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The Role of R&D Center for Technology Commercialization : The Case and Implication to The Developing Country*

Kim, Jong Jin(Korea National Open University)**
Choi, Jong In(Hanbat National University)***

Abstract

The role of R&D center for technology commercialization can be categorized into three distinct stages: the first stage consists in developing industrial problem-solving capability; the second consists in catching up with industrialized economies developing creative imitations of imported technologies; and the third consists in acquiring advanced knowledge creation capability. Accordingly, the R&D center's organization should be aligned with this development strategy. This case study of Kazakhstan provide a managerial implication for the other developing countries. The first stage of development, which may be called the 'industrial problem solving stage,' the center will build the infrastructure in terms of both technology and human-resources. The second stage will involve building up 'knowledge capability' with a view to becoming a major industrial R&D hub in Central Eurasia. In the third stage, the center will create advanced knowledge as a 'world-class knowledge center'. In this regard, the evolution of the R&D center should be described according to the features of the center's services.

Keywords: commercialization of technology, R&D center, FDI, Korean experience(KSP), KIST, Nazarbayev University, Republic of Kazakhstan

Ⅰ. Introduction

Concerns in the commercialization of technology increased significantly in the past decade. In many increasingly knowledge-based 21st century, effective managers will need more training in dealing with scientists and technologists and in creating business growth and advantage through commercializing of technology(Barr et al., 2009; Choi et al., 2012).

During the early stage of industrialization, developing countries acquire the existing mature foreign technologies from advanced countries. Lacking local capability to establish production operations, local entrepreneurs develop production processes through the acquisition of 'packaged' foreign technology, and this time is adequate to make a center which includes assembly processes, product specifications, production know-how, technical personnel and components and parts(Kim, 2003). The aim of this study is about the evolutionary role of R&D center in the university. Center will evolve in accordance with changing industrial needs, the establishment of industry' R&D capabilities, the status of R&D capabilities and resources in the center, and the development of national R&D policies. According to the experience of former developing countries like Korea, there exists a sequential, evolutionary pattern according to which the types and orientation of research strategy change.

Ⅱ. Republic of Kazakhstan and Nazarbayev University

2.1 Republic of Kazakhstan

The Republic of Kazakhstan is a important country to Korea for the national resource strategy(Kim and Choi, 2012). It is located in Central Asia and Eastern Europe. The ninth largest

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** First Author, Professor, Department of Management, Korea National Open University, jjkim@knou.ac.kr
*** Corresponding Author, Professor, Department of Management and Accounting, Hanbat National University, jongchoi@hanbat.ac.kr
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country in the world by land area, it is also the world's largest landlocked country; its territory of 2,727,300 square kilometers (1,053,000 sq. mi) is larger than Western Europe. Moreover, lying on both sides of the Ural River makes Kazakhstan one of only two landlocked countries in the world lying on two continents. It is neighbored clockwise from the north by Russia, China, Kyrgyzstan, Uzbekistan, and Turkmenistan, and also borders on a large part of the Caspian Sea. The terrain of Kazakhstan includes flatlands, steppe, taiga, rock-canyons, hills, deltas, snow-capped mountains, and deserts. With 16.6 million people(2011 estimate). Kazakhstan has the 62nd largest population in the world, though its population density is less than 6 people per square kilometer (15 per sq. mi.). The capital was moved in 1998 from Almaty, Kazakhstan's largest city, to Astana, northern area(Aitken, 2009).

For most of its history, the territory of modern-day Kazakhstan has been inhabited by nomadic tribes. By the 16th century, the Kazakhs emerged as a distinct group, divided into three Jüz. The Russians began advancing into the Kazakh steppe in the 18th century, and by the mid-19th century all of Kazakhstan was part of the Russian Empire. Following the 1917 Russian Revolution, and subsequent civil war, the territory of Kazakhstan was reorganized several times before becoming the Kazakh Soviet Socialist Republic in 1936, a part of the Soviet Union.

Kazakhstan declared itself an independent country on December 16, 1991, the last Soviet republic to do so. Its communist-era leader, Nursultan Nazarbayev, became the country's first supreme chancellor, a position he has retained for more than two decades. President Nazarbayev maintains strict control over the country's politics. Since independence, Kazakhstan has pursued a balanced foreign policy and worked to develop its economy, especially its hydrocarbon industry. The post-Soviet era has also been characterized by increased involvement with many international organizations, including the United Nations, the Euro-Atlantic Partnership Council, the Commonwealth of Independent States(CIS), and the Shanghai Cooperation Organization. Kazakhstan is also one of six post-Soviet states who have implemented an Individual Partnership Action Plan with NATO(Horvat et al., 2012)

Kazakhstan is ethnically and culturally diverse, in part due to mass deportations of many ethnic groups to the country during Joseph Stalin's rule. Kazakhstan has a population of 16.6 million, with 131 ethnicities, including Kazakh, Russian, Ukrainian, German, Uzbek, Tatar, Uyghur and Korean. Around 63% of the population is Kazakhs. Kazakhstan allows freedom of religion, and many different beliefs are represented in the country. It is a very tolerant country to religions like Islam, Christianity, Judaism and Buddhism. Islam is the religion of about 70.2% while Christianity is practiced by 26.2% of the population. The Kazakh language is the state language, while Russian is also officially used as an equal language to Kazakh in Kazakhstan's public institutions. Under the leadership of Nursultan Nazarbayev, the Republic of Kazakhstan has enacted some degrees of multiculturalism in order to retain and attract talents from diverse ethnic groups among its citizenry, and even from nations that are developing ties of cooperation with the country, in order to coordinate human resources onto the state-guided path of global market economic participation. This principle of the Kazakh leadership has earned it the name "Singapore of the Steppes", referring to the authoritarian capitalist guiding principle initiated by Lee Kuan Yew(Aitken, 2009).

