INNOVATION ACTORS IN SOUTH KOREA: AN ANAYLYSIS OF UNIVERSTY, INDUSTRY AND GOVERNMENT RESEARCH CENTERS

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Abstract: Korea's rapid economic growth and industrial transformation are treated as a success story in world economic history. Innovation efforts of government, industry and universities to develop technological competitiveness have built competitive power of Korea globally. This article will investigate the status of innovation actors, university, government research institutes (GRI) and industry, and their relationships with each other.

Firstly, although universities hire 27% of the total research personnel of Korea and Ph.D. holder scientists and engineers are mostly concentrated in universities (66%), most of the patents registered from the early years of industrialization to present come from industry. Most important output of universities is the scientific publications. Korea now ranks 15th in the world in terms of the number of SCI publications.

Secondly, GRIs helped domestic industries to acquire foreign technology and to develop their own technology. They also cultivated experienced researchers and spread them to newly founded private research centers and universities.

Thirdly, another important innovation actor was industry, especially big family holdings namely Chaebols that were working to produce a few types of products with mass customization in early years of industrialization. Over time, they were busy on improving quality, R&D and technological superiority. Role of SMEs was either suppliers of big companies in some processes or manufacturing of simple, labor oriented products. However, support policies of Korean government for SMEs caused to focus on R&D oriented production since Asian financial crisis in 1997.

Key Words: Korea, Innovation, Government Research Institutes, University, Industry

GÜNEY KORE'NİN İNOVASYON AKTÖRLERİ: ÜNİVERSİTE, SANAYİ VE KAMU ARAŞTIRMA MERKEZLERİNİN ANALİZİ

Özet: Teknolojik bir rekabet gücü elde etmek için hükümetin, endüstrinin ve üniversitelerin inovasyon gayretleri Kore'nin küresel rekabet gücüne sahip olmasının önünün açtı. Bu makale üniversiteler, kamu araştırma kurumları ve özel sektör gibi inovasyon aktörlerinin durumlarını ve birbirleriyle olan ilişkilerini araştırmaktadır.

Üniversiteler Kore deki araştırmacıların % 27'sini, doktoralı mühendis ve bilim insanlarının ise %66'sını bünyesinde barındırmalarına rağmen, kalkınmanın ilk yıllarından bu yana patent başvurularında özel sektör her zaman önde oldu. Üniversiteler daha çok bilimsel yayınlarda öne çıkarak, SCI endeksli yayın sayısına göre Kore'nin dünyada 15. ülke olmasını sağladılar.
Kamu araştırma merkezleri yerli sanayinin yabancı teknolojiyi içselleştirerek geliştirmelerine yardımcı oldular. Ayrıca tecrübeli araştırmacıları yetiştirip üniversitelere ve yeni kurulan endüstriyel araştırma merkezlerine gönderen bir okul vazifesi yaptılar.

Üçüncü önemli inovasyon aktörü özel kuruluşlarıdır. Rekabet gücünü elde etmede büyük aile holdingleri olan 'chaebollerin' katkısı büyüktür. Kuruluşlarının ilk yıllarında seri üretimle bir kaç kalem üreten chaeboller zamanla kalite artırımı, teknolojik üstünlüğü elde etme gibi amaçlarla araştırma ve geliştirme faaliyetlerine önem verdiler. Daha çok büyük holdinglerin teminatçısı olan ve emeğe dayalı üretim yapan küçük ve orta ölçekli işletmeler ise özellikle 1997 Asya finansal krizi sonrasında uygulanan hükümet politikalarıyla araştırma ve geliştirme merkezli üretime odaklandılar.

Anahtar Kelimeler: Kore, İnovasyon, Kamu Araştırma Merkezi, Üniversite, Endüstri

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1. Introduction and Historical Background

Korea developed from agrarian and underdeveloped country to a high-technology producer society since 1950s. Korean economy grew at an average rate of 8 % and per capita income has increased from from $ 87 in 1962 to $ 20.759 in 2011. It was also a poor country in terms of underground resources, national infrastuructre, technological accumulation, trained technical labor and educated human resources that were fundemental requirements for industrialization.

