to support municipal and regional industry sector specialization as a driver for business development and knowledge transfer. Within Finland, at the national, regional and city level, there is an appreciation that regions and cities, enterprises and universities, have a place in the national innovation ecosystem, have, using regional and local economic, scientific and industrial advantage, the potential to position themselves as entrepreneurial and innovation friendly environments. A cluster-based approach to innovation, which encouraged numerous interactions and knowledge and technology transfers among small start-up companies and larger firms, service providers, research institutes, and universities, was pursued, and policies to encourage a business-driven approach for the transition to a knowledge-based economy were enacted. In short, national mechanisms to foster such regional, local, and cluster competitiveness are strongly advanced and supported.

Outward Focus with Intent to Change Attitudes and Expand Networks

Today, as in previous years, Finland's NIE and the development of a revised national innovation strategy are driven by an appreciation of global forces shaping and impacting Finland. As competition for enterprise activities and production processes increases, Finland recognizes the need to embed entrepreneurialism and risk taking in society, and promoting innovations and enhancing national and regional competitiveness have become core goals of national policy. As part of such policies, the country has undertaken a comprehensive review of education and university policies, resulting in specific mechanisms to foster university-based inter-disciplinary activities that embed an inter-cultural innovation and learning society. In addition, Finland has actively sought partnerships with the world's leading centers of innovation, and the nature and locations of such partnership continue to expand. For Saudi Arabia, the dedication of Finland, an advanced economy but one with a relatively small population on the peripheral north of Europe, to expanding periodically its internal and external outreach and societal development efforts is noteworthy.

Attention to Monitoring and Assessment of Progress

The role of innovation metrics in informing the rate of progress of Finland's NIE has been substantial, and the country has benefited from the extensive availability of relevant national and international metrics. The comparative lack of such innovation metrics in the Kingdom indicates a need to initiate a national policy and program to facilitate the development of such a system.

KOREA'S NATIONAL INNOVATION ECOSYSTEM (NIE)

Introduction

Summary of Innovation Performance

Korea has achieved one of the fastest rates of economic development in the world, and many scholars have taken note of the country's dramatic development process. In 40 years, the country has transformed from a mostly agrarian society to a developed member of the global knowledge economy. Korea's commitment to technology innovation continues to the present day, as the country maintains a target research and development (R&D) expenditure of 5% of GDP.

Impetus Behind and Stages of the NIE

In the late 1950s, several years after the Korean War, South Korea found itself far behind the developed world in terms of quality of life and technological capacity. The evolution of Korea's National Innovation Ecosystem (NIE) has been characterized as a game of "technology catch up," which acknowledged the agrarian state of the economy at the outset of its development plan, and the plan's explicit focus on technology development[66]. The Korean NIE developed in three stages, which are summarized in the timeline below and described in detail on the following page[67]:

Figure. Decadal Timeline of Korea's NIE Development Stages

	1960s	1970s	1980s	1990s	2000s
Development Stage	Factor-Driven	Factor-Driven			
		Investment-Driven	Investment-Driven	Investment-Driven	
				Innovation -Driven	Innovation -Driven
Industrial Policy	Expand export-oriented light industry	Expand heavy & chemical industries, import technology	Grow technology-intensive industry	Promote high-tech innovation	Transition to knowledge-based economy
Government Role	Establish scientific institutions; Expand primary & secondary education - MOST / KIST	Build scientific infrastructure - GRIs - Science Parks	Encourage private R&D - National R&D Plan	Expand higher education; Increase basic research capacity w/ university R&D	Combine ministries to co-ordinate research efforts; Increase private sector involvement -Ministry of Knowledge Econ.

1) **Factor-Driven Stage –** 1960s-1970s. During this phase, Korea relied on its low wage rates to build a base of import-substitution and export-oriented manufacturing. To promote growth, the government identified six strategic industries to promote.

[66] Hong, Y. S. (2005), *Evolution of the Korean National Innovation System and Technological Capability Building*, Korea's Science & Technology Policy Institute (STEPI).

[67] Terminology borrowed from Anthony Bartzokas of UNU-MERIT and Policy Mix. Dr. Young Roak Kim of the Korean Technology Transfer Center also used these terms to categorize Korea's stages.

However, the country had limited technology to pursue the chosen industries, so the government established Government Research Institutes (GRIs) to build the country's technological base. The GRIs were created to study modern technologies and disseminate them to industry, and they led the development of Korea's science and technology. Collaboration and technology transfer were relatively easy in this stage and, over time, private companies took leading roles in S&T development. Universities were not yet performing much R&D in this stage.

2) **Investment-Driven Stage** – late 1980s- early1990s. During this period, Korea invested substantially to develop its heavy and chemical industries. However, with little native technological capability, the country was forced to continue its strategy of importing technology from other countries. They used various methods to acquire technology, including buying turnkey factories and hiring consultants from Japan. In the 1980s, industry R&D spending began to expand. In the 1990s, large Korean companies (e.g. Samsung, Hyundai) needed basic and fundamental research support for their products. This need led universities to expand their R&D efforts.

3) **Innovation-Driven Stage** – 1990s and forward. During this period Korea invested heavily in IT infrastructure, with a stated goal of having one computer per person by 2010. Intellectual property protections and entrepreneurship initiatives sparked private sector activity in the traditionally government-led innovation system. In previous development stages, Korea had paid little attention to long-term NIE planning, so the country now lagged its peers in developing a modern knowledge economy. In 2008, more than 76% of Korean R&D came from private industry, though there is still little collaboration between public and private R&D.

In the 1960s, Korea did not have indigenous technology or the financial resources necessary to fund large production facilities. The government confronted this problem with a strategy that relied on imported technology and focused on import-substitution and export-oriented industries. Korea started its first modern research activity when it established ten Government Research Institutes (GRIs) in the 1970s. These institutes were established under government authority because Korean industry did not yet have sufficient capacity to perform R&D to the level that would bring Korea into modern economic times.

Over time, particularly in the 1980s, the GRI system was criticized for inefficiency and mismanagement, problems that many say led to research activity moving out of the government and into the private sector. Up to the 1990s, the government had used a "lump sum" method of disbursing research money, wherein research institutions were given an amount of cash with little specifications on how it should be spent. In 1996, however, the government changed its funding system from a lump-sum method to a Project-Based System (PBS). The PBS awards research contracts competitively, with more spending oversight to promote efficiency. The "Key NIE Initiatives" section below contains more details on the PBS.

In 1982, the government established the National R&D Program, which liberalized the country's FDI policy to try to induce more advanced technology through foreign investment. In 1999, the Research Council System (RCS) was created to oversee the GRIs under the unified control of the Prime Minister's office. Korea recently overhauled its whole NIE in 2005, shrinking the number of government institutions that were steering it.

National-Level NIE Structure and Collaboration Mechanisms

In 2005, the Korean government implemented a major overhaul of the country's NIE, though the results of this restructuring are difficult to determine at this relatively early stage. This section will first describe the institutions that comprise the Korean NIE up to 2005 and the issues that led to their restructuring. The post-restructuring NIE will then be presented, along with the outcomes that the changes are expected to bring about.

Key Institutions and their Roles

Main Institutions for NIE Governance and Oversight until 2005

Ministry of Science and Technology (MoST) – Established in 1967, MoST was originally called the Science & Technology Agency. Its mission was to lay the groundwork for scientific and technological infrastructure by formulating a straightforward and comprehensive S&T policy. MoST was meant to be the coordinating agency behind S&T policymaking.

National Science and Technology Council (NSTC) – The NSTC was formed in 1998 to calm infighting taking place between ministries that were frequently quarrelling over the boundaries of their jurisdictions and overlapping research interests. The NSTC was originally arbitrated by Korea's President and administered by MoST.[68] The NSTC is empowered at the highest levels of government, making coordination of various innovation policies possible.

Research Councils (RCs) – Three research councils operated by MoST interpreted S&T initiatives and determined which R&D projects to pursue:

- Korea Research Council of Fundamental Sciences & Technology (KRCF);
- Korea Research Council for Industrial Science & Technology (KOCI); and
- Korea Research Council of Public Science & Technology (KORP).

Each RC was tasked with the management of about ten member government research institutes (GRIs); the RCs governed their GRIs by establishing criteria such as research performance evaluations. In 2004, the RCs were transferred under the jurisdiction of the National Science and Technology Committee (NSTC). Korea's Councils are steered almost entirely by individuals from academia. For example, the KRCF is steered by a Board of Directors with ten rotating members. As of 2009, ***every one*** of its board

[68] Baker, Michael. "Korea: Major Reforms Proposed to Improve Science Payoffs." *Science* 10 July 1998, Vol. 281. no. 5374, pp. 163 – 164, DOI: 10.1126/science.281.5374.163

members was drawn from academia[69]. KCRF has three subcommittees that are directed by boards which are also mostly composed of academics.

Korea Institute of S&T Evaluation and Planning (KISTEP) – Established in 1999, KISTEP is a think tank for national and regional innovation systems and R&D planning. It is tasked with reviewing all of the research projects nationwide and identifying gaps in Korea's knowledge-creation efforts. KISTEP compiles and maintains a projects database and sets R&D priorities. This is a direct means of research coordination that is meant to ensure government research dollars are not paid to pursue overlapping projects in different labs.[70]

Korea Science and Engineering Foundation (KOSEF) – In 1977, KOSEF was established as the central organization to support basic research in science and engineering, to promote science education, and to oversee university-related research institutes.

Korea Industrial Technology Association (KOITA) – KOITA was established in 1979 to strengthen the innovative capabilities of Korean companies. On the basis of this mandate, KOITA is responsible for accrediting corporate R&D centers in Korea. KOITA is the nation's premier institution for the support of industrial R&D, and it provides assistance to corporate R&D centers throughout the country. KOITA also collects and disseminates industry R&D statistics.