Kazakhstan is divided into 14 provinces. The provinces are subdivided into districts. Almaty and Astana cities have the status of State importance and do not relate to any province. Baikonur city has a special status because it is currently being leased to Russia with Baikonur cosmodrome until 2050. Each province is headed by an Akim (provincial governor) appointed by the president. Municipal Akims are appointed by province Akims. The Government of Kazakhstan transferred its capital from Almaty to Astana on December 10, 1997.

Source : Wikipedia(2014)

<Figure 1> Kazakhstan's 14 provinces

In the past, Kazakhstan was known for its scientific excellence and substantial scientific capacity. With 41,000 research scientists at its peak in 1990, Kazakhstan used to be an important centre of research and development in the Soviet Union. However, only 16,578 R&D personnel continued to work in the sector by 2003, corresponding to a 60% fall compared to 1990. According to the joint OECD-World Bank Report on"Higher Education in Kazakhstan", the reason for this decrease was multiple factors as follows. The most talented and entrepreneurial staff left the sector and went into private business, which offered better opportunities and higher salaries. Also significant number of researchers left the country to pursue careers abroad. For instance, the termination of space research and military orders combined with older scientists eventually reaching retirement age and not being replaced by a younger generation(World Bank, 2007).

Despite continuous legal and institutional reforms, indicators of innovative activity show limited progress. R&D intensity remains very low, with intramural expenditure on R&D standing at 0.16% of GDP in 2010. Such a low level of R&D expenditure means a significant barrier to upgrading the quality of research capacity. Technology transfer from overseas through the exploitation of patents and licenses is considered a key part of Kazakhstan's catch-up strategy due to underdeveloped domestic knowledge capabilities.

2.1.1 Economic Growth

Buoyed by high world crude oil prices, GDP growth figures were comprised between 8.9% and 13.5% from 2000 to 2007 before decreasing to 1-3% in 2008 and 2009, and then rising again from 2010. Other major exports of Kazakhstan include wheat, textiles, and livestock. Kazakhstan predicted that it would become a leading exporter of uranium by 2010, which has indeed come true. The inflation figures are very high, 2005(7.6%), 2006(8.6%), 2007(18.8%), 2008(9.5%), 2009(6.2%).

<Table 1> The economic growth of Kazakhstan

	2008	2009	2010	2011	2012	2013
GNI, Capita, PPP ($)	15,460	15,990	16,710	17,710	18,860	20,570
Population	15,674,000	16,092,701	16,321,581	16,556,600	16,791,425	17,037,508
GDP Growth (%)	3	1	7	8	5	6
Life expectancy	67	68	68	69	70	-

Source : World Bank(2014)

Since 2002, Kazakhstan has sought to manage strong inflows of foreign currency without sparking inflation. Inflation has not been under strict control, however, registering 6.6% in 2002, 6.8% in 2003, and 6.4% in 2004.

In 2000, Kazakhstan became the first former Soviet republic to repay all of its debt to the International Monetary Fund (IMF), 7 years ahead of schedule. In March 2002, the U.S. Department of Commerce granted Kazakhstan market economy status under U.S. trade law. This change in status recognized substantive market economy reforms in the areas of currency convertibility, wage rate determination, openness to foreign investment, and government control over the means of production and allocation of resources.

In September 2002, Kazakhstan became the first country in the CIS to receive an investment grade credit rating from a major international credit rating agency. As of late December 2003, Kazakhstan's gross foreign debt was about $22.9 billion. Total governmental debt was $4.2 billion, 14% of GDP. There has been a noticeable reduction in the ratio of debt to GDP. The ratio of total governmental debt to GDP in 2000 was 21.7%; in 2001, it was 17.5%, and in 2002, it was 15.4%.

2.1.2 Leading Economic Sector

Production of crude oil and natural gas condensate from the oil and gas basins of Kazakhstan amounted to 51.2 million tons in 2003, up 8.6% from the production in 2002. Kazakhstan raised oil and gas condensate exports to 44.3 million tons in 2003, 13% higher than in 2002. Gas production in Kazakhstan in 2003 amounted to 13.9 billion cubic meters (491 billion cu. ft), up 22.7% compared to 2002, including natural gas production of 7.3 billion cubic meters (258 billion cu. ft).

Kazakhstan holds about 4 billion tons of proven recoverable oil reserves and 2,000 cubic kilometers (480 cu mi) of gas. According to industry analysts, expansion of oil production and the development of new fields will enable the country to produce as much as 3 million barrels (480,000 m3) per day by 2015, and Kazakhstan would be among the top 10 oil-producing nations in the world.

The banking system of Kazakhstan is developing rapidly and the system's capitalization now exceeds $1 billion. The National Bank has introduced deposit insurance in its campaign to strengthen the banking sector. Due to troubling and non-performing bad assets the bank sector yet is at risk to lose stability. Several major foreign banks have branches in Kazakhstan, including RBS, Citibank, and HSBC. Kookmin and UniCredit have both recently entered the Kazakhstan's financial services market through acquisitions and stake-building.

Despite the strength of Kazakhstan's economy for most of the first decade of the 21st century, the global financial crisis of 2008–2009 has exposed some central weaknesses in the country's economy. The year on year growth of Kazakhstan's GDP dropped 19.81% in 2008. Four of the major banks were rescued by the government at the end of 2008 and real estate prices have sharply dropped.

Over the past decade, extractive industries have grown rapidly. They represented 19.5% of GDP in 2010, against 11.4% in 2001 and accounted for 61.3% of industrial production, up from 37.3% in 2001. The main driver of this increase was the expansion of the extraction of crude oil and natural gas and associated services, which rose from 26.1% to 51.9% of industrial production over this period. Price increases have contributed to boost the importance of the extractive industries. According to the 2010–2011 World Economic Forum in Global Competitiveness Report Kazakhstan is ranked 72nd in the world in economic competitiveness.