Japanese colonical forces from 1910 to 1945 occupied it. Although some scholars argue that basis for economic development established by Japanese government during colonical period, Japanese wanted to remain Korea as an agrarian country, a source of agricultural products for the Japan and supplier of cheap labor force. Some earlier Japanese owned industrial production facilities in Korean peninsula demolished by Korean War. In addition, most of the production facilities and underground resources remained in the Northern part of the peninsula. Korea was left with damaged manufacturing facilities and hopeless, desperate human resources (Chai, 2007:163).

The main economic policy during 1960s was characterized by import substitution and export orientation. The government encouraged the establihment of some basic industries for export-oriented goals and brought long term, long scale foreign credits to support massive import of raw materials or to finance establishment of turnkey plants. Automobile production (1960), ship building (1967), mechanical engineering (1967), and the electronics industry (1967) financed mainly by long-term foreign credits. National innovation sytems characteriezed by imitation of imported products and absorption efforts of critical technologies from advanced countries (Chung, 2011:169; Suh-Aubert-Ahn-Chen 2006:19).

Korean government focused on development of technology oriented critical industries for industriliazation and strenghtening national defence industry purposes during 1970s.Certain level of technological capability requiring heavy and chemical industries were financed. Establishment of turnkey plants and technical training programs from abroad were used for the development of chemical industries. Foreign licensing has been used for the import of heavy industries. focus of national innovation strategy shifted form the imitation of imported foreign Technologies to adoption and development of less complex Technologies (Chung, 2011:169; Suh et all. 2006:151).

Korean government established 16 government research institutes (GRIs) including the Korean Institute of Science and Technology (KIST), Korea Institute of Machinery and Metals, the Electronics and Telecommunications Research Institute, the Korea Research Institute of Chemical Technology, the Korea Research Institute of Standards and Science, the Korea Institute for Energy Research, and the Korea Ocean R&D Institute to support domestic industries for their technological weakness (Chung, 2011:169; Park-Leydesdorff, 2010:642-643).

Korean organizations began to lose their competitiveness in global markets because of emergence of new competitors those have cheap labor force. Korean government shifted its policy from labour intensive products to technology intensive industries and used vaious support mechanism for the establishment of rd denters in organizations. A great increase in industrial R&D institutes. In the country characterized the 1980s. Coorporate R&D centers rose using several policy instruments, the government motivated industrial enterprises to establish their own R&D institutes. The number of private private research institutes rose greatly from 53 in 1981 to 966 in 1990 (Chung, 2011: 170).

The government introduced variety of financial and tax incentives including technology fund system, tax credit on expenditures for R&D, technical human resources development programs and exemption form the military duty for research personnel hired by institutional research centers. The government also expanded science and engineering student admission quota in universities in order to supply qualified engineers and scientitist for the need of industrial sector. For example research oriented science & engineering universities were estanlished such us “the Korea Advanced Institute of Science and Technology (KAIST)” and “the Kwang-Ju Institute of Science and technology (K-JIST)” and The Pohang Science and Technology Institute (POSTECH) (Lee, 2007:146).

From 1990s, the private industries started to function as an important driver in Korean national innovation system. The role of GRI has diminished and their portion of national R&D expenditure declined from 18.4 per cent in 1990 to 14.7 percent in 2000, and 13.8 per cent in 2003.The government promoted innovation capabilities of universities very strongly. The government has initiated two important programmes for strenghthening universities R&D outputs. The first one was the brain Korea 21 programme to develop university research centers in the area of basic science and engineering. When a center in a university qualified as a government affiliated research center, it receives generous funding during 10 years. The one of the aim of the program was to encourage university researchers and postgraduate students to produce high-quality research output that could be published in internationally peer-reviewed journals. Onether one was the new university for regional innovation (nuri) programme that was initiated just after inauguration of the local government system in march 1995 for the aim of improving regional econonomies and helping regional industries and universities to work together (Lee, 2007:146; Chung, 2011:170). In order to broaden the role of universities in Korean national innovation system new research-intensive universities were founded such as GIST (Gwangju Institute of Science and Technology) in 1993, KIAS (Korea Institute for Advanced Study) in 1996, and ICU (Information and Communications University) in 1998 (Park, 2010:643).