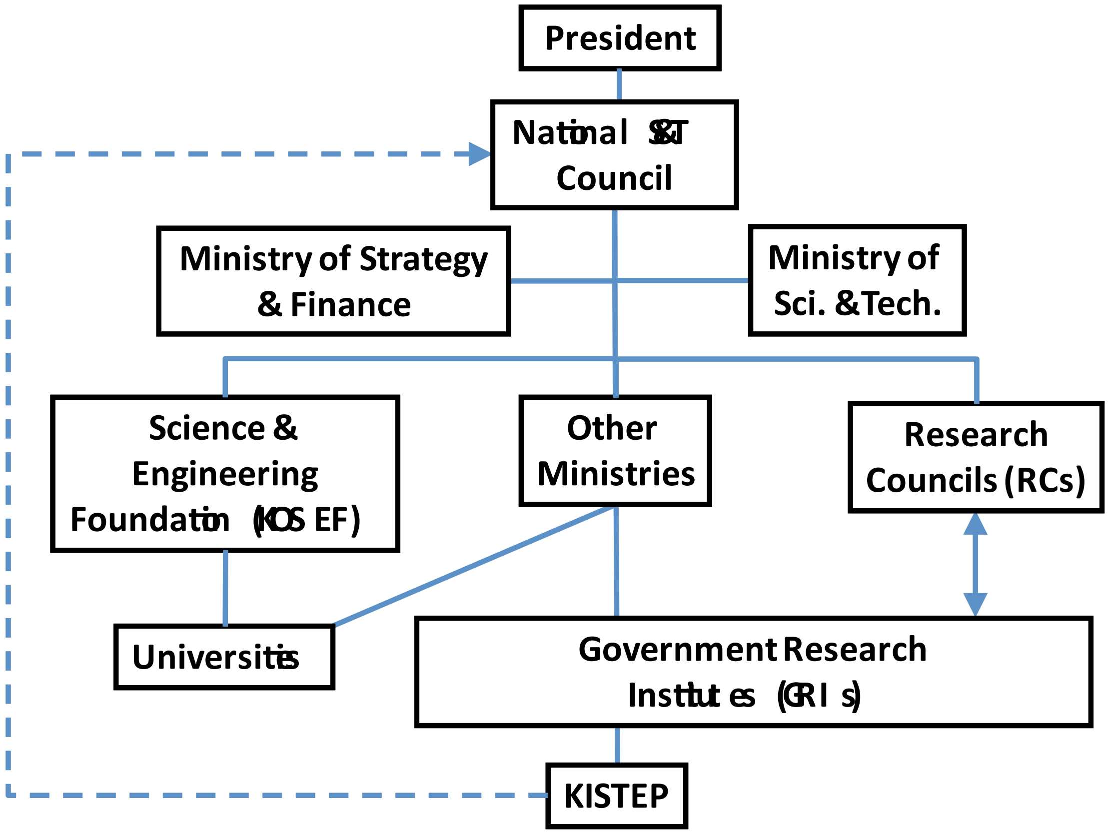
R&D Performing Institutions

Government Research Institutes (GRIs) – Ten GRIs were established in the 1970s during the government's early-stage industrialization efforts. About 100 GRIs were operating by 2004. Other national labs and local government-owned labs complement the work performed in GRIs. Initially, each GRI was subordinate to one of various government ministries. However, this structure was believed to cause sub-optimal performance and inefficiency among the GRIs due to excessive intervention by the ministries in research activities. In 1999, the government decided to separate the GRIs from the ministries to which they belonged and place them under the control of the Research Councils.

[69] Per the member list on KRCF's website, http://eng.krcf.re.kr.

[70] KISTEP may allow or even encourage minor instances of overlapping research projects if, say, investigators are pursue different aspects of a similar project. In this case, KISTEP's role is to encourage collaboration.

Figure 1. Diagram of Korea's NIE, before the 2005 reforms[71]



Korea Institute of Science and Technology (KIST) – The first GRI, KIST was a multidisciplinary research institute established in 1966. Launched in partnership with the United States, KIST was meant to build Korea's scientific and technological infrastructure. KIST's position as Korea's flagship research institute continues today; in 2007, KIST received the largest share of government R&D grant money.

Other Advisory Institutions

Korean Technology Transfer Center (KTTC)[72] – KTTC was established in 2000 to promote technology transfer and commercialization. The Center reviews salable technology, estimates its commercial viability, and identifies potential licensees or partners with whom researchers can work. It also encourages universities and public research institutions to have technology transfer offices within their respective institutions. KTTC is supported by the Ministry of Commerce, Industry, and Energy (MoCIE) and other ministries.

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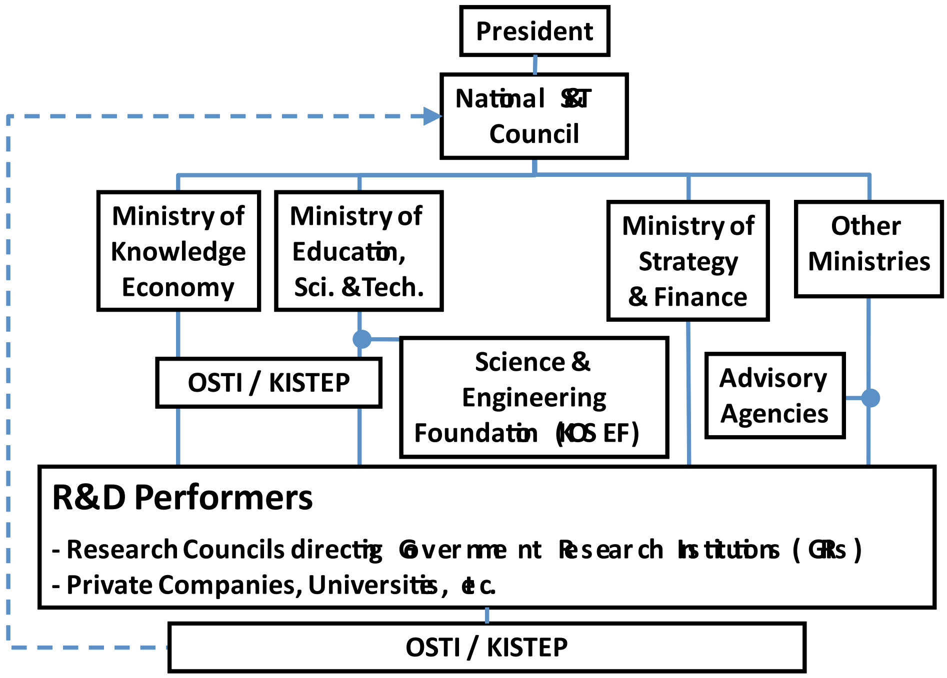
[71] Yu, Seongjae, 2007, *Evaluation of R&D Institutes: An Integrated Approach – The Korea's Model*, presented at the Korea-France Seminar on Science and Technology Policy, Sep 20, 2007, Seoul, Korea.

[72] Kim, Young Roak (2005). "Technology Commercialization in Republic of Korea." Korean Technology Transfer Center, www.wipo.int/export/sites/www/uipc/en/documents/pdf/tmc_korea.pdf.

The 2005 Restructuring of Korea's NIE

The 2005 restructuring of Korea's NIE was prompted by a desire to remove inefficiencies from the country's innovation governance.[73] The reforms sought to shrink the size of Korea's national government by merging institutions across the board. MoST merged with the Ministry of Education to create a new Ministry of Education, Science, and Technology. For private sector governance, the Ministry of Commerce, Industry & the Economy (MOCIE) merged with elements of the Ministry of Information and Communications, Technology, and the Ministry of Finance and Economy. The Research Councils were reorganized: several councils were relocated under different ministries and one council was closed.

Figure: Diagram of Koreas NIE ***after*** *the 2005 restructuring*[74]



The 2005 restructuring gave the NSTC a stronger role as coordinator of innovation and research policies. The Office of Science, Technology Innovation (OSTI) was established to act as the secretariat of the NSTC. It has the responsibility of supervising, coordinating, and evaluating S&T related policies (including policies dealing with industrialization, financing, regional innovation, human resource development). OSTI also coordinates and allocates the entire government R&D budget. As an exclusive support agency for OSTI, the Korea Institute of Science & Technology Evaluation and Planning (KISTEP) plays a key role in planning national S&T strategies, setting priorities for the coordination and allocation of R&D budgets, evaluating and analyzing national R&D programs, and capitalizing R&D knowledge. KISTEP manages a nationwide database of research projects, so they are able to evaluate which new research

[73] www.scj.go.jp.

[74] Young-Hwa Cho, Ph.D., President, KISTEP. "Korea's Advancing National R&D Management Supporting System," May 2008 presentation at Launch Meeting for International Science, Technology and Innovation Centre (ISTIC), Kuala Lumpur, Malaysia.

priorities align with the projects that different R&D performers are currently pursuing. Korean planners expect that, with one unified ministry to coordinate research efforts, the GRIs will cooperate with universities more after this merger.

Process and Mechanisms Used to Build Effective Inter-Institutional Consensus and Collaboration

Korea encountered many coordination problems during the evolution of its NIE[75]. In particular, there were overlapping research projects, institutions competed excessively for research work, and there were weak links between S&T policy and government budgeting. As mentioned above, the recent restructuring and ministry mergers are intended to address these co-ordination problems. The mechanism used in the restructuring was to simply merge institutions with similar agendas. The government's hope is that the new unified ministries will be better able to address overlapping projects and other inefficiencies.

In the past two decades, Korea has implemented initiatives to enhance the collaboration between public and private research labs. In early 1990s, the government began encouraging universities to collaborate with industry and to create spinoff companies. They began to think about technology transfer more and to pair up SMEs with university labs. Still, one policy observer lamented that the private sector in Korea tends to see public projects as a distraction from more lucrative open market technology development[76]. The government is currently organizing a planning committee to further address the issues of coordination between the public and private sectors.

Nature of Collaboration on Different NIE Functions

Korea has several lessons to offer on how **not** to foster collaboration on different NIE functions. That is to say that, until about five years ago, institutions within the country did not collaborate well or, in many cases, at all. So, while this case study offers lessons for how one might structure a successful NIE, this particular subsection points to problems that may arise from poor organizational choices.

During the 1960s and 1970s, the Korean Institute of Science and Technology (KIST) and many of the GRIs that it spun off suffered from poor linkages with industry. Most of the Korean scientists that the government recruited came from universities or research institutes and there was very little demand for the kind of expertise available in the GRIs during this period. The products of GRI research projects were never put to use, which demonstrates how far out-of-touch the GRIs were from industry's needs. This disconnect between research institutes and industry may have risen from the extreme dichotomy of company sizes in Korea. On the one hand, the country had massive

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[75] Hung, Yoo Soo (2005), "Evolution of the Korean National Innovation System: Towards an Integrated Model," Chapter 3 in *Governance of Innovation Systems Volume 2: Case Studies in Innovation Policy*, OECD 2005, Paris.

[76] Interview with Dr. Jeong Hyop Lee of Korea's Science & Technology Policy Institute (STEPI), 4/17/2009.

chaebols[77], which were large enough to house their own R&D divisions and, on the other hand, there were much smaller enterprises that had few resources to collaborate. Some experts argue that the situation was aggravated by the facts that (1) the Korean government promoted the large *chaebols* with its import policies and (2) the *chaebols* easily outcompeted the SMEs and impeded their growth. In effect, the government's import policies encouraged the polarization towards an industry space with very large and very small companies. This in turn, left few medium-sized companies as potential research collaborators for the GRIs and stunted the interactions between GRIs and industry.[78] The situation began to change for the better after the year 2000, when Korea started reforming the import policies that had allowed *chaebols* to dominate large parts of its economy.

Another missed opportunity for coordination came in the 1970s and 1980s. During this period, the Ministry of Science and Technology (MoST) was charged with formulating Korea's S&T policy. A subcommittee of MoST, the Science and Technology Review Committee, was charged with actually coordinating the S&T policy once it was drafted. The Science and Technology Review Committee was chaired by the Prime Minister and consisted of 14 ministers who had science and technology responsibilities. This committee was not active in the 1970s and 1980s, but it became very active during the first half of the 1990s, as more and more ministries came to participate in R&D programs. However, the committee convened irregularly and was known for its weak coordination of S&T policy. The poor coordination led to excessive competition between researchers and to many overlapping and inefficient research projects. The Science and Technology Review Committee has since been replaced by a council external to the MoST, the National Science and Technology Council (NSTC).