2.1.3 Dependence on The Foreign Countries

FDI inflows have been largely directed to resource-based activities in 2000-2010, including geological exploration and research (33% of gross FDI), the oil and gas industry (28%), metallurgy (5.5%), trade and financial activity (5%). Developed countries are the main sources of FDI inflows, including the Netherlands (23.2% of gross FDI), the US (15.7%), the UK (7.8%), France (6.3%), Virgin Islands (5.6%) and Italy (4.4%). Kazakhstan has demonstrated strong performance in attracting FDI, particularly in the extractive industry. However, this pattern of specialization does not support existing plans to diversify the economy and promote the transfer of knowledge.

Gross domestic expenditure on R&D has not grown as fast as GDP in recent years. It declined in absolute terms in 2010, as a result of the delayed impact of the financial crisis, with the ratio to GDP falling to 0.16%, from an average of 0.22% in the three preceding years. By contrast, this figure is much higher in advanced countries. In the USA, spending on R&D as a share of GDP is 2.6%, with comparator figures being 2.4% in Germany, 3.0% in Japan, and 3.7% in Sweden.

The economic crisis and accompanying decline in funding from the state budget during the 1990s led to a sharp fall in R&D, as well as in scientific and technical employment. By 1996, the number of R&D personnel had decreased to around 20,000, from around 50,000 in 1990; by 2010, the number of R&D personnel stood at 17,000.

Despite legal and institutional reforms, indicators of innovative activity show limited progress. R&D intensity remains very low, with intramural expenditure on R&D standing at 0.16% of GDP in 2010. Gross expenditure on research and development (GERD) per capita in purchasing power parity (PPP) terms in Kazakhstan (US$22.9) is lower than in Russia (US$165.4) and Belarus (US$105.3). Such a low level of expenditure constitutes a significant barrier to upgrading the quality of research equipment, and compensating for previous under-investment. This reality contrasts with the target expressed in the SPAIID which envisages an increase in state expenditures on science and innovation to 1% by 2015(United Nations, 2012)

Technology transfer from overseas through the exploitation of patents and licenses is considered a key part of Kazakhstan's catch-up strategy due to underdeveloped domestic knowledge capabilities.

2.1.4 'Bolashak' Scholarship : Human Resource Development

The human resource development is very precious factor to the economic development in the developing countries to overcome the dependence on the foreign countries. The Kazakhstan government runs a highly successful 'Bolashak' scholarship scheme, awarded annually to around 5,000 Kazakhstan citizen applicants. The word "Bolashak" is translated into English as 'future'. The scholarship funds their education and all living expenses abroad as well as transportation expenses once in a year from home to a university and back home. The choice of an institution of higher education and research as well as any corporation that provides both undergraduate and postgraduate education has no restrictions, if an applicant complies with the eligibility requirements of an institution abroad. Awarded students can study at a number of institutions including the University of Edinburgh, University of Cambridge, Harvard University, University of Toronto, University of Waterloo, University of Oxford, Massachusetts Institute of Technology, University of Sydney, Technical University Munich, University of Tokyo, and others. The terms of the program include mandatory return to Kazakhstan for at least five years of consecutive employment. Currently this program apply to just graduate in aborad program and locally this program have to direct for Nazarbayev University(NU), undergraduate education.

2.2 Nazarbayev University

2.2.1 Main Directions of Nazarbayev University

Nazarbayev University, created on the initiative of the President of the Republic of Kazakhstan Nursultan Nazarbayev, aims to become the first research and world-class university in Kazakhstan. The activities of the University are associated with the implementation of the main priorities of the country, including the development of advanced research capacity, innovation in technology and industry, and the transition to a system of education that meets the demands of a changing and globally integrated economy.

The academic process at the University is based on international educational standards, which contributes to the advancement of the education system of the Republic of Kazakhstan and takes it to the international level. This is the first university in Kazakhstan that is committed to working according to international academic standards and guided by the principles of autonomy and academic freedom. The University's autonomous status was granted by the Law of the Republic of Kazakhstan of 19 January, 2011, "On the status of "Nazarbayev University", "Nazarbayev Intellectual Schools" and "Nazarbayev Fund".

The Main Directions of Nazarbayev University Development Strategy for 2012-2020 were approved on June 16, 2011 at the first meeting of the Supreme Board of Trustees. The University is creating graduates prepared according to the highest international standards in order to contribute to research, education, and the national economy.

The Strategy of Nazarbayev University defines the main strategic goals and directions for the development of the University toward the goal of becoming a leading model of higher education which will establish a benchmark for all higher education institutions of the country. The Strategy sets out the mission, vision, strategic goals, stages of development and the results of the joint efforts by administrative staff, faculty, students, and researchers of the University for 2013-2020.

The Vision is to give Kazakhstan and the world the scientists, academics, managers and entrepreneurs they need to prosper and develop. Mission is to be a model for higher education reform and modern research in Kazakhstan and to contribute to the establishment of Astana as an international innovation and knowledge hub. Strategic goals are as follows.

Goal I is the Educational reform leadership, to ensure that the lessons of Nazarbayev University's experience are transferred and understood by other universities, schools, and research centers

Goal II is the Academic excellence to achieve Nazarbayev University's mission by developing and maintaining academic excellence

Goal III is the Research excellence to develop a program of world-class research by partnering with the world's best researchers and research institutions.

Goal IV is the Creating a model for healthcare services to establish a healthcare system that will provide a model for healthcare services throughout Kazakhstan

Goal V is the Innovation and translating research into production to become Kazakhstan's main driver of innovation, leading the way for Astana to become a regional hub of innovation

NU has three centers such as Nazarbayev University Research and Innovation System(NURIS, former Energy Research Center), the Center for Life Sciences, the Centre for Educational Policy. Specific contents are as follows.