Asian financial crisis in 1997 hit Korean economy strongly and lots of industrial organizations bankcrupted or laid of reserarch personnel for economic reasons. Korean companies reduced their R&D investments in response to financial crisis. Hovewer, Korean government initiated a series of policy to help the formation of innovative venture companies in order to overcome economic crisis. They were regarded as new growth engines of the country and effective tools for the development of innovative high-tech industries. Former reserachers in GRIs and big Korean family holdings left their organizations to start up government sponsored venture businesses. Then umber of venture companies increased form 2042 in 1998 to 11392 in 2001 (Lee-Kim, 2000:339; Chung, 2011:188).

During 2000, continuous government tried to restructure the natioanal resaearch system to boost cooperation among innovation actors. Government identified new research areas to support and allocated funding. In addition, Project-Based System (PBS) was introduced at GRIs in order to increase performance levels of reseachers and increase the level of communication and joint projects (Park, 2010:643).

General characteristics of innovation system development can be explained as follows: First, Korean governments export oriented policies forced domestic companies to the international markets and exposing them to high global competition. İn order to catch up the levels of their competitiors Korean organizations continiously developed their products by investing on research and development. Secondly, government supported big Korean family holdings enjoyed great financial sources. They were able to investin risky and expensive research and product development projects. This is well explained by the fact that top 30 chaebols share on total R&D investments was more than 60% in industrialization period (Chung, 2011:169; Joong et all. 2006:153). Thirdly, twin dominance of government and big family holdings dominated korean natioanal innovation system, however role of universities and small and medium ındustries was very weak with respect to other innovation agents during industriliazation period from 1960s to 2000s (Eoma-Lee, 2010:626). Fourthly, education policies aimed to raise qualified human resources paved the way for successful implementation of innovation policies and industrialization of the country (Kim, 1997:60). Fiftly, unlike other developing countries Korea limited the inflow of foreign capital by forcing inverstors to catch established high standards set by government. Instead, Korea chose to acquire technology by informal modes of technology transfer, imitation, reverse engineering, turnkey plant construction, foreign licensing and original equipment management.

BOX 1.GOVERNMENT INITIATED R&D SUPPORT PROGRAMS FOR INNOVATION ACTORS

Excellent Research Center Programme (ERC):

The government selected research-intensive universities that have masters and ph. d courses in engineering sciences. About 20 researchers should join research group in order to accomplish national R&D projects. The governments allocate research funds for selected projects and groups. ERC are promoted for nine years and in every 3 years, a satisfactory research progress report should be submitted to authorize government authorities. This program brought a competitive innovation spirit to teaching oriented traditional university environment. The program had no direct relationship with other innovation actors but helped to establish a R&D infrastrucute to universities during 1990s.

Regional Research Center Programme(RRC):

It was started to spread the positive effects of ERC programme to regional level in 1995. Regional University affiliated research centers are selected to contribute economomic development of local regions by focusing on regional strategic engineering and science areas. There were 112 affiliated centers in 15 regions. Participating companies, universities, local and central governments supply research budget.RRC programme mainly contributed to strenghten research capacity of regional universities and regional economy.

Technology Innovation Center Programme (TIC):

It had similar characteristics with rrc program but main aim was to collect all innovation actors including university, industry and grıs into specific centers located in regional universities in order to use their synergic research efforts for developing region specific Technologies. Training of industrial personnel, supply of resarch information, common usage of research equipment and joint research among universities, GRIs and industry are promoted. Local governments, universities and participating companies, burn operation costs of centers. TIC program was merged with RRC program later.

Technology Business Incubator Programme:

The aim was to encourage establishment of start up venture companies by supplying start-up, research, management information and commercialization of research results services.

Universities and grıs were responsible for supplying an office space, basic research and office equipments within one year from establishment. Government supported venture companies up to 100 million won on condition that they should reimburse half of the funding in 5 year.