The two examples above diagnose some of the problems that led to Korea's recent NIE policy reforms. Korea was able to restructure and move past these issues, but it is important to examine the lessons from these setbacks, namely:

- For successful interaction between companies and research institutes, the companies involved must have research departments that can benefit from the interaction; and
- Merely establishing a committee to coordinate policies does not guarantee that the job will get done – the committee must actually meet and perform their duties.

Sub-National, Regional and International Linkages

Korean policies aimed at the sub-national level include the establishment of S&T parks, regional science and engineering research centers, and the formation of clusters such as Inchon-Songdo Digital Valley and Busan-Gyunghnam Ulsan Valley. In 2003, government planners in Korea adopted the concept of Regional Innovation Systems in pursuit of balanced regional development. To increase and balance its regions, the

[77] Chaebols are large, powerful, government-supported corporations that often own numerous international enterprises. The Korean word chaebol means "business family" or "monopoly".

[78] Kim, Linsu and Richard Nelson (2000), *Technology, Learning, and Innovation: Experiences of Newly Industrializing Economies.* Cambridge University Press, New York, pp. 337-9.

national government provided each province and metropolis with grants for infrastructure and research in strategy industries that were chosen by the regions themselves[79]. Korea's international NIE linkages, which are forged and managed by the Science and Technology Policy Institute, are described in detail below.

Roles of Key Institutions in Delivering the NIE

Government ministries in Korea have established their own agents for financing, managing and evaluating R&D the projects under their purview. For public sector projects, the Ministry of Education, Science, & Technology (MoEST) has the Korean Science & Engineering Foundation (KOSEF) for *financing* projects and KISTEP for *implementing* projects. The analogous institutions for private sector R&D are: the Ministry of the Knowledge Economy (MKE); the Korea Industrial Technology Foundation (KOTEF); and the Institute for Industrial Technology Evaluation and Planning (ITEP).

KISTEP plays a crucial role in delivering Korea's NIE and, in July of 2001, KISTEP was re-established as a specialized institute supporting NIE planning, evaluation, and coordination.[80] There are three main functions that KISTEP strives to fulfill: First, it formulates, coordinates, and supports major S&T policies, including S&T workforce policy, industry policy, and regional innovation policy. Second, it analyzes and evaluates the S&T-related projects implemented by *all* of the government ministries, and it helps the ministries distribute their R&D budgets. Third, it studies domestic and overseas research planning, evaluation and management systems, and disseminates knowledge in these fields to Korea's planning institutions. These three functions put KISTEP in a fairly powerful position with respect to Korea's S&T policy.

Korea takes a "bottom-up" approach to R&D funding: R&D institutions submit budget requests to the ministries that govern them and those requests are packaged and passed to the NSTC, where they are harmonized with national research priorities and initiatives. Then, the NTSC's budget is passed through KISTEP where proposed projects are referenced against lists of existing projects and technology gaps. Finally, with KISTEP's advice, the MoEST and MKE ministries parcel out their budgets to projects and initiatives.

Approaches and Roles for Supporting International Linkages[81]

Korea industrialized later than most developed countries, so it has a shorter history of modern R&D efforts. To catch up to more developed countries, Korea has had to rely largely on international cooperation for the development of S&T. Until the early 1980s, Korea's international S&T cooperation was geared toward acquiring foreign technologies and obtaining the technical know-how and technical training to operate the technologies it acquired.

[79] Ibid.

[80] www.kistep.re.kr/ksp/eng/International/01consultancy.jsp.

[81] This section is drawn mainly from http://english.mest.go.kr/main.jsp?idx=0302020101.

Korea launched the **International Joint Research Program (IJRP)** in 1985 to fund international joint research based on bilateral, inter-governmental and inter-institutional agreements. The program has funded almost 2,000 joint projects, though most of them have been small in scale and have been used more as a means of scientific exchange than as projects for serious R&D. The international joint research projects have also been very concentrated on a limited number of countries: Japan, the U.S., Germany, France, Russia, China, and the U.K. Now that Korea is less reliant on technology transfer, the IJRP is being restructured so it can facilitate bona fide international R&D.

With regard to NIE policy research, Korea's Science and Technology Policy Institute (STEPI) forges and manages international linkages with foreign technology policy institutes. STEPI has linkages to similar organizations in the U.S. (STPI Rand), the UK (SPRU), the Netherlands (MERIT), Japan (NISTEP) and the United Nations (INTECH UNU).

Roles of International Associations and Knowledge Networks

In addition to the one-off linkages mentioned in the previous subsection, Korea is also a member of several international associations. Many of Korea's research councils are members in the international organizations that are relevant to their field of research. For example, Korea's STEPI is a member of three networks that share experiences and information regarding innovation and economic policies:

- Asia-Pacific Economic Cooperation (APEC) is the primary regional vehicle for promoting open trade and practical economic cooperation. Its goal is to advance the Asia-Pacific region's economic development and sense of community.
- The Science and Technology Policy Asian Network (STEPAN)[82] is a regional network of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) that conducts workshops and cooperative projects among its members. STEPAN provides S&T management information and policy advice to enhance its members' national decision making.
- The OECD's Committee for Scientific and Technological Policy (CSTP-OECD) encourages cooperation among OECD member countries regarding science, technology, and innovation policy, and it advises member countries on how to integrate these policies with other government policies. Each of these organizations helps Korea to benchmarks its competitor countries and to keep abreast of current developments in S&T policymaking.

Responsiveness to Local Conditions

In developing the country's educational system, the Korean government was prompt and orderly. Its educational initiatives came in phases that steadily and deliberately made Korea one of the best educated nations in the world. After its educational ramp-up, Korea began the research push that would launch it into the Innovation-Driven stage of its development.

[82] www.stepan.org/index.htm.

Experience Simultaneously Building Capacity and Cooperation

Aligning Education Policies with Industry Needs[83]

Throughout the different stages of Korea's development, the country's educational initiatives were launched in anticipation of its labor needs. In the early stage of development, during the 1950s and 1960s, Korea's economy consisted of subsistence farming and light manufacturing. During this stage, Korea's education policies focused on expanding primary and secondary education and providing universal primary and secondary education. This focus provided an industry workforce that was at least literate. During the 1960s, vocational high schools were established to provide training in craft skills while labor-intensive light manufacturing industries were growing. In the 1970s, Korea set up junior vocational colleges to train technicians in preparation for the expansion of the chemical and heavy industries. Then, to train the white collar workers and R&D personnel required for a successful innovation economy, Korea expanded its higher education system in the 1980s. In the 1990s, Korea began deploying industries in communications, information technology, and electronics. The expanded higher education system ensured an ample supply of workers for the country's growing R&D programs.

The stage-by-stage approach to development in Korea required the coordination of industrial and educational policies. Beyond increasing the quantity of education, Korea has also changed the types of education that are delivered.[84] For example, the country's vocational learning programs used to target teenagers and consisted of process-oriented rote memorization. In response to industry needs, the programs have been revised to offer *lifelong* learning, with a focus on outcome-oriented creative problem solving. These reforms were prompted both by a response to local industry needs and by observations of education policies in other countries.

A Series of Research Programs

Once Korea had built a foundation of education, the country began major research efforts in the early-to-mid 1980s. These efforts were collectively contained in the overarching **National R&D Program (1982-present)**. Established by MoST, the goal of the National R&D Program (NRDP) was to develop technology to enhance Korea's industrial competitiveness. The NRDP was closely related to the development of the Government Research Institutions (GRIs), and it has many research programs under its umbrella. NRDP intended to complement private research in areas that would not be pursued by the private sector. The program uses the principle of "selection and concentration", where fields of study are selected and resources are concentrated on projects in the selected fields.

The National R&D Program includes many sub-programs, initiatives, and laboratories. One of them is the **Highly Advanced National (HAN) R&D Project (1992-2002)**, the

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[83] The World Bank (2006), *Korea as a Knowledge Economy: Evolutionary Process and Lessons Learned: Overview,* Joonghae Suh et al., Washington, DC.

[84] MoEST, Educational reform and lifelong learning, http://english.mest.go.kr/main.jsp?idx=0301030101.

first government R&D program developed through a full cycle of planning processes[85] (including technology foresight activities, inter-ministerial consultation, and so forth). HAN is a 10-year inter-ministerial R&D program aimed at developing core technologies for 21st-century industrial development. Another one of NRDP's sub-programs is the **21st Century Frontier R&D Program (1999-2009)**. The 21st Century Frontier R&D Program launched with $3.5B in funding to host 23 projects over 10 years in new frontier areas, such as bioscience, nanotechnology, and space technology. This program was unique in that its project directors had complete autonomy in managing their projects. NRDP funding was also distributed to regional labs through the **National Research Laboratory Program (1999)**, which fostered research centers of excellence. Each laboratory that is designated as an NRL receives $250,000/yr for 5 yrs. There are currently 444 NRLs in operation (278 in Academia, 114 in Gov. Research Institutes, 52 in Industrial R&D centers).

The objectives for new research programs in Korea are often decided by Technology Foresight committees, which are described in more detail below. Essentially, the foresight committees are collections of stakeholders from the public, private, academic, and governmental sectors of the NIE. The foresight activities require these stakeholders to form balanced subcommittees and debate the current status and future directions for Korea's NIE. In these fora, the cooperation between sectors is enhanced as different stakeholders in the NIE discuss their priorities and ways to work towards them.

Experience Building on Institutional Strengths and Programs

To build its institutional strengths, Korea first examines the strengths and gaps that already existed in its NIE. To do this, the country used **"Technology Foresight" studies**, which try to identify Korea's current status of development and what the country should focus on in the future. "Foresight" studies were pioneered by the RAND Corporation in the United States and were first applied in Japan in the early 1970s. Korea has conducted three foresight studies of increasing sophistication in the years 1994, 1999, and 2005[86]. The first two studies were conducted by the Science and Technology Policy Institute (STEPI). The first study (1994) was entirely focused on S&T and only polled experts from technological fields. The second study (1999) mixed technology and markets more, and it helped Korea select seven fields to focus on for development[87]. The latest foresight exercise (2005), which was performed by the Korea Institute of S&T Evaluation and Planning (KISTEP), put more weight on social applications of technology.

The survey portion of the most recent National Foresight Exercise lasted eighteen months and consisted of three distinct phases: Phase 1 brought together a distinguished

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[85] Until the HAN Project, the design of most research projects had relied on planners' intuition or very limited panel discussions. HAN was the first Korea public research project that was designed in a rigorous manner.

[86] According to Korean law, Technology Foresight exercises are supposed to be carried out every five years.

[87] The fields selected in the second Technology Forecasting exercise were: materials, telecommunications, urbanization, transportation, health and medical, life sciences, and environmental technology.

panel of experts from diverse academic fields to identify the future prospects and needs of Korean society; Phase 2 administered a survey to 1,000 experts and 1,000 members of the general public; and Phase 3 had teams of experts visualize future scenarios for Korea in different social service fields.