① The energy sector is the main driving force of the Kazakhstan economy. Nazarbayev University Research and Innovation System(NURIS) in NU will play an important role in the realization of the above program, and will stimulate research activities in the fields of the NURIS competences. The center will be a research base for the departments in the School of Engineering and the School of Science and Technology.

② The Center for Life Sciences (CLS) mission is to pursue fundamental and acquire new knowledge about the nature and behavior of living systems and the application of that knowledge to extend healthy life and to reduce the burdens of illness and disabilities. CLS strives to transform medicine and healthcare in Kazakhstan through innovative scientific research, rapid translation of breakthrough discoveries, educating future clinical and scientific leaders, advocating and practicing evidence-based, personalized, and predictive medicine to improve health and quality of life.

③ The Centre for Educational Policy(CEP) created on the basis of NU, will become a leading centre ('think-tank') for research on the issues and realization of the policies in the sphere of educational services for the Eurasian countries. The CEP is to promote development of NU as an unique educational model based on the international principles of educational policy.

NU plans to establish an R&D Center of Samruk-Kazyna (hereinafter R&D Center) which is engine for the innovation in the IIC(Innovative Intellectual Cluster) and Kazakhstan. New R&D Center has aim the creation and development of engineering competence in the field of new technologies in first. But later the concept of R&D Center is enlarge to constitute absorption and transfer of new technologies in economics and industries in the country. It will contribute an active participation in economy modernization in the country.

Samruk-Kazyna, officially known as the National Welfare Fund "Samruk-Kazyna", s a joint stock company in Kazakhstan which owns, either in whole or in part, many important companies in the country, including the national rail and the state oil and gas company KazMunayGas, the state uranium company Kazatomprom, Air Astana, and numerous financial groups. The state is the sole shareholder of the fund. It was created in October 2008 with the merger of two funds, "Samruk" and "Kazyna", by decree of the president of Kazakhstan, Nursultan Nazarbayev. Samruk-Kazyna controls $78 billion in assets, or nearly 56% of GDP. Kazakhstan's government expects assets held by its sovereign wealth fund to reach $100 billion by 2015

Samruk-Kazyna is the very important role to support the new Center(R&D Center of Samruk-Kazyna) and their companies ask to R&D Center to solve their problems. R&D Center will be a linking pin and problem solver role between companies and Nazarbayev University. An innovative intellectual cluster is planned at NU(2012~2015) and the R&D Center is the one of the core components for the cluster.

It has been asked to undertake an in-depth study and to provide NU research-based recommendations on detailed strategies after benchmarking relevant the existing international engineering and applied research organizations.

It is our understanding that this research is focused on the effective R&D Center creation, development strategy and the operation for Nazarbayev University and Samruk-Kazina, regarding R&D functions for the industries in Kazakhstan and supply of modern engineers. The research objective is to create and develop the R&D Center on the basis of the "Nazarbayev University and Samruk-Kazina".

This study has managerial implication as follows. R&D Center is to promote industrial innovations and national economic development by way of matching industrial and corporate needs and university research seeds which involve a variety of organizational forms, including research project, research lab, and research center in R&D Center. Aiming at advancing industrial technology innovations, the activities of matching seeds and needs include not only searching, identifying, and targeting of applied research needs of business enterprises and industry level, but also marketing, searching, and allying with academic and corporate researchers domestically as well as internationally in order to generate joint research activities. This results for the basic structure of R&D Center has a form in which the applied research functions (such as research project, labs, and affiliated centers), technology Platform, and technology transfer role will closely interact and collaborate one another.

2.2.2 The Role of Leadership to University

President Nazarbayev asked the NU and Samruk-Kazyna to progress for the national competitiveness as follows(Zhakupov, 2012).

"Around Nazarbayev University must be established intellectual innovative cluster that will enable transfer and promotion of new technologies". This is the message from the President of the Republic of Kazakhstan, N.A. Nazarbayev to the people of Kazakhstan(January 27, 2012)".

"I assign to «Samruk-Kazyna» jointly with Nazarbayev University to work out the creation R&D Center, working on orders of industrial enterprises." This is another lecture content in the President of the Republic of Kazakhstan, N.A. Nazarbayev, at Nazarbayev University, September 5, 2012.

Ⅲ. Role of Commercialization and Applied R&D Center

Key success factors of international applied centers are several factors as follows(McGowen, 2012). University factors are IP policy, facilities, funding. Industry factors are the fit with center, center membership, outsourcing R&D power, and long-term research goals. And center factors are visibility/prestige, strategic planning, students, research area, caters to stakeholders, mission, funding, leadership, faculty, and technology transfer. It will review the I/UCRC and the early stage of KIST, Korea.

3.1 I/UCRC

The I/UCRC(Industry/University Cooperative Research Center) Program in US, is designed to Industry to provide the means to leverage research and development (R&D) investments with multi-university centers renown for their innovative research capabilities. And I/UCRC is designed to University to provide opportunities to partner with other leading institutions to conduct industrially relevant research, receive seed funding and recognition as a National Science Foundation (NSF) research center with access to professional resources and guidance aimed towards enhancing global competitiveness(McGowen, 2012). This kind of mention and interest in NU is the key factor to the development of university and commercialization center for innovative custer.

3.1.1 The Basic Principles and Provisions of The Program

Program funding timeline is eligible for 5 years and an additional 5 years. I/UCRCs program develops long-term partnerships among industry, academe, and government.… and a plan to work toward self-sufficiency from NSF. NSF's investment in the I/UCRCs is intended to seed partnered approaches to new or emerging research areas, not to sustain the Centers indefinitely. The Foundation intends for I/UCRCs to become fully supported by university, industry, state, and/or other non-NSF sponsors(National Science Foundation, 2014)

After ten years, the Centers are expected to be fully supported by industrial, other Federal agency, and state and local government partners. Over 80% of the centers established under the I/UCRC program continue on as successful centers without NSF funding. That means the centers trying to make a sustainability for the future growth.