Business Incubator Programme:

The Small and Medium Business Administration (SMBA) supported business incubators with land, an expert consulting service and marketing education. Universities and government research institutes operate the incubators. They provided research equipment and researchers for new companies**.**

The Technopark Programme:

Technoparks were established to use the synergic research effects of innovation actors by collecting innovative enterprises and research institutions in one place.11 technoparks were established since 1997. They are expected to play a significant role in colllobration efforts of industry-grı and industry.

Industry-University-G.R.I. Consortium Programme:

The SMBA initiated the consortium program to support small and medium business development and purchase their products. At least seven SMEs and a research institute in affiliation with a university should co-operate together to conduct research on the creation of a new product or model in one or two years.They can get the financial support from the consortium of the participating SMEs (%25), local government(%25) and SMBA (%50).

Adapted from: Chung, 2011: 196-2000; Korea Small and Medium Business Administration (http://eng.smba.go.kr/pub/poli/poli040101.jsp (accessed at 25/07/2012)) ; Asia Pacific Economic Cooperation (http://www.apec-smeic.org/newsletter/newsletter_read.jsp?SEQ=301 (accesssed at 03/08/ 2012)).

2. Theoretical Background: From Linear, Push Model to Triple Helix Model

There was a tendency to explain technological and scientific innovation by "linear push model" after Second World War (Freeman, 1995:9). The linear model emphasizes that there a linear relationship between knowledge creation and production of goods. Knowledge is disseminated from universities and flows to other innovation actors through patents and academic papers. This model explains innovation as a linear process in which production or economic output is created by previous scientific research. Innovation actors are separate from each other. It is difficult to mention about mutual exchange relationship (Tidd, 2006).
Unlike static linear model, national innovation system (NIS) approach suggest a more dynamic model, in which all sources and systems in national borders are in mutual interaction and cooperation is a necessary requirement for synergic production. Niosi-Saviotti-Bellon-Crow (1993) defines this process as:

"... A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology" (Niosi et all, 1993: 212)

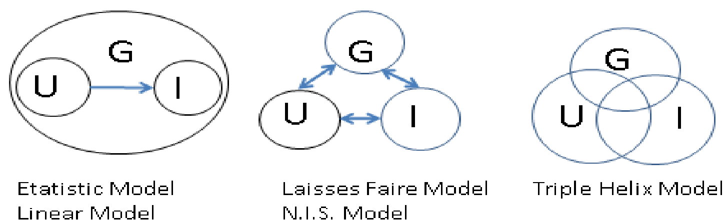
However, roles of universities, research institutes and government is separate from each other and each are functioning their traditional roles. Operating boundaries are segregate. Actors channel their knowledge, products or legislation through mutual interaction. All actors maintain their defined identity.

Later, Etzkowitz and Leydesdorff (1997) introduced a triple-helix model of university, industry and government relations, emphasizing both the social and economic roles of a university. In this new model, roles of the innovation actors shifted to a more interactive direction. The Triple Helix model argues that a university has another important role in the innovation system, which is entrepreneurship, beyond their traditional roles of teaching and research. This new role needs to directly link strongly to other innovation actors to maximize the industrialization of knowledge.

The triple helix model postulates that more interactive and strong relationships should be created between innovation actors. Industry has a role of production; government prepares necessary legal infrastructure and provides funds; university is creator of new industrial knowledge and competent human resources. Industry and government have always been the primary institutions in the innovation system. Triple helix model elevates the roles of universities to an inseparable position by emphasizing their research function. Arrangements and networks among innovation actors drive the efficient functioning of the system. Innovation actors do not have superiority on each other. None of the innovation actors has a role of superiority but all have indispensable duty of efficient functioning. New interactions, initiatives and exchanges arising from mutual connections become the generating force for policies, knowledge and products at regional and national level. New organizational mechanisms such as incubators, consortiums, clusters, science parks become a source of knowledge exchange, creative thinking and economic output (Etzkowitz, 2003: 296-297).

Triple helix model gives innovation actors equal and overlapping functions. It opposes a statist model of government controlling industry and university and laissez-faire model, university, industry and government apart from each other and only has modest exchange relationship. In addition to each of innovation actor's traditional function, each triple helix partner in the model "takes the roles of other". Therefore, each partner in the system operates as the creator of knowledge, product and economic output (Etzkowitz, 2000:111).