These exercises were coordinated with Korea's policy making process as well: the 1999 exercise was conducted in parallel to the formulation of Korea's Frontier Research Program (FRP) and the results of the 2005 exercise are being pursued as a complement to the "Next Generation Engines of Economic Growth" program. Additionally, the personal interaction involved in the surveys has formed interdisciplinary connections between researchers that are important for a healthy NIE.

Experience Fostering Growth and Enterprise Development

Until the early 1990s, the Korean government did not pay much attention to developing new enterprises. In fact, some government policies (including their lax import laws that benefitted the *chaebol* conglomerates) served instead to stifle the development of small and medium enterprises (SMEs). This legacy of past policies promoting large companies left Korean SMEs with a low capability to carry out technology innovation. To reverse these disincentives, Korea created the **Technology Property Rights Concession Program** in 1993 to make SMEs more competitive and to enhance their technological capabilities. Under this program, SMEs may adopt pre-commercial technologies offered by researchers in public sector organizations free of charge. STEPI coordinates the advertisement and acquisition of these technologies, and the SMEs acquiring technology through the program are liable for expenses only if the commercialization succeeds. An average of 120 SMEs participated in the Technology Property Rights Concession Program each year for the first four years of the program.[88]

The attention to the needs of SMEs continued into the late 1990s and 2000s. Until 1997, researchers at public institutions were not allowed to form businesses or spin-off technologies by themselves. Then, in 1997, the Korean government enacted the **Special Measure Act for the Promotion of Venture Businesses**, reversing the previous rule and allowing GRI researchers to start up businesses while keeping their GRI jobs. Researchers and professors are now permitted to use their laboratories and equipment when they start up new enterprises. In 2001, the KIST research institute launched an SME assistance program called the **Korean Techno-Venture Foundation**, which provides advice and incubator support to young SMEs. By 2004, there existed about 300 business incubation programs spread across Korea. The **Korean Small Business Innovation Research (KOSBIR)**, modeled on the SBIR program in the United States, aims to foster SME R&D by requiring 18 government agencies in various areas (including state-owned-enterprises) to allocate certain proportions of their R&D budgets to help SMEs develop technologies. In sum, Korea was late to offer support to

[88] Choi, Y. and J-J. Lee (2000), "Success Factors for Transferring Technology to Spin-off Applications: the Case of the Technology Property Rights Concession Program in Korea," *Journal of Technology Transfer*, 25, pp 237-246.

SMEs and venture businesses, but they have compensated by enacting a host of small business support programs.

Key NIE Initiatives

Several initiatives have driven the evolution of the NIE in Korea, though only a select few are presented here. The pillars that these initiatives support are largely related to organizational management. Over its history, the Korean NIE was restructured several times. The government learned to conduct program evaluations and to hold researchers accountable for how they spend their grants. As the government has become more satisfied with the structure of the NIE, it has begun to invest more heavily in state funded research.

Pillar: Infrastructure

Broadband Penetration[89]

Thanks to a long history of infrastructure investments, Korea now has the most advanced national network infrastructure in the world. The government's investments were driven by a desire to first develop a leading IT industry and to later be a global leader in the digital era. The government's investment in information technology began in 1984, with the **National Basic Information System (NIS)** initiative. The goal of this initiative was to stimulate Korea's information technology industry. A recession halted the infrastructure investments in 1994, but the government picked them back up the next year with the **Korea Information Infrastructure (KII)** Plan. The KII plan aimed to establish a high-speed internet connection to every government and public entity in Korea. After the Asian financial crisis in the late 1990s, Korea invested heavily in its public and commercial broadband infrastructure and, by 2005, Korea ranked second in the OECD in terms of "broadband penetration"; 89% of households had access to internet services, most with speeds up to 1 Mbps.

In February 2004, the MIC announced a new strategy called the **IT839 Strategy**, which pays more attention to the development of content and services that can make use of the infrastructure that is now in place. The next infrastructure step that Korea has planned is to install a **nationwide *super*-broadband** fiber optic network by 2013 that will enable download speeds of 1 Gbps (200 times the average connection speed in the U.S.). This project is headed by the Korea Communications Commission (KCC) and will require an investment of $1.1 billion from the government and $23.5 billion from the private sector.[90]

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[89] The main sources for this section are http://point-topic.com/content/operatorSource/profiles2/south-korea-broadband-overview.htm, www.nationmaster.com/graph/int_bro_int_acc_wor_bro_sub_in_oec_cou_tot-worldwide-subscribers-oecd-countries-total, and www.asiaone.com/Digital/News/Story/A1Story20090203-119136.html.

[90] "South Korea's super broadband," AsiaOne Digital, www.asiaone.com/Digital/News/Story/A1Story20090203-119136.html, last accessed 5/19/2009.

These infrastructure investments have enabled Korean companies to get a head start on other countries in developing new high-bandwidth products, such as media content delivery systems, online gaming products, and communications tools.

Pillar: Infrastructure

Reducing Government Size

Korea's previous administration recognized that Korea is a small nation and needs to keep its innovation efforts focused. This was one reason that the president restructured the NIE and reduced the number of ministries governing the NIE. Earlier sections of this study noted that, with a large national government, there were many overlapping research projects, there was excessive competition for research funds, and there were weak links between S&T policy and government budgeting. In the 2005 restructuring, many institutions merged, and the overall size of the government shrank.

The restructuring also came at a time when the government was trying to shift more R&D spending into the private sector. Some government officials have complained that all of the effort that Korea has spent restructuring has actually hindered the NIE. However, there are few publications about the new system, and it will be several years before the results of the restructuring are clear.

Pillar: Governance

Improving Accountability and Evaluation[91]

As late as 1995, the Korean government was allocating research funds with a "lump sum" method. Under this method, the manpower costs of state-supported researchers were paid from the governmental budget and research institutes only charged their direct research costs to each project. With their salaries guaranteed, researchers could drag out the timelines on their research grants almost indefinitely. This proved to be an enormous drain on government resources and, in 1996, the government changed its funding system from a lump-sum method to a **Project-Based System (1996)**. The project-based system awards research contracts to GRIs, universities, and industry on a competitive basis. Under the new system, researchers charge their manpower costs to a specific research project, which (in theory) encourages more efficiently run projects. In actuality, the PBS system is criticized for increasing national R&D spending. Critics also claim that Korean researchers have shifted their research away from basic research projects toward short-term application-oriented projects in order to secure their manpower costs.

As another step towards improving the accountability and evaluation of research labs, Korea enacted the **National R&D Performance and Results Assessment Act (2005)**.[92] This act requires that public R&D budgets be coordinated and allocated to

[91] This section is drawn primarily from Kim, Y., Lee B. and Lim Y. 1999,"A Comparative Study on Managerial Features Between Public and Private R&D Organizations in Korea: Managerial and Policy Implications for Public R&D Organizations", *International Journal of Technology Management*, Vol. 17 No. 3.

[92] Information about the act is drawn primarily from Mushin Lee, Byoungho Son, Kiyong Om , "Evaluation of national R&D projects in Korea," *Research Policy*, Volume 25, Issue 5, August 1996, Pages 805-818, and KISTEP, www.kistep.re.kr/ksp/eng/document/03document.jsp.

reflect the results of KISTEP's R&D evaluations. There had traditionally been a disconnect in Korea between those institutions evaluating R&D performance and those that designed the R&D budget. This act removed that disconnect by assigning both of the functions of R&D evaluation and budget review to KISTEP and further requiring that the committees performing these functions share several members.

These efforts are intended to provide more transparency and coherence to Korea's R&D funding. The lesson to draw from Korea's experiences here is that, to maintain public support for R&D spending, there must be checks in place to make sure that R&D money is not wasted. Furthermore, it is important to evaluate the results of R&D initiatives, but those evaluations are worth little if their findings are not incorporated into future iterations of budget planning.

Pillar: Innovative Capacity

A Battery of Planning

In its pursuit of economic development, the Korean government has been overzealous at times in their planning activities. Every five years from 1962 to 1997, Korea published a Five-Year Plan that updated the country's economic development strategy. These plans laid out the country's economic policies and made recommendations on education initiatives, science investments, and trade strategies. The last of the five-year *economic* plans emphasized that the government should lessen its intervention in the economy and that Korea's innovation should drive the country's growth instead. In practice, the government continued planning in five-year increments, but the plans focused on S&T policies rather than economic policies.

What follows here are brief descriptions of the S&T plans that have been put in place over the years, to give a sense of how much planning was taking place (seven plans in twelve years). Some plans were five years in length and some were longer. Several of them overlapped in time, causing confusion among the agencies asked to enforce them. Korea developed in spite of these setbacks and has recently scaled back and organized their intervention initiatives to make a less convoluted NIE.

- **Five-Year Plan for S&T Innovation (1997-2002)** – The plan was designed to promote the national R&D capacity to the level of G7 countries by 2002 through innovation of strategic technologies and the promotion of S&T activities.
- **Vision 2025 (1999-2025) –** This initiative includes a series of tasks and recommendations designed to guide the development of S&T. One major goal of Vision 2025 is to shift from a government–led innovation system to one that is led by the private sector.
- **First Five-Year S&T Principal Plan (2001-04)** – This serves as the action plan for reaching the first stage of the development goal set in Vision 2025 and supplements the Five-year Plan for S&T Innovation. The plan aims to rank Korea within the top ten S&T powers by the year 2006.
- **National Technology Road Map (2001)** – Developed with input of over 800 experts, this plan describes target technologies, timetables, and anticipated effects for development.

- **Revised S&T Basic Plan (2003-07)** – In this plan, the Korean government distinguishes its five areas of S&T policy priorities and stipulates that Korean S&T should take deeper social responsibilities and contribute to solve social problems.
- **Implementation Plan of National Technological Innovation System (2004)** – The implementation plan was meant to transform Korea's innovation system from a "catching-up" model to a creativity-based system.
- **Basic Plan of Science and Technology (2008-12)** – The basic plan has two main goals: to continuously expand the future growth engine and so strengthen the science technology strategy related to the social demand.

NIE Indicators

The two main agencies that collect innovation indicator data in Korea are the Korea Industrial Technology Association (KOITA) and Korea Institute of S&T Evaluation and Planning (KISTEP). KOITA undertakes surveys and research projects throughout the year to provide both objective information to government and industry and to postulate hypotheses on the direction and impact of industrial R&D.[93] KOITA compiles databases on R&D investment and personnel plus industrial R&D activity, and detailing R&D trends. The association offers NIE data two annual publications: *Major Indicators of Industrial Technology* and *Key Statistics in Korean Science and Technology*. To measure R&D expenditure in the public arena, KISTEP conducts an annual government R&D survey, the results of which are published annually. Like many countries, Korea is focusing on increasing indicators that are commonly associated with innovation, such as R&D expenditure as a percentage of GDP and the number of researchers per capita.

Key Findings and Implications for Saudi Arabia

The following points are seen as key takeaways for KSA from the case study of Korea's NIE. These are lessons demonstrated in Korea's development that are relevant to the planning and structure of the NIE in Saudi Arabia.