3.1.2 Rules and Amount of Funding

Each I/UCRC is expected to maintain at least the minimum amount of industrial support through membership fees derived from at least the minimum number of members outlined in the current solicitation. Each Center is also required to develop a plan to work toward self-sufficiency from NSF. Over 80 percent of the centers established under the I/UCRC program continue on as successful centers without NSF funding(Gray and Walters, 1998).

NSF supports these Centers through a cooperative leveraging mechanism. NSF's financial contribution to the Centers is relatively small—about $15 million in FY 2011. Funding from sources other than NSF is much larger, totaling more than $68 million in FY 2000. Currently, the Centers have well over 1,000 memberships. Of these, about 85 percent are industrial firms, with the remaining 15 percent including State governments, National Laboratories, and other Federal agencies. Research at each center is formulated, selected and executed in close partnership with the center's membership. Center research is supported via a partnership between the center's universities and members through which membership fees are pooled and assessed just 10 percent indirect by the performing universities. Individual industry members are able to highly leverage their membership investment while universities build trusted relationships across entire industry sectors yielding return on investment across their mission areas.

For instance, CIMS(Center for Innovation Management Studies) supported from NSF, represents a synergistic network that is greater than the sum of its parts. This network includes industry-leading companies, world-class researchers and scholars, and the nation’s top universities for science, engineering, entrepreneurship, and business. When the allied forces of CIMS join together, the product is a powerful web of connections and resources supporting a tremendous amount of knowledge. As part of the CIMS network, member companies share best practices, researchers collaborate on ideas, data and projects, the status of innovation management is elevated among potential funders and subject matter experts. Without the sustaining support of its member companies, CIMS would be unable to carry on its mission. The arrangement is mutually beneficial, membership in CIMS comes with many valuable benefits, including the access to academic and industry fellows and their research/contacts, member networking, industry-segment exclusivity, unique assessments and tools, opportunities to participate in member sponsored and custom research, custom training, classes and workshops, a subscription to the CIMS newsletter and access to research publications(NC State University Center for Innovation Management Studies, 2014)

3.1.3 History of The Realization by Stages

An I/UCRC often begins with a small collaborative planning grant to a group of university faculty members able to demonstrate the scientific, organizational, and entrepreneurial skills necessary to form a team and initiate and run a successful Center. If the prospective Center can obtain commitments of strong support from industry and the affiliated university or universities, it may submit a proposal to NSF describing the progress that has been made and documenting the team's potential to operate successfully as an I/UCRC. Two or more universities are required to propose a multi-university Center. Following successful merit review of the proposal, NSF may make an initial five-year I/UCRC award for Phase I operation of between $80,000 and $90,000 annually to the lead site of a multi-university Center and $60,000 annually to each Center site. When the initial five year grant expires, NSF funding may be extended for funding for two subsequent five year periods for Phase 2 and Phase 3 operation at a reduced level.

Currently there are approximately 60 I/UCRCs, all administered by the Industrial Innovation and Partnerships (IIP) Division of NSF's Engineering Directorate. More than 900 faculty members, along with some 1,500 graduate students and 300 undergraduate students, carry out the research at these Centers annually, which encompass almost the entire spectrum of current technological fields. A primary purpose of the I/UCRC Program is providing high-quality interdisciplinary education. The Centers have produced several thousand M.S. and Ph.D. graduates, who can be found throughout American industry and academe.

3.1.4 The Factors that Determined The Success or Failure of The Program

Across the program, these Centers have established an extraordinarily effective partnership with industry. This partnership takes full advantage of the strength of each participant. University faculty contribute their skills in research and their understanding of the knowledge base; industrial researchers contribute their knowledge of both the technical needs of industry and the challenges associated with competing successfully in the marketplace. The partnership is formalized in each Center's Industrial Advisory Board (IAB), which advises the Center's management on all aspects of the Center, from research project selection and evaluation to strategic planning. It is important to note that all IAB members have common ownership of the entire I/UCRC research portfolio; however, individual firms can provide additional support for specific "enhancement" projects under separate arrangements with the respective university.

The partnership is given even greater strength by the direct involvement of industry representatives in research projects. Each project in the Center has a principal researcher (typically the project's research professor) and in many cases also has one or more mentors from industry (who may be a IAB representatives or engineers or scientists assigned from an IAB member company). The principal researcher maintains close oversight of the progress of the research by the student(s) and briefs the industrial mentor on a regular basis. The mentor can, and often does, have direct input into the direction of the research.

This extensive industrial involvement in research planning and review leads to direct technology transfer, bridging the gap that traditionally has kept U.S. industry from capitalizing fully and quickly on the fruits of research at American universities. The close involvement of industry in the Centers also eliminates the perennial problem of "Not Invented Here"; in the cooperative research model, all Center developed research products are owned by all the members.

The participation of NSF, although small financially, nevertheless sets the tone for the I/UCRCs. Strong program management ensures that each of the Centers continues to follow the I/UCRC model and this helps each to build strong and successful centers. With such extensive industrial support and participation, NSF's role is crucial in influencing industry to take a more long-term view of its needs, with appropriate attention to research quality. This ensures that the fundamental research conducted in the Centers continues to add to the knowledge base that will be vital for solving the problems and meeting the needs of the future.