Figure 1. Innovation Models
Government (g), Industry (I), University (U)
Interactions



Source: Adapted from Etzkowitz, (2003), p: 302

3. Innovation Actors

3.1 Universities

Universities are a rich pool of high-quality scientists and engineers. They have 93.509 highly qualified researchers, 53.974 (66.2%) of whom hold Ph.D's and 34,164(31%) of them have master's degrees. Universities hire 27% of the total research force of Korea. Compared with other innovation actors, PhD-level research scientists and engineers are extremely concentrated in universities (66.2%).

Table 1. The Distribution of Researchers by Degree, 2010

	Public research institutes	**Universities**	**Enterprises**	**Total**
PhD	12.818 (15, 7%)	53.974 (66, 2%)	14677 (18, 0%)	81442 (100%)
Master	10.132 (9,3%)	34.164 (31, %)	64928 (59, 4%)	109224 (100%)
Bachelor	3.011 (2, 2%)	4374 (3,2%)	130900 (94, 7%)	138285 (100%)
Others	274 (1, 6%)	1024 (6, 0%)	15663 (92, 3%)	16961(100%)
Total	26.235 (7,6)	93.509 (27%)	226.168 (65, 4%)	345932 (100%)

Source: National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, (2010)

Korean universities are controlled by Ministry of education Science and Technology and receive financial support from government mainly. There is a high degree of similarity in terms of overall administrative procedures and research policies because government decides admission policies centrally. Universities traditionally prefer to hire their own graduates. This establishes barriers to information flow in between universities. Academic workload is mainly concentrated on undergraduate teaching and graduate programs have not been well developed. So academicians have less time to focus on research and commercialize their study for the need of industry. They have personnel connections with industrial sector to consult on ongoing projects (Sohn-Kenney, 2007: 994). Academicians are almost automatically tenured, once employed. They should meet minimum lecture hour's criteria to stay at the teaching job. University research is very much concentrated in a few research universities. University R&D activities are more directed toward basic research than others sectors.

Rather than an effective cooperative actor on innovation process and knowledge supplier, universities main role is to educate qualified, well-educated workforce. In Korea, wide population in the Korean society has respected professors in universities as a kind of social mentors rather than the technology providers.

Since industry developed their ways to access technology through reverse engineering, turnkeys, official licensing agreements, OEM production and later established their own researches centers or imported foreign technologies they didn't have so much expectations on competitive technical knowledge flow from the universities because most basic scientific knowledge is not generally applicable to economically valuable product development and easily reproducible. It was specific to firms and applications.

Although universities hire 27 % of the total research personnel of Korea and Ph.D. holder scientists and engineers are mostly concentrated in universities (66.23%) as of 2010, most of the patents registered from the early years of industrialization to present are made by industry. An indication of this fact is the comparison of patent registrations made by leading holdings and universities last 10 years. The total numbers of patents registered by world-known Korean research universities are fewer patents registered by leading electronics appliances producer, Samsung Electronics in last 10 years.

Table 2. Comparision of Major Industry and University Patents

Ranking	Industry	Patent	University	Patent
1	Samsung Electronics	11.033	KAIST	2338
2	LG Electronics	7.871	Seoul National Unv.	1540
3	Samsung SDI	3.916	Yonsei University	1369
4	Hynix Semiconductor	2.558	Postech	1036
5	Hyundai Motor Company	1.847	Korea University	974
6	Dongbu Electronics	1.706	Hanyang University	730
7	Posco	1.671	GIST	562
8	Samsung Electromechanics	1.372	Sungkyunkwan Unv.	449
9	SK telecom	1.248	Pusan National Unv.	419
10	Daewoo electronics	1.184	Inha University	74

Source: Korea Research Foundation, Korea İntellectual Patent Office (www.kipo.go.kr)

Most important output of universities is the scientific publications. Korea now ranks 15th in the world in terms of the number of SCI publications. Korea recorded the highest growth rate in SCI publication over the past decade. In sum, interactions between the industry and the university have largely been informal and personal. In this respect, the university–industry relationship in Korea can be sumarized in two general principles: First, there were few formal research contracts, but numerous informal linkages. Second, there were few long-term relationships (Suh, 2009:45).