Inadequate Coordination and Collaboration

Korea's 2005 reforms to its NIE framework are intended to address (among other goals) persistent coordination and collaboration problems. These challenges center upon the lack of interaction between government researchers and the private sector and on inter-governmental in-fighting and fragmentation and duplication of efforts. Regarding the first issue, Korea's NIE advisory agencies are dominated by academics, and many analysts point to this underrepresentation of industry in government as a cause for the weak links between industry and public R&D in Korea. To address inter-governmental coordination issues, Korea has merged institutions with similar agendas, but for the most part, has not eliminated organizations.

Reducing the Number of Institutions over Time

A major complaint that prompted the 2005 restructuring of Korea's NIE was that Korea's Government Research Institutes engaged in unhealthy competition for research

[93] www.koita.or.kr/eng/data/Brochure.PDF.

grants and that their research projects tended to overlap with both universities and other GRIs. Korea's *Vision 2025* document stated that a common problem with GRIs was that they lacked a customer-service orientation. Other observers have noted that most GRIs lack technology transfer offices. Each of these issues points to a problem inherent in the scale and number of the institutes that operate in Korea. At one point, Korea's NIE counted 100 GRIs and 444 national research labs. It is not efficient for one hundred medium-sized GRI labs to each have their own customer service and technology transfer officers. Nor is it efficient for each GRI to keep track of what 99 other GRIs are pursuing to identify possible conflicts or opportunities for collaboration. Korea restructured its NIE in 2005 and attempted to address the problems listed above by consolidating ministries and other oversight organizations. One can imagine that consolidating the institutes themselves would have alleviated some of the country's coordination woes.

Stakeholder Involvement

Korea's Technology Forecasting activities are described above in the "Building Institutional Strengths" section. While these forecasting methods are not unique to Korea, they are worthy of mention here because of the strong commitment that Korea has made to the forecasting process as a means for policy guidance. Essentially, the technology forecasting activities give all of the stakeholders in Korea's NIS an opportunity to voice their concerns through panels and surveys. The forecasting process also promotes interaction between stakeholders in the NIE, which could promote collaboration and, in turn, innovation. This interaction only occurs every five years or so, though, when the forecasting activities are conducted. In the meantime, Korea could do much more to include industry and government opinions in the country's R&D management, as outlined above.

Accountability for Research Funds

During the evolution of its NIE, Korea made several changes to hold researchers more accountable for the research money that they accepted from ministries. The first big change came in 1995 when Korea's shifted from a "lump sum" funding system to a project-based system (PBS). This change is described above in the "Pillar: Governance" section. The change meant that researchers had to bill their person hours to specific projects, as a consulting firm would, in order to justify their research grant spending. In the aggregate, the PBS system held researchers more accountable to their timelines and caused them to spend their research dollars more efficiently[94].

Korea had problems when the Ministry of Science and Technology (MoST) was performing both the allocation of research funds and the evaluation of the programs on which those funds were spent. After MoST had helped to design and fund research programs, it was difficult for the Ministry to turn around and cut unsuccessful programs. Cutting unsuccessful programs seemed (to some) to be an admission of bad judgment that begged the question, "Why were these unsuccessful programs selected in the first

[94] Hong, Y. S. (2005), *Evolution of the Korean National Innovation System and Technological Capability Building*, Korea's Science & Technology Policy Institute (STEPI).

place?" MoST desired a reputation of sound judgment so, ironically, the ministry cut few of their unsuccessful programs. After KISTEP was formed in 2001, the government separated the allocation and evaluation functions: MoST retained the allocation and KISTEP took over the analysis and evaluation of S&T-related projects. According to several reports on the evolution of Korea's NIE, this separation of duties helped Korea to trim their less productive projects and to improve researchers' accountability for their work.

Educating for Industries' Needs

As Korea's NIE developed, the government shifted its education priorities in anticipation of its workforce needs. In the 1960s, the government focused on providing universal primary and secondary education to create a workforce that had the basic literacy and mathematical skills necessary for the light manufacturing that Korea pursued in that timeframe. In the 1970s, the focus shifted to vocational training to provide the trade skills that were necessary for the growing heavy and chemical industries. Higher education expanded in the 1990s to provide a white collar workforce capable of advanced research. The development of Korea's educational system shows that the government anticipated the labor needs of the country's economic development.

Rather than front-loading their workforce with white-collar professionals, Korea built their workforce from the bottom up to meet the labor needs of their aggressive industrialization. The country has also made lifelong learning programs available, to keep its workforce up to date with new tools and techniques. In the early 2000s, Korea's educational system was criticized for being too homogeneous and for focusing on rote memorization rather than learning. Korea has been slow to respond to these criticisms, though; much of students' time in secondary school is still spent preparing for their college entrance examinations rather than actually learning. At present, the government is considering policies to reform Korea's educational system so that it is better suited for today's global knowledge economy.

SINGAPORE'S NATIONAL INNOVATION ECOSYSTEM (NIE)

Introduction

When Singapore became an independent nation in 1965, it had an underdeveloped agrarian economy. Owing largely to targeted government policies over the past four decades, the country has built a world class knowledge economy and joined the ranks of the developed world. Singapore's GDP per capita (in 2009 US dollars)[95] has risen from $427 (1960) to $37,597 (2008). This case study will examine the history of Singapore's industrialization and will detail the current structure of the country's National Innovation Ecosystem (NIE).

Summary of Innovation Performance

The Global Innovation Scoreboard, which uses composite innovation indicators to compare the innovation performance of the major R&D spenders in the world, ranks Singapore as 12th in the world in 2005. Singapore has increased its innovation performance in the last ten years; in 1995, it ranked 19th on the Scoreboard.[96] This progress reflects advances in several aspects of the country's NIE, including improvements in infrastructure and human resources. The table below shows that Singapore's R&D spending increased eight-fold in the period 1990-2004.

Table: R&D Indicators for Singapore, 1990 and 2004

Indicator	1990	2004
Total R&D Spending ($ millions)	$ 572 M	$ 4,062 M
Total R&D Spending, % of GDP	0.85%	2.25%
Business R&D Spending, % of GDP	0.46%	1.43%

While these statistics help to describe Singapore's performance relative to other countries, they do not illustrate the policies, institutions, and initiatives that drive Singapore's performance. The balance of this study will describe those topics and examine how they contribute to Singapore's NIE.

Impetus Behind and Stages of the NIE

The motivation behind Singapore's planned development was a desire to raise the country's standard of living and to create wealth and jobs for its citizens.[97] When Singapore attained self-governance in 1959, it was an underdeveloped country with widespread poverty, low levels of education, inadequate housing, and high unemployment. Since Singapore had virtually no natural resources, all exports rely on

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[95] Unless otherwise noted, all monetary values are given in U.S. Dollars at 2009 market value.

[96] InnoMetrics, *European Innovation Scoreboard 2008: Comparative Analysis of Innovation Performance*, January 2009, p. 26 (Table 5: Global Innovation Scoreboard).

[97] Soon, Teck-Wong, and C. Suan Tan, "Singapore: Public Policy and Economic Development," pp. 213-276, in Leipziger, Danny M., ed., *Lessons from East Asia*.

imported inputs, and the country's new government quickly set about creating coordinated economic development policies that took advantage of its geographic location and its hard working people.

Throughout Singapore's development, its government has taken an active role in formulating industrial and technology policies and government interventions have been extensive, yet purposeful. The chief elements of its early industrial policy were (1) liberal fiscal incentives to encourage foreign investment, and (2) industrial targeting via investment incentives, shifting over time from low-tech industries to high-skills industries. Planning in Singapore never involved detailed blueprints because of the priority accorded to reaction to the international market, impossibility of predicting its course, and need for flexibility.[98]

Singapore has developed its NIE in three stages:

1. **Developing Stage, 1965-1973** – In its first years of self-rule, Singapore invested heavily in education and vocational training, to provide a workforce suitable for the country's planned industrialization. The government focused its investment promotion on labor-intensive, export-oriented manufacturing. The textile and electronics industries accounted for a large portion of job growth to 1973; then the manufacturing emphasis shifted to electronic and electrical products. To attract FDI, Singapore leveraged its low wages and manufacturing costs, and offered tax incentives for investment that were, on average, more generous than other developing countries. Throughout this period, the government relied on attracting multi-national corporations (MNCs) and learning technologies from them.
2. **Upgrading Stage, 1974-1997** – Faced with labor shortages, the government moved its efforts away from labor-intensive exports and focused on upgrading the quality, skills, and technological content of its industrial base. The government pursued complementary efforts of upgrading infrastructure while expanding education and industrial training. It used tax benefits to promote industrial training and established an "open door" policy for admitting qualified foreign engineers and other professionals. The Economic Development Board (EDB) intensified its investment promotion efforts by establishing 22 overseas offices in the U.S., Europe, and Japan. The government targeted eleven industries for promotion, including machine tools, specialty chemicals, and computers. The EDB established a $60 million venture fund to enable it to co-invest in new technology companies. The country's business and financial service industries gained momentum in this stage.
3. **Knowledge-based Stage, 1991-present** – This stage marked the beginning of Singapore's clearly articulated, 5-year national technology plans. The goal of these plans was to build R&D infrastructure. From 1990-2000, the government

[98] Huff, W.G. (1995), "The Developmental State, Government, and Singapore's Economic Development Since 1960," *World Development*, Vol. 23 No 8, pp. 1421-1438.

funded mostly applied, industry-oriented R&D. After 2000, the focus shifted from application-based research to more fundamental knowledge-based research. To overcome the constraints of Singapore's size, the government pushed to internationalize local firms. Academic institutions were given more autonomy and the government chose niche fields for its national labs to pursue (biomedical sciences, environmental & water technologies, interactive & digital media). The Economic Development Board is working closely with A*STAR to lead several initiatives to increase business R&D expenditures at universities.

In Singapore's first decade (1960s), the government focused on attracting labor-intensive manufacturing. Because of low manufacturing costs (driven largely by low labor cost), Singapore saw some foreign investment from textile and electronics manufacturers during this period. In the following two decades (1970-80s) the country subsequently focused on upgrading its technological capabilities and its workforce. Since the country did not possess any indigenous resources or technology, much of the country's early growth was driven by foreign investment. A large portion of this FDI (and of worker wages that it generated) was reinvested in the country's NIE.

Up to 1990, Singapore did not have a formal entity coordinating its science and technology policy. Then the National S&T Board was created to oversee the subsequent five-year technology plans that the government has pursued to this day. Until 2000, Singapore was primarily a value-adding manufacturing base and was dependent on export-led development. Since the year 2000, government actions have shown a move towards more knowledge- and research-intensive industrialization. Their focus has shifted towards supporting indigenous small and medium enterprises, rather than attracting multinational corporations. Singapore has decided that it is too small to specialize in many different avenues of research and product development, so it has narrowed the "industries" it wants to pursue: biomedical sciences, environmental & water technologies, interactive & digital media.