In addition to the basic I/UCRC award, Centers and Center researchers can compete for other NSF support for research and education projects. At any point—even at the end of its life cycle—NSF may provide funding to the Center under special arrangements involving joint participation by other NSF program offices. NSF supplemental support may include collateral programs such as a Cooperative Opportunity for Research Between I/UCRCs (CORBI) project, whereby two or more Centers and their industrial members engage in a cooperative research project of interest to all parties (with NSF and industry sharing costs). Through programs such as GOALI (Grant Opportunities for Academic Liaison with Industry), fellowships are offered to Center faculty, whereby the faculty member can spend time in a corporate research lab or factory, again with NSF sharing the cost. Other supplements to I/UCRC awards may be made in the form of joint sponsorship of projects with other federal agencies, Research Experiences for Undergraduates, Teachers and Veterans and other educational activities, workshops, and other purposes consistent with the goals of the Program.

NSF also helps to ensure high standards among the I/UCRCs through a mechanism that is unique to this program: Independent professional Evaluators are engaged to study the industry university interaction onsite, both qualitatively and quantitatively, to determine (1) the quality and impact of Center research, (2) the satisfaction level of faculty who participate in the program, and (3) the degree of satisfaction of industrial participants. A historical profile of each Center is maintained; and annual assessments are conducted of Center processes and results, finances, and structural issues. One indication of the high quality of I/UCRC research is that faculty publish their work in the most prestigious journals. I/UCRC faculty as well as students regularly garner awards from their respective professional societies for their innovative research.

3.1.5 The Findings for The R&D Center

There are very important considerations to establish the new R&D Center in Korea as follows; Initial government role of grant, industry membership, center capacity(faculty and graduate students), board’s role for partnership, leadership of professor, cooperative research model, long-term view of industry needs.

3.2 Korean Case : KIST

In the spring of 1965, Korean President Park, Chung-hee and U.S. President Lyndon Johnson had met to discuss the challenges and opportunities for education and economic development in Korea. There the idea of U.S. support for establishing an industrial research laboratory was suggested, leading to the establishment of KIST(Korea Institute of Science and Technology) in 1966. The creation of KIST, then, was a product of science diplomacy, a product of the strong alliance between the United States and the Republic of Korea, and a product of the shared belief that science is essential to the progress of any nation(http://eng.kist.re.kr).

Founded in 1966, KIST is a premier multi-disciplinary research institute in Korea. KIST's goal is to research, develop, and transfer creative, original technologies that are necessary to advance our nation’s science and technology base. Specifically, KIST focus on fusion technologies that will power Korea’s economic growth, especially in the areas of the environment, energy, health, security, and materials(KIST, 2007).

The establishment of KIST in 1966 created a national interest in science and technology. It was also followed by the foundation of other institutes and organization for the development of science and technology. The construction of research institutes boomed and some journalists and scientists started raising issues over the administration for science and technology, human resource management, and research environment(Boffey, 1970).

In 1971, KIST's first director, Dr. Choi, Hyung Sup was appointed the Minister of Science and Technology in recognition of his distinguished service at KIST. He served for 7 years and 7 months, which was the longest term for any minister in Korean history. He formulated the first-ever systematic policies for the national science and technology in the 1970s that included the construction of Daedeok Science Park. He had experience as a director at both national and GRI. The balanced experience helped him to have a firm stance on the strengths of GRIs. Therefore, his leadership was the most active in supporting and extending the mandate for GRIs. During the his ledership, he promoted the establishment of a research complex and the switchover of AERI into a non-profit private organization, KAERI(Moon, 2011).

<Table 2> Overview of KIST

	Details
Mission	Focusing on frontier and global-agenda research by concentrating on large-scale, long-term, and interdisciplinary R&D projects
Major development item	1970s : optical fiber for optical communication 1980s : drug synthesis technology, high-strength aramid fiber 1990s : an artificial heart-lung machine and operative suture, the ultra-precision position-control linear motor 2000s : plasma surface modification technology, hydrogen fuel cells, syringeless anticancer drug, Spin FET device technology, etc…
History	1966 : KIST was founded, and Dr. Hyung Sup Choi was appointed as the first President of KIST. 1989 : KIST was re-established as an independent entity from KAIST to be the leading R&D institute for the development of creative original technologies. 1996 : KIST Europe was established in Saarbrucken, Germany, to play an important role as the hub for the exchange of technology and joint research with Germany, EU, and other Eastern European countries in the field of basic and applied sciences. 2003 : KIST Gangneung was established in Gangneung, Gangwon-do, to implement the national policy of 'Innovating Science and Technology in the Region for a Balanced National Development.' 2008 : KIST Jeonbuk was established in Wan-ju, Jeollabuk-do, to lead the development of the composite materials industry. The construction will be completed in August 2012.

Source: KIST(2007)

3.3 Findings and Implication for The R&D Center

3.3.1 Suggested Concept of R&D Center

Such evolutions of GRIs and Daedeok Innopolis by the Korean government offer diverse lessons for Kazakhstan's eager to emulate the Korean experience. The following points are worth noting (Yim and Kim, 2005; Kim, 1997).

First, Korea's experience indicates that in the early stage of industrialization, GRIs can be a most powerful tool for both technological development and human resource training. For example, KIST covered a broad spectrum of industrial R&D and helped find solutions for simple and practical problems arising from industries in the absence of research in industries and universities. KIST also played an important role of training center for researchers who would be needed at corporate R&D centers in the following stages of economic development.

Second, it is also important for the governments to offer various program for promoting linkages among industry, academia and GRIs. This program include national R&D program sponsored by the government that can act as a seed for cooperative researches among innovative actors in technology development.

Third, as industrialization progresses, it becomes necessary to move its paradigm from a GRIs-centered to an industry-oriented purpose. Although GRIs are useful in the early stage of industrialization, it tends to generate inefficient bureaucracy at later stages. The Korean experience indicates that though GRIs centered S&T policies were very effective early on, but later, in the 1980s, GRIs led to serious inefficiencies through research duplication and their bureaucratic behavior.