Universities have a share of 10.8% in total national research and development expenditure and they are highly dependent on the government for research funds—87 percent of the university research funds are from the government as of 2010. 23.4 percent of research is conducted on production technology, 20.3 % on health and medicine and 10.7 % on telecommunication sector spent on engineering research as of 2010. (National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, 2010)

Table 3. Source of Research Funds for Private Universities

	1997	1998	2000	2003	2006	2010
Government	52.0%	52.1%	60.4%	75.1%	86%	87%
Industries	47.5%	47.7%	39.4%	24.5%	13.7%	12.5%
Foreign	0.5%	0.2%	0.2%	0.4%	0.2%	0.5%

Source: National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, (2010)

Starting from late 1990s government changed salary structure of academic personnel and researchers in national universities and accordingly private universities followed new scheme. Previously performance evaluation of academicians was dependent on weekly teaching hours and academic research, but new policy emphasis on joint projects with industry and patent applications. Their weights in the evaluation were around the number on average from 14% to 22% of the weights on the academic paper publication in SCI journals (Yang, 2009: 115; Lee-Koh 2007).

Another important application that can ease knowledge flow from universities to industry is university related venture enterprises. There are several practices according to establishment models like when academicians establish a venture, university or institute invest in venture, graduate school students involve, the case when the businesses use incubator in university and if firms receive the technology transfer from universities in developing their current product. The number of university-related venture business reached 1,473 at the end of April 2005. Most of university-related venture firms were established out of the joint research projects with universities (**Yang, 2009:118).**

To reorient Korean universities toward more research-oriented institutions and to increase research ouput, the government has taken various measures, including the Brain Korea 21 program, which is designed to support selected universities in their transformation into research-oriented and graduate education–oriented institutions. BK21 provided fellowship funding to graduate students, postdoctoral researchers, and contract-based research professors who belong to research groups at top universities.Recipients are selected on the merit of the research groups and universities to which they belong, not on individual merit. government allocated US$ 290 million per year since 1999. Number of publications in academic journals increased rapidly. Industries laso have invested more than $100 million of investment for the joint work with universities participating in this Project (Yang, 2009:121). Another initiative taken by government was the establishment of "industry–university cooperation foundation" As of 2007, 134 universities having established industry–university cooperation foundations within their campuses (Eoma, Lee 2010:626).

3.2 Government Research Institutes (GRIs)

Korea lacked technological knowledge for industrialization as a post war country and imported foreign technologies for domestic production in 1960s. Korean government decided to establish government supported research centers in order to support and improve technical capabilities of industries. There were only two public research centers, namely National Defense R&D Institute and Korea Atomic Energy Research Institute before 1960. Researchers were fewer than 5,000 in all around country. Korea İnstitute of Science and Technology was founded in 1966 to meet the technical research needs of industry. President Park Chon Hee initiated capital-intensive heavy and chemical industry policy in 1970s. In order to meet the demands of industry for newly established industries and help to develop existing manufacturing industries 20 more of specialized research institutes established like Korea Institute of Machinery and Metals, the Electronics and Telecommunications Research Institute, the Korea Research Institute of Chemical Technology by different ministries (Chung, 2010:334).

GRIs helped domestic industries to acquire foreign technology and to develop their own technology. They also cultivated experienced researchers and spread them to newly founded private research centers and universities. After the late 1980s, growing R&D activities in private sector and universities have led to many criticisms about inefficiency of GRIs. Government also believed that many specialized GRIs under different ministries was causing inefficient coordination of government policies and poor collaboration among similar research institutes and duplication of research. The major criticisms on the GRIs were poor research management, excessive monitoring by related ministries, government unstable budget allocation, perceived low productivity, being a place for retired bureaucrats for administrative positions (OECD, 2009:126-128; Sohn-Kenney, 2007:997).