National-Level NIE Structure and Collaboration Mechanisms

Singapore's NIE is directed by a small number of institutions, each having a large amount of responsibility. At the highest level of the NIE, the Prime Minister's office solicits advice from a council (the RIEC) representing government, industry, and academia. The Prime Minister uses this advice to articulate priorities for the NIE and these priorities are acted upon by the National Research Foundation (NRF) and the Ministry for Trade and Industry (MTI). In pursuit of the national priorities, these organizations delegate responsibilities to sub-organizations; the NRF has sub-programs and the MTI has statutory boards. This section details each institution's responsibilities and some mechanisms through which they collaborate.

Key Institutions and their Roles

Research, Innovation, and Enterprise Council (RIEC) – The RIEC is a council chaired by the Prime Minister that is comprised of 17 individuals from government and industry. The mission of the RIEC is: (1) To advise Singapore Cabinet on national research and innovation policies and strategies to drive the transformation of Singapore into a knowledge-based economy, with strong capabilities in R&D; and (2) To lead the national drive to promote research, innovation and enterprise, by encouraging new initiatives in knowledge creation in science and technology, and to catalyze new areas of economic growth.

National Research Foundation (NRF) – The National Research Foundation was set up in 2006 within the Prime Minister's Office. The NRF provides secretarial support to the RIEC and manages a US$3.2 billion National Research Fund to support research, innovation and enterprise. The main responsibilities of the NRF are to:

- Coordinate the research of different agencies within the larger national framework in order to provide a coherent strategic overview and direction;
- Develop policies and plans to implement the national R&D agenda; and
- Implement national research, innovation and enterprise strategies approved by the RIEC, and to allocate funding to programs that meet NRF's strategic objectives.

The Foundation currently focuses on three areas of research: biomedical sciences, environmental and water technologies, and interactive and digital media.

Ministry of Trade and Industry (MTI) – The Ministry of Trade and Industry was created in 1979 and tasked with anticipating problems ahead, identifying opportunities for growth, rationalizing existing policies and giving broad directions for growth. The MTI oversees ten statutory boards, which are semi-independent agencies that specialize in carrying out specific plans and policies of the Ministry. The statutory boards relevant to innovation promotion are described below.

Statutory boards under MTI

The Agency for Science, Technology and Research (A*STAR) (formerly the National Science and Technology Board) – A*STAR was established in 1991 and was the first government agency in Singapore devoted to S&T policy development. Its primary mission is to raise the level of science and technology in Singapore. The agency funds and manages several national laboratories, including the recently opened Biopolis and Fusionopolis sites. The agency's Graduate Academy offers scholarships to undergraduates who wish to pursue doctoral degrees. A*STAR has administered four recent five-year National Technology Plans, which are described below in the "Key NIE Initiatives" section.

Since 1991, A*STAR has conducted an annual **National Survey of R&D** to monitor the performance of research institutes in patenting, licensing of technologies, and joint R&D ventures with private firms. This survey is described in more detail in the "Indicators" section. A*STAR has the largest pool of intellectual property available for licensing in

Singapore. Companies can tap onto this pool of intellectual property and thus gain access to the work of over 2000 scientists and engineers. **Exploit Technologies** is the commercialization arm of A*STAR that works with industry to take the technologies to market with the goal of turning a profit from the scientific research conducted by its institutes.

Economic Development Board (EDB) – The EDB was established in 1961 (pre-independence) to centralize all industrial promotion activities. It started with a budget of $100 million, which it used to grant loans to industrial enterprises, to acquire land for industrial sites, and to establish industrial estates furnished with the necessary utilities for industrial activity. EDB is the lead government agency responsible for planning and executing development strategies and, by some accounts, it was the most important government agency in Singapore's economic growth through rapid industrialization.[99] In the 1980s, during Singapore's Upgrading phase, the EDB used a strategy of outreach, establishing 22 overseas offices in the U.S., Europe, and Japan to intensify its investment promotion efforts. The EDB also provides feedback to the government on which policies are working and which policies are just creating more red tape.

Standards, Productivity and Innovation Board (SPRING) – SPRING is a statutory board under the Ministry of Trade and Industry that concerns itself with productivity and innovation; standards and quality; and the support of small and medium-sized enterprises (SMEs). SPRING's activities are described further in the "Responsiveness to Local Conditions" section below.

Process and Mechanisms Used to Build Effective Inter-Institutional Consensus and Collaboration

Two key elements of an effective NIE are (1) institutions in academia, government, industry; and, importantly, (2) the interaction and consensus of these existent institutions. A key mechanism that Singapore uses to build inter-institutional consensus is one that can be termed "cross-pollination". Cross-pollination involves executives from innovation institutions participating in the direction of other boards outside of their sphere of influence. For example, an academic institution may tap the government and industry sectors to form its advisory panels. This mixing, or cross-pollination, corresponds with the portrayal of NIEs as a triple helix of institutions that not only co-exist, but are intertwined as well.

Some examples of cross-pollination in the Singaporean NIE include: (1) the 13-member A*STAR board of directors counts four members from academia, four members from industry, and five members from government careers; (2) the Directors of the Economic Development Board count ten industry and four government representatives; and (3) the National Research Foundation's board of directors has six members from government, nine members from industry, and one academic. These examples stand in

[99] Parayil, Govindan, "From 'Silicon Island' to 'Biopolis of Asia': Innovation Policy and Shifting Competitive Strategy in Singapore," *California Management Review*, Vol. 47, No. 2, Winter 2005, p. 54.

stark contrast to, say, Korean boards of directors that are almost uniformly composed of academics.

Following consensus at the top of the organization chart, it is important to have collaboration amongst the actual researchers in Singapore's NIE. Singapore's agencies list plenty of cross-institutional collaborative efforts. For example, A*STAR's Biomedical Research Council works in close partnership with the Singapore Economic Development Board's (EDB) Biomedical Sciences Group and Bio*One Capital, to develop Singapore's biomedical sciences cluster. The mechanisms for these partnerships include A*STAR's joint grants that require collaboration between research institutes (i.e. a grant may be issued that requires participants from both the Singapore Bioimaging Consortium and the Singapore Immunology Network). Joint grants such as these help researchers to identify synergies, develop lasting relationships, and build innovation networks.

Nature of Collaboration on Different NIE Functions

There are three specific collaboration mechanisms[100] in Singapore's NIE that this report highlights. Each of the three mechanisms below involves the coordination or connection of two or more stakeholders in the NIE.

1) The previous sub-section observed that the governing boards of Singapore's ministries are comprised of representatives from government (including other ministries), industry, and academia. This facilitates inter-institutional coordination at the highest level and helps to prevent overlapping projects and initiatives. Singapore's sub-ministerial agencies also collaborate to avoid inefficiencies at the implementation level. When researchers submit a grant proposal to an institution in the NIE, they must certify that they do not have a similar proposal pending at any other Singaporean grant-issuing institution. Then, the committees at these institutions that review grant proposals are seeded with representatives from other institutions. For example, the NRF's biomedical grant review panel may have members from A*STAR. Grant proposals have been denied in the past because they would have been duplicative.
2) With millions of dollars of research funding from national strategic programs at stake, there is always the risk that ministries will engage in excessive competition with one another to win research grants. To reduce the competition between ministries, the executive committee of each national strategic program Singapore is co-chaired by two separate ministries. Some examples include Singapore's Biomedical Initiative (headed by both A*STAR and the Ministry of Health) and the Interactive Digital Media Initiative (co-chaired by the Ministry of Arts & Culture and the Ministry of Education). This notion of collaboration through shared leadership is similar the "joint chiefs" structure that the United States uses to coordinate its defense forces.

[100] Telephone Interview with Dr Michael Khor, Projects Director of NRF's National Framework for Innovation and Enterprise (NFIE), 5/13/2009.

3) In the aggregate, working professionals in Singapore tend to drift towards academia over the course of their careers because academia is viewed as more prestigious. While many professionals change from industry or government career paths to academic careers, there is little movement in the opposite direction. The inherent risk of this "academic drift" is that universities may become detached from the needs of industry and that the two sectors will not work together as often as they should. Singapore has a mechanism, though, to prevent its academics from being "locked away in an ivory tower." University professors are often seconded[101] to industry or government posts for a year or two. On these brief stints, the professors can update industry with the latest theoretical research and, when they return to academia, they have a better idea of the issues that other sectors are tackling.

These three mechanisms are examples of Singapore's efforts to connect the different actors in its NIE in order to increase collaboration and efficiency within the system.

Sub-National, Regional and International Linkages

Singapore is a city-state comprised of only 710km^2 in area, so little co-ordination is directed at the sub-national level. The nation has, however, expanded its presence in the region of South Asia by installing overseas industrial parks in Indonesia, Vietnam, and China. These parks are discussed in more detail in the "Initiatives: Infrastructure" section below. Since 1990, Singapore has ramped up its efforts to become a global city by creating international links to other innovation centers. This section describes Singapore's limited sub-national activity and the methods by which the city-state has established and leveraged its international linkages.

Roles of Key Institutions in Delivering the NIE

The agencies and boards listed in the previous section are the primary actors in Singapore's NIE and their roles are clearly defined. In several words, the roles can be summed up as follows: national strategy (RIEC), R&D coordination (NRF), funding distribution and R&D management (A*STAR), business development (EDB), entrepreneur/SME support (SPRING). Several of the institutions above have additional roles outside of the NIE framework which, in most cases, have synergies with the institutions' duties inside the NIE.

[101] "Seconding" is a term of British origin. The "second" someone is to release then (as a military officer) from a regularly assigned position for temporary duty with another unit or organization

Approaches and Roles for Supporting International Linkages

One of the ways that Singapore forges international linkages is through outreach in the higher education sector. Government grants were given to set up joint research centers between local and reputable foreign universities and to fund collaborative projects between them. Sixteen foreign schools have set up campuses in Singapore and many world class universities offer courses in Singapore. Among them are MIT, Wharton School of Business, Johns Hopkins, Shanghai Jiaotung University, INSEAD, and the Chicago Graduate School of Business. To attract INSEAD, Europe's leading business school, Singapore's government offered bargain-priced land and $6 million in research subsidies.[102] In addition to linking with institutions, Singapore vigorously recruits teaching talent and students from overseas. A*STAR states that, in 2003, only 13% of the students pursuing doctoral degrees in Singapore were citizens or permanent residents; and in 2002, 19% of all scientists and engineers in Singapore's R&D were foreign citizens. Linking researchers on specific projects may involve mechanisms such as joint grants. For example, the British High Commission in Singapore has a Strategic Program Fund that supports new collaborations between the two countries in the field of medicinal chemistry.[103]

Roles of International Associations and Knowledge Networks

The Agency for Science, Technology and Research (A*STAR, under the MTI) represents Singapore on Science & Technology matters at international forums. Research collaborations are most effectively driven by research institutions and their individual researchers and research groups. A*STAR encourages the research institutes under its management to collaborate with other research institutions, and welcomes other research institutions to make contact and explore collaboration opportunities in areas of common interest. A*STAR itself also has agreements on cooperation in Science & Technology with agencies in several countries, including China, Japan, Korea, Canada and Germany, that aim to foster research collaborations, the exchange of researchers and students, and joint symposia, seminars and workshops.