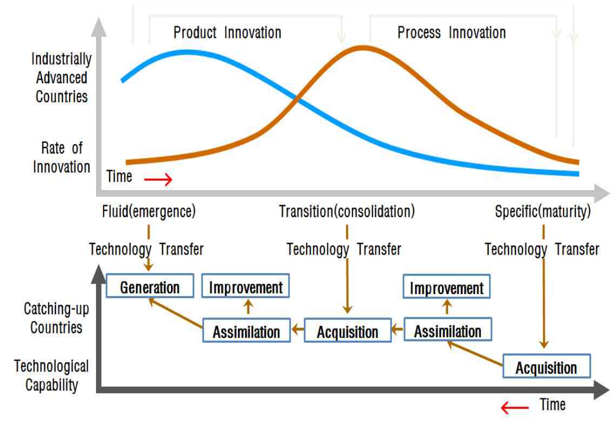
Fourth, it is important to recognize that there is no one best way for GRIs at all times. That is, the configuration of GRIs regarding their strategy, structure, and funding and management systems should fit into the national S&T and social environment. The Korean GRIs case shows that a centralized structure with an efficiency-oriented strategy by the central government can be very effective in an early stage. But as industrialization progresses, the feature worked as a bottleneck, requiring empowerment to the individual institute level and competitive funding system.

Fifth, there is a need for constant evaluation and reforms for GRIs. They tend to become bureaucratic and inactive organizations over time. Therefore the evaluation system and activity itself is very important because it provides the momentum to think over their performance and future direction at both GRIs' and individual researchers' level. Moderate reforms can also expedite active learning by constructing creative crisis. Koreangovernment had introduced performance-based system, such as, annual salary and Project based performance system.

3.3.2 Dual Technology Development Strategy

We suggest two kind of technology development strategy, the first one is catch-up strategy based on the national innovation vision and the other one is technology transfer strategy, localization from the advanced country.

In the 1960s and 1970s when the local technological base was very primitive, Korea first acquired and assimilated mature technologies to undertake duplicative imitation of existing foreign products with their skilled but cheap labour force. Then the accumulation of technological capability through learning by doing, together with the quality upgrading of the educational system, enabled these countries to undertake creative imitation in the face of rising labour costs and increasing competition from the second tier NIEs. Singapore also underwent a similar process, producing mature foreign products at a lower cost under foreign direct investment. In contrast, other countries such as coastal China and some of the East European economies may not evolve from the duplicative imitation to the creative imitation and to the innovation stages, as they have a longer history of technological accumulation and have already reached the duplicative imitation stage before they opened their economies. Some of the sectors in these economies may have enough capability to enter the intermediate technology stage at the outset. If they evolve from the mature technology stage, the speed of evolution to the intermediate technology stage is expected to be faster than that of others(Kim, 2003) as <Figure 2>.



Source: Kim(1997), p.89.

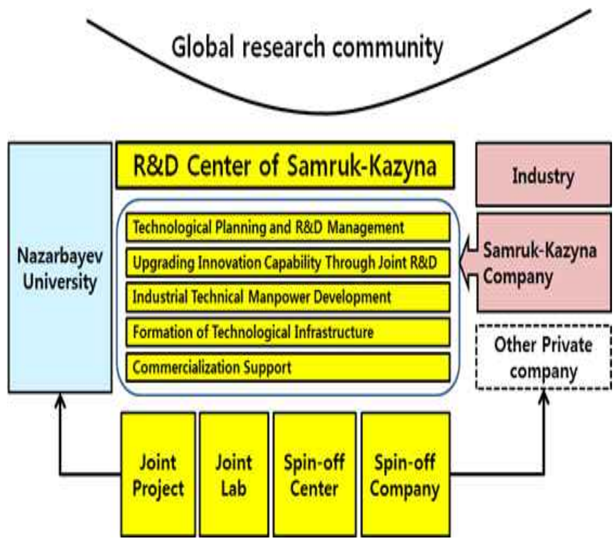
<Figure 2> Technology Development Process: A Model for a Developing Country with a Global Perspective

According to the 'Concept of creating intellectual and innovative cluster of Nazarbayev University for 2012-2015, the Engineering Center will play an important role in Catch-up Technology Development. The objectives of the Engineering Center should be development of engineering skills in areas such as machine building and instrument engineering, materials science, chemical engineering, etc. And the center's role is the absorption and transfer of new knowledge and technologies from advance technological countries including Korea. It involve from professor, researchers and students of the University of Nazarbayev to the solution of practical problems of the industry. It will be the generation of new high-tech spin-off companies.

Ⅳ. The Policy for The Commercialization of Technology

4.1 Platform of Challenging Technology Development

Mission of R&D Center is to promote industrial innovations and national economic development by way of matching industrial and corporate needs and university's research seeds which involve a variety of organizational forms, including research project, research lab, and research center in R&D Center as <Figure 3>.



<Figure 3> Mission and roles of R&D Center

R&D Center's roles and main activities are as follows. Fostering R&D capabilities and systems in corporations. Educating and training R&D personnel to advance R&D

capabilities of industries. Providing technological support and solutions for industries via successful R&D outputs. Providing consulting for government for formulating R&D policy and technology policy. Serving as a bridge of international technological cooperation. Serving as a center of diffusing foreign-imported technologies for domestic corporations. Serving as a incubator of research activities, such as joint research projects, research labs, and spin-off centers, in order to expand the scope of new research fields and explore into frontier researches. Educating and providing on-the-job training to the coordinator who will perform matching between university seeds and industrial needs. Forming close collaboration with Engineering Department of the University in order to form joint research projects and develop an effective education program for graduate students

4.2 Operational and Business Model

The operational and business model of the R&D Center has to be composed by the mission and service of the Center as we proposed before. The mission, in other aspect, the functions of the Center are said to be (1) coordination, (2) applied research, (3) education and training. And the five services of the Center are (a) technological planning and R&D management, (b) upgrading innovation capability through joint R&D, (c) industrial technical manpower development, (d) formation of technological infrastructure, (e) commercialization support(<Table 3>). Each service of the Center can have more than one business and revenue model respectively.