In an effort to cope with inefficient operation of GRIs, they were re-organized several times. A contractual project-based management system (PBS) was introduced to replace the lump – sum system in order to increase collaboration with industry. Before the introduction of PBS, government supported salaries of researchers and GRI charged only direct research cost to projects. Under new system, GRIs has to charge salaries of researchers to each project in order to compete with industry and other research centers in universities. Another change was about coordination of nationwide GRIs in late 1990s. In order to improve performance, coordination among research centers and give more autonomy, most of the GRIs placed them under research councils (OECD, 2009:127-128).

Currently, they operate with the financial assistance of the government but GRI researchers are not government officials. There are 26 GRIs placed under two research councils.They are Korea Research Council of Fundamental Science and Technology and the Korea Research Council for Industrial Science and Technology.

GRIs employs about 15000 researchers, of whom about 13, 5 % have Ph.Ds. and 8.3 % have master's degrees. Over 95 % of research funds came from the government, while the inflow of funds from industries was less than 5%. Despite they were established with industry oriented research purpose, expected interactions and collaborations could not realize satisfactorily. They are considered as not as productive as they were invested amount. Another criticism is that their research activities should be focused on industry needs like new technologies rather than basic science and research (Suh, 2009:42-43; Koo, 2010).

Even as of 2010 more than 50% of the government financed R&D, expenditure allocated to GRIs, whereas universities have four times more researchers than GRIs. R&D expenditure for per GRI researcher was approximately 4 times more than university researchers (154.718.000 Korean Won to 36.959 Won as of 2008). This unbalanced budget allocation caused university academicians on teaching rather than research from the earlier years of development.

Table 4. Major R&D Indicators

	2005	2006	2007	2008	2009	2010
R&D Expenditure (0.1 billion won)						
*	241.554	273.457	313.014	344.981	379.285	438.548
R&D Expenditure as Percentage of GDP (%)						
	2,79	3,01	3,21	3,36	3,56	3,74
R&D Expenditure Rate by Source (% Government/ %Industry)						
	24.3	24.3	26.1	26.8	28.7	28
	75	75.4	73.7	72.9	71.1	71.8
R&D Expenditure Rate by Sector (%)						
Government Research Ins.	13,2	12,8	13,1	13,5	14,7	14,4
Universities	9,9	10	10,7	11,1	11,1	10,8
Enterprises	76,9	77,3	76,2	75,4	74,3	74,8

Source: National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, (2010)

GRIs played an important role in the early technological development of Korean science and technology. They worked closely with big Korean family holdings and helped them to step further in technology acquisition. However, Korean industries developed their research capability in order to catch quickly changing world markets and customer needs. GRIs and industries capability and needs differentiated and GRIs role became less clear in national innovation system. Data shows that 20% of R&D expenditure was devoted to basic research in 2006, down from 27% in 1998. However, over the same period, the share of R&D allocated to experimental development increased from 38% to 44% (Keenan-Michael, 2012: 27-28).

GRIs is in the turning point whether to support the needs of industry or to establish a strong basic science research. This is may be the result of implemented performance evaluation system in 1990s. There should be a determination on whether to invest on basic research or to focus on outcomes-based fundamental research.

3.3 Industry

The significance of Korean industrialization had been almost on development of chaebols, not on the balanced growth with SME. Effects of entrepreneurial spirits of founder families and innovative reengineering processes can'not be denied during growth period. Government supported chaebols differentiated in all segments of industry. Chaebols were working to produce a few types of products with mass customization. Over time, they were busy on improving quality, R&D and technological superiority. Role of SMEs was either suppliers of big companies in some processes or manufacturing of simple, labor oriented products. Chaebols were growing rapidly by integrating successful SMEs to their huge structure.

SMEs were only a weak shadow of chaebols. While SMEs were generally limited by their lack of advanced technology, capital, expertise and qualified researchers, they had entrepreneurial spirit too. A good example for this case is the economic development of Taiwan, in which SMEs were the backbone of industrialization. Indeed, sustained economic development is possible only when national innovation efforts are established on strong interaction of big to small and medium sized organizations. Fortunately, the position of SMEs in national innovation and production has begun to chance after 1997 Asian Crisis. Korean government presented support packages for SMEs like direct funds for research, tax waivers, tariff exemption for R&D equipment, preferential procurement of SME products and military service exemption for researchers hired by SMEs (Ungson