Responsiveness to Local Conditions

Throughout its history, the Singaporean government has taken a flexible approach to planning that does not depend on a rigid time frame. Apart from the initial five year plan (1960-64), the government did not produce any more five year economic plans. This flexibility has allowed it to tweak its interventions in response to both local and global conditions. An example of this flexibility came in the early 1970s, when Singapore attained full employment and was beginning to face labor shortages. The government modified its economic strategy and its investment promotion efforts, moving away from labor-intensive manufacturing industries and focusing instead on upgrading its labor force. In designing its NIE, the government incorporated the same flexible approach to policy planning.

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102 www.smu.edu.sg/news_room/smu_in_the_news/2007/sources/IHT-AsahiShimbun_20070131_1.pdf.

103 http://ukinsingapore.fco.gov.uk/en/working-with-singapore/science-innovation/collaborative-opportunities.

Experience Simultaneously Building Capacity and Cooperation[104]

Over the past 19 years, Singapore has issued four National Technology Plans, which are described in more detail in the "Initiatives" section below. The formulation of these plans has served as an important venue for cross-institutional collaboration to tackle the technological issues of the moment. For each Plan, a large number of individuals were approached to provide their views, and committees were formed to brainstorm and assess the potential for Singapore's success in different technology sectors. These brainstorming and discussion sessions pull individuals from academia, government, and industry, and cause them to interact and to discuss each other's strengths and weaknesses. Through these interactions, researchers may discover synergies identify areas for collaboration. This style of mass interaction in technology planning is a variation of the "Foresight" program that is used in the UK and some European countries; the "Foresight" method has since been adopted by South Korea in their national strategy formulation.

Experience Building on Institutional Strengths and Programs

In the mid-1990s, Singapore began to use "technology forecasting" (a.k.a. 'technology foresight) as a source of guidance for its science policies. The goals of forecasting are twofold: (1) identify where current technology trends are leading, and (2) identify any gaps in the nation's capacity to keep up with technology trends. So, while forecasting studies are typically forward-looking, they also provide an opportunity to evaluate the current status of the NIE. Technology forecasting typically involves intensive interviews with panels of thought leaders, visionaries, industry players, researchers, and academic and government notables. The development of Singapore's second National Science and Technology Plan (1996) involved a panel-based technology foresight activity in which a steering committee and five working committees were set-up to evaluate Singapore's performance and predict the future. The foresight activity determined nine key sectors[105] that are central to the nation's S&T strategy.

Singapore's Infocomm Development Authority (iDA) is active in forecasting activities. The iDA prepared a *Singapore Infocomm Foresight 2015*[106] and hosted a Technology Foresight Seminar in 2008 to guide developments in information technology. Representatives from Singapore have also participated in international technology forecasting workshops: Technology for Learning and Culture (1999) Sustainable Transport for APEC Megacities (1999), and Nanotechnology: the Technology for the

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[104] The information for this section is drawn mainly from SMU, NUS, and http://papers.ssrn.com/sol3/papers.cfm?abstract_id=626342.

[105] Information Technology/Communications, Microelectronics/Semiconductors, Electronic Systems, Manufacturing Technology, Materials and Chemicals Technology, Environmental Technology, Energy, Water and Resources, Food and Agrotechnology, Biotechnology, Medical Sciences.

[106] Infocomm Development Authority (2005), *Singapore Infocomm Foresight 2015*, www.ida.gov.sg/doc/Technology/Technology_Level1/20060417212727/ITR52005.pdf, last accessed 05/10/2009.

21st Century (2001). Singapore's NRF has proposed that the government create a new innovation policy agency that would be responsible for technology forecasting.

Experience Fostering Growth and Enterprise Development

Government support has been a key feature of venture capital industry development in Singapore since the mid-1980s. The government was instrumental in setting up early venture capital funds such as Vertex Management and EDB Ventures. In the late 1990s, it launched a $1 billion "Technopreneurship" Investment Fund to attract leading venture capitalists from around the world and to spur training for venture capital professionals. There are currently more than 100 venture capital firms in Singapore managing a total VC fund size of $9 billion.

Enterprise development in Singapore is under the purview of SPRING (Standards, Productivity and Innovation Board) Singapore. SPRING is an agency under the EDB committed to growing innovative companies and fostering a competitive SME sector; it is essentially a gateway for start-ups and SMEs who seek funding or want to connect with investors. The Board offers many different forms of support geared at startups, SMEs, and entrepreneurs. This support comes in the form of advice, financing, awards, networking. An example is the **Startup Enterprise Development Scheme (SEEDS)**, which matches dollar-for-dollar (to a max of $1 million) any third-party investor who puts money into early stage start-ups.

SPRING's programs are also responsive to local conditions. One of the growing concerns in Singapore is the nation's ability to source clean water once its water supply contracts with Malaysia expire in 2012. In 2008, SPRING launched a $7.6 million Center of Innovation for Environmental and Water Technology to assist with the development of water supply technologies. The applied research facility helps Singapore's SMEs develop commercially viable products and solutions.

In 1998, the government announced the **Technopreneurship 21** (**T21**) initiative to foster high-tech start-ups.[107] This initiative led to liberalization in business regulations that were thought to stifle start-ups. Bankruptcy laws were amended, regulations and taxation governing company stock options were revised, and new loss protection mechanisms for investors in high tech start-ups were introduced.

Indicators for S&T Performance and Program Evaluation

Performance evaluation is an important feature of a functioning NIE. Evaluation helps determine the effectiveness of different institutions and programs, so that policymakers can cancel ineffective programs and draw lessons from successful programs. Most agencies and statutory boards in Singapore collect and disseminate data on their activities. For example, SPRING's website reports indicators relevant to SMEs and

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[107] Sources: NMU, NUS, and http://papers.ssrn.com/sol3/papers.cfm?abstract_id=626342.

enterprise development.[108] The bulk of S&T indicator collection is performed by the Agency for Science, Technology and Research (A*STAR). Since 1991, A*STAR has conducted an annual National Survey of R&D. The results of this survey are used to monitor the performance of research institutes in patenting, licensing of technologies, and joint R&D ventures with private firms. The Survey collects comprehensive data on Research and Development (R&D) activities in all sectors. It tracks typical R&D indicators, such as workforce demographics, fields of study, expenditure, intellectual property, and licensing revenue.

The indicators collected by A*STAR and other boards are used to benchmark Singapore's performance against other countries and to identify areas that for improvement. Singapore's National Technology Plan 2010 is very specific about the indicators it uses for performance evaluation. Typically, these benchmarking indicators are standard measures of innovation capacity, such as R&D spending as a percentage of GDP, the number of researchers per capita, the percentage of total R&D spending that comes from private funds, and others.

Key NIE Initiatives

Several initiatives have driven economic development in Singapore and a select few are presented here. The pillars that these initiatives support parallel the government's evolving economic development strategy. The country first focused on infrastructure, to create a business environment suitable for foreign investment. Singapore then invested in human capital during its upgrading stage. And, more recently, the country has developed its innovative capacity. The initiatives pursued in these movements are described below, along with a profile of the e-Government initiative, which has revolutionized the transparency and accessibility of Singapore's government.

Pillar: Infrastructure

Singapore's Industrial Estates Initiative[109]

Singapore's initiative to build industrial estates was driven in part by their desire to attract foreign investment. Early in Singapore's development, the EDB developed several industrial estates, which offered industrial sites with superb management and excellent infrastructure at subsidized rates. In Singapore's "Upgrading" stage, land constraints and rising wages prompted the government to begin locating Singapore-managed parks in other Southeast Asian nations. On average, these ventures were not as profitable as expected, and the government has returned its attention to the homeland, focusing its new parks on high-skill, high-wage job creation.

Singapore began construction on its first industrial estate in 1961 in its western town of Jurong. By 1963, twenty-three factories had been established at the 17,000-acre

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[108] SPRING's indicators are cited at www.spring.gov.sg/Content/WebPage.aspx?id=0e7aee48-13fc-4a68-91f7-14e053a68523.

[109] Sources for this section include: www.accessmylibrary.com, www3.interscience.wiley.com, www.pmo.gov.sg, http://courses.nus.edu.sg, and www.nature.com/nature.

Jurong industrial Estate. In 1969, when Jurong Port was declared a free trade zone, the number of operational factories stood near 160. In the 1980s, this flagship park was expanded, when the Jurong Town Corporation and EDB filled the ocean space between seven nearby islands to create Jurong Island. The new island is now home to an integrated petrochemical and manufacturing complex, as well as several logistics parks.

As Singapore moved into its Upgrading stage in the late 1970s, the government became interested in attracting R&D jobs to the country. To that end, the EDB and the Jurong Town Corporation were directly involved in the planning and creation of the **Singapore Science Park**, which was established in 1980. The Park is a specific state-driven exercise to bring R&D to Singapore. As of 2007, the Park housed 350 tenants, half of whom represented the IT and electronics industry. In the following years, Singapore established parks with more specific foci, such as the **Tampines Industrial Park** (semiconductors) and the **Tuas Biochemical Park**.

The industrial park initiative changed shape in the 1990s, as Singapore began looking beyond its borders for more land to house their industrial activity. The goals of this trans-border industrialization strategy were to generate additional economic space for Singapore-based companies (both indigenous and foreign), and to redistribute resource-dependent operations to lower-cost production sites. Singapore's first trans-border regional park was **Batamindo Industrial Park (BIP)**, launched in 1992 on the Indonesian island of Batam. The **Vietnam-Singapore Industrial Park (VSIP)** was launched in 1996 north of Ho Chi Minh City. Both of these parks were designed to be self-sufficient and self-contained, with communication and business linkages running through Singapore, thus bypassing their host nation's bureaucracy. Between 1994 and 2001, Singapore's government was involved in the development and management of the **China-Singapore Suzhou Industrial Park** project. The strategy involved servicing the industrial needs of multinational corporations seeking to locate operations in China. However, Singapore disengaged from the project in 2001, citing a lack of profitability. The construction of regional industrial parks was a critical component of Singapore's regionalization drive, but the effort was not as rewarding as they had hoped. Among other issues, the politics of managing an industrial park in a foreign country caused significant tension between Singapore and its host countries.

In the late 1990s and early 2000s, Singapore returned the focus of its industrial park initiative back to the homeland. The government began the multi-stage, 200-hectare **One-North** development in 2001 with the goal of creating a world class R&D hub for scientists and entrepreneurs working in the biomedical sciences, ICT, and media. **Biopolis**, the massive, $290 million biomedical research facility, was completed in 2003. **Fusionopolis** is an equally large ICT and media facility that is due to finish construction in 2012. To enhance the networking opportunities between actors in its NIE, the entire One-North campus is located proximate to the National University of Singapore, the Singapore Polytechnic, the Ministry of Education, the National University Hospital, and Singapore's original Science Park (1980).

In sum, Singapore's initiative to build industry-concentrating parks has existed since the country gained independence. The initiative has evolved in parallel with the country's development, moving from low-tech manufacturing through upgrading to knowledge-based production. Through generous government policies regarding taxes and ownership, the parks have succeeded in attracting foreign investment to Singapore. This investment has, in turn, created wealth and jobs for Singapore's citizens and sped the development of the country's NIE.

Pillar: Innovative Capacity

Singapore's Technology Planning Initiative

Before 1990, Singapore had not codified any plans for its NIE; it was content instead to focus on attracting foreign investment and increasing educational attainment. But the country experienced a recession in 1985-86 that forced the government to re-evaluate its economic policies, with the dual purpose of recovering from the recession and preventing further economic trouble. The years after the recession marked the beginning of Singapore's Technology Planning Initiative. The broad motivation for technology planning was laid out in the **Strategic Economic Plan (1991)**, published by the Ministry of Trade and Industry. The Plan outlined the elements of a strategy (based on science, technology, and R&D), that was meant to transform Singapore into a developed nation in 30 years. A further goal that the plan outlined was for Singapore to have the same per capita Gross National Product as the United States by the year 2030. Several recurrent themes were stressed: the need to upgrade the education levels of the population and to nurture a pool of skilled personnel in key technologies, along with the importance of developing innovative and creative skills.

The details of the Technology Planning Initiative were laid out in a series of **Five-Year National Technology Plans (1991-2010)**[110]. The goals and investments for each of the four plans are presented in a table on the following page. Both of the first two National Technology Plans sought to target mainly short term applied technological innovations. The later plans attempt to deepen the culture and practice of innovation across the whole economy by developing basic innovation and cultivating a scientific culture. In the third and fourth Technology Plans, the mandate shifted from a total focus on applied research to a significant focus on basic research. This shift occurred as the sector performing the basic research (universities and national labs) grew and began to take form. Each Plan has identified the technology sectors where Singapore should focus its research efforts and expenditures. As described in the "Responsiveness to Local Conditions" section, these sectors are identified through an extensive brainstorming and discussion process that brings together stakeholders from academia, government, and industry.

[110] In 2002, the National Science and Technology Board (NSTB) was restructured and renamed the Agency for Science,Technology and Research (A*STAR). This agency (NSTB / A*STAR) has been the lead agency in implementing the National Science and Technology Plans.

Some notable products of these plans are the **Innovation Development Scheme (1995)** and the **Biomedical Sciences Initiative (2000)**. The Economic Development Board launched the Innovation Development Scheme to build innovation capacity in Singapore. Using grants, the Scheme encourages and assists Singaporean companies to develop capabilities in the innovation of products, processes, applications and services. The IDS is primarily used as a tool to build up capability gaps that EDB identifies in Singapore's industry. From 1995-2008, $170 million have been disbursed to cover expenditure on manpower, equipment, intellectual property and professional services. The Biomedical Sciences Initiative was launched by A*STAR in 2000 to develop the biomedical sciences cluster as one of the key engines of Singapore's economy, alongside electronics, engineering and chemicals.

National Technology Plan	**Timeframe**	**Investment**	**Actions**
First	1991-95	$1.4 B	▪ Encourage private sector R&D through loans and grants. ▪ Identify the manpower and technologies needed to build a long-term advantage in R&D. ▪ Support and finance institutes and centers to meet the R&D needs of companies. ▪ Development areas: Information technology and communications (ITC), electronics, manufacturing technology, materials and chemicals, environmental, water/energy, biotechnology, agro-technology, and medical sciences
Second	1996-2000	$2.8 B	▪ Develop additional infrastructure and attract international talent ▪ Increase the ratio of R&D expenditure to GDP to 2.6% by the year 2000 ▪ Develop R&D manpower, target of 65 researchers per 10,000 workers
Third	2001-05	$3.5 B	▪ Shift focus to basic research ▪ Setup two new research councils: the Biomedical Research Council (BMRC) and the Science and Engineering Research Council (SERC) ▪ Establish a system for effective technology transfer and intellectual property management ▪ Develop strong international relationships and networks.
Fourth	2006-10	$8.6 B	▪ Increase the ratio of R&D expenditure to GDP to 3% by year 2010 ▪ Added sectoral focus: Environmental & Water Technologies and Interactive & Digital Media ▪ Strengthen ties between R&D and businesses

Sources: http://www.apec-isti.org/IST/abridge/sgz/sgzpol00.htm, http://www.wtec.org/loyola/em/c_nstb.htm, http://www.med.govt.nz/templates/MultipageDocumentPage____38536.aspx

Pillar: Governance

Singapore's e-Government Initiative[111]

The Singapore government was one of the first nations in the world to implement an e-government system. On their own computers, or at e-Citizen Centers, Singaporeans can obtain information and bid for certificates to register a vehicle, file their taxes, download forms to file for bankruptcy, register a marriage, baby, car or pet, apply for a passport, housing or utilities, check their provident fund accounts or their child's

[111] Information in this section is drawn mainly from www.ida.gov.sg/, www.igov.gov.sgwww.mfa.gov.sg/.

school registration status, etc. Singapore's e-government initiative began in 1980 with the **Civil Service Computerization Program** which sought to improve government efficiency by automating work functions and reducing paperwork. The effort continued in 2000 with three multi-year action plans, administered by the Infocomm Development Authority of Singapore.[112]

Singapore's first **e-Government Action Plan (2000-03)** established the governments "eCitizen" portal, where citizens can interact online with the Government on a vast range of matters 24 hours a day, seven days a week. Individual agencies could construct their online tools with centrally developed "building blocks" (such as payment or messaging options) to minimize development time. The second **e-Government Action Plan, eGAPII**, was launched in 2003 with an investment of $0.76 billion. In eGAPII, the focus was on e-service delivery and consultation. The plan made all of the government services that could be placed online available via the internet and public agencies worked together to integrate their e-services. The Public Service's Consultation Portal was launched as a channel for Singaporeans to air their views on national issues and policy proposals. Five "CitizenConnect" centers were launched in 2005 to help citizens or residents who do not have access to, or who need help with a computer or the Internet, to transact online with the Government. By 2007, the government had opened a total of 28 CitizenConnect centers. The latest e-government plan, **iGov2010**, was launched in 2006. The $1.3 billion plan actively engages citizens in the policy-making process and further improves the efficiency of the e-Government portal.

The e-government initiative has enhanced the efficiency and transparency of Singapore's government and has been received very well by the public: in 2006, about 90% of customers who needed to transact with the Government did so electronically at least once and about 90% of those who transacted electronically expressed satisfaction with the overall quality of e-services delivered.[113] Singapore has won international accolades for its aggressive development of government ICT services – Singapore topped the e-Government sub-index of the World Economic Forum Global IT report for seven consecutive years from 2002 to 2008. Beyond saving money and time, the system has developed indigenous information technology talent, which Singapore is now using to export IT services abroad.

Key Findings and Implications for Saudi Arabia

Flexibility

Singapore's economic development policies were largely successful because the system they set up was flexible: it allowed the government to be responsive to global conditions. Policy makers were not confined to a rigid blueprint, nor were they overly committed at any time to a few specific technologies. This allowed the country to

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[112] The Infocomm Development Authority of Singapore functions as the Chief Information Officer for the Singapore Government.

[113] e-Government Customer Perception Survey conducted in March 2006.

respond quickly to their 1985-86 recession and to the 1997 Asian financial crisis. The government was also keen on program evaluation and was not afraid to restructure or cancel ineffective programs. The lesson for KSA is that their policymakers should incorporate flexibility in designing the Kingdom's NIE.

Promotion of Foreign Investment

The Singaporean government has never been shy about promoting foreign investment. Since it began attracting foreign investors, the country has seen stiff competition from other developing nations. The key to Singapore's success was providing more hospitable conditions than its competitors. The government was keen to maintain an economically and politically stable environment for investors. It also benefitted from its English-speaking, hard-working population. In addition the benefits that Singapore offered to potential investors were, on average, better than its competitors. For example, in the early 1980s, Singapore guaranteed foreign countries 100% ownership of their investments. By establishing overseas offices, the EDB drew attention to Singapore's investment promotion policies.

The vast majority of KSA's foreign investment comes from overseas oil companies who locate within KSA's borders because their extraction operations must be proximate to the resources with which they work. It is more difficult to attract knowledge-based foreign investment than resource-based foreign investment. Knowledge-based companies are typically more mobile and they do not need to locate near natural resources. Like Singapore, KSA's investment promotion efforts will face intense competition from developing countries. In addition to offering tax breaks and development incentives to investors, the Kingdom should highlight aspects of its economy that are attractive to foreign enterprise.

Investment in all levels of education

Early in its Development stage, the Singaporean government realized that, to attract foreign investment, the country had to provide a competent workforce to meet industry's labor needs. To that end, the government began investing heavily in primary and secondary education. As industry's labor needs progressed from competent to semi-skilled to skilled labor, so did Singapore's investments shift into vocational training and higher education. The country's National Technology Plans 1990-2010 called for investments in worker re-training as domestic production moved from traditional manufacturing sectors to high technology and service industries. In sum, Singapore has been keen to provide a workforce that meets the needs of its economic base, whether that base requires manual or skilled labor. The government's education policies have anticipated labor needs several years in advance, but have also been adaptive in the face of changing local conditions. The implication here for KSA is that, rather than focusing solely on producing white collar, university-trained professionals, the Kingdom should devote some energy to developing a cadre of vocationally trained workers.

Broadening of NIE Scope over Time

The Singaporean government first began developing their innovation system in 1990, with the formation of A*STAR (then the National Science and Technology Board). The initial mission of A*STAR was very narrow: it was created to promote science and technology. But as Singapore's knowledge resources and R&D investments grew over time, the government broadened the scope of its NIE. New councils and statutory boards such REIC and SPRING were established in due course and research parks were eventually created to capitalize on the knowledge base that the country was building. Institutions that did not function well were restructured or closed.

The important takeaway here is that Singapore did not try to build a full scale NIE overnight. Because their NIE developed gradually, the institutions within the NIE had time to assume and explore their responsibilities before they were forced to interface with other newly created institutions. The Singaporean government also had time to evaluate and tweak new institutions, and to see which initiatives worked and which ones did not. The modestly-paced evolution of Singapore's NIE had several benefits for the country: it helped to minimize turf wars between institutions and to reduce inefficiencies in the country's innovation policy.

Use of Numerous, Concrete Cooperation and Consensus-building Mechanisms

Singapore has put in place numerous mechanisms to encourage cooperation across the multiple institutions involved in its NIE. At the highest level, the Research, Innovation and Enterprise Council (which is responsible for national strategy) is comprised of members representing government, industry, and academia. The council's secretariat – the National Research Foundation – holds primary responsibility for coordinating the research of different agencies to ensure coherency and effectiveness. In addition, the boards overseeing almost all of Singapore's NIE institutions represent examples of cross-pollination, involving government, academia, and the private sector, thereby promoting inter-institutional interaction and coordination. At the operational levels, Singapore's institutions also endeavor to promote collaboration, avoid inefficiencies, and reduce turf battles. Examples of such efforts include:

- A*STAR's issuance of grant solicitations requiring joint research projects (i.e., those that entail collaboration between two or more research organizations);
- The requirement that researchers submitting a grant proposal to an institution in the NIE certify that they do not have a similar proposal pending at another institution;
- Grant review panels that are seeded with representatives from many NIE institutions; and
- Co-chairmanship of the executive committees of Singapore's national strategic programs by two separate ministries.