<Table 3> Service and Business Model of the R&D Center

Service	Business (Revenue) Model
1) Technological Planning and R&D Management	- Consulting (fee) - R&D Management Service (Cost Center)
2) Upgrading Innovation Capability Through Joint R&D	- Applied R&D outcome (patent, royalty) - Performance / Distribution
3) Industrial Technical Manpower Development	- Training Programs (fee) - Human resource development
4) Formation of Technological Infrastructure	- Common use of basic and advanced technological facilities (cost saving) - Certification issue (fee)
5) Commercialization Support	- Commercialization success - Transfer and Adaptation - Spin-off

Ⅴ. Conclusion and implication

Kazakhstan’s President Nazarbayev tried and approved the new R&D Center for the intellectual innovation cluster (IIC) in the Republic of Kazakhstan. The goal is to form the state’s new economic development infrastructure through the applied R&D Center, with the focus on achieving the stable development of Kazakhstan by means of collaboration between Nazarbayev University and Samruk-Kazyna, industry(Zhakupov, 2012).

The missions of the R&D Center are as follows: (1) to promote industry innovation through collaboration with foreign countries; (2) to enhance the technological competitiveness of the Samruk-Kazyna companies; and (3) to develop Kazakhstan’s national economy through knowledge transfer and diffusion. These missions will be accomplished by means of matching industrial and corporate needs with university research seeds, which involves various organizational forms including research projects, research labs, research centers, joint labs, spin-off centers and spin-off companies in the R&D Center.

Regarding the fostering of the R&D capabilities and systems of the Samruk-Kazyna companies in Kazakhstan, the details of the five services provided by the R&D Center include the mentioned five activities and achievements:

The R&D Center should have a functional structure that provides the technology platform and facilitates applied research and technology diffusion. These functions are carried out by various organizations such as research project teams, labs, and affiliated institutes, which will interact and collaborate closely with each other.

Many economists consider that the role of government in economic, social and political issues has been effective and brought about an economic miracle. One of the main Korean policies was science and technology infrastructure development. The KIST is a good example for the R&D Center in Kazakhstan in this respect. KIST was established in 1966 under the auspices of the Korean and US governments. The mission of KIST was to assume a central role as the first comprehensive research center for the promotion of the nation’s economic growth and the modernization of engineering fields. KIST was an integrated technical center designed to support the industry's technological learning. As Korea's first multidisciplinary research center, KIST covered a broad spectrum of activities in applied research ranging from project feasibility studies to R&D for new products and processes. KIST spent a large proportion of the nation's total R&D expenditure in its early years. To keep pace with increasing sophistication and diversity, the government established several GRIs as spin-offs from KIST. Each was designed to develop in-depth capabilities in areas of high industrial priority such as shipbuilding, electronics, telecommunications, energy, machinery, and chemicals.

The R&D Center’s organization includes these five areas of industry, and can be broadly categorized into three development stages during next the fifteen years. The purpose of the first stage is to develop industrial problem-solving capability. The second stage will involve catching up with the industrialized economies and producing creative imitations of imported technologies. The third stage will consist in securing advanced knowledge creation capability. Accordingly, the R&D Center's organization should be aligned with this development strategy.

The business model will consist of Smaruk-Kazyna's support, R&D project revenue, general companies' membership, training and education, technology planning and consulting, laboratory analysis and testing, and technology transfer revenue and so on.

We expect that the R&D Center will serve as an integrated technical center to support Kazakhstan industry's technological learning and capacity, like the Korean precious experience, in the near future.

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기술사업화를 위한 연구개발센터의 역할 : 개발도상국의 사례 및 시사점*

김종진(한국방송통신대 경영학과 교수)**
최종인(한밭대학교 경영회계학과 교수)***

국 문 요 약

기술사업화를 위한 연구개발 센터 조직은 크게 세 가지 단계로 구분된다. 첫째는 산업계의 문제를 해결하는 역량을 개발하는 것이며, 둘째는 선진국을 따라잡기 위해 수입된 기술을 창조적 모방을 통해 개발하는 것이다. 셋째 단계는 선진화된 지식창조 역량을 습득하는 것이다. 따라서 센터의 조직은 대학과 정부의 발전전략과 잘 연계되어야 한다. 본 연구는 개발도상국에게 연구센터의 개발을 통해 경제개발과 관련된 관리적 시사점을 제공하고 있다. 사례연구로 든 카자흐스탄의 경우 산업계 문제해결 단계인 첫 번째 단계에서 센터는 기술과 인적자원 측면에서 인프라구조를 구축한다. 두 번째 단계는 지식 역량을 구축하는 것으로 중앙아시아에서 주요 산업 연구개발 허브로서의 역할을 하는 것이다. 셋째 단계에서는 센터가 선진화된 지식을 구축하여 세계수준의 지식센터를 만드는 것이다. 이같은 점에서 연구개발과 사업화 센터의 진화는 센터의 서비스 형태에 따라 다르게 나타나야 할 것이다.

핵심주제어: 기술사업화, 연구개발센터, 해외직접투자, 한국의 경험(KSP), 한국과학기술연구원(KIST). 나자르바에프 대학, 카자흐스탄.

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** 제1저자, 한국방송통신대 경영학과 교수, jjkim@knou.ac.kr
*** 교신저자, 한밭대학교 경영회계학과 교수, 창업대학원 사업단장, jongchoi@hanbat.ac.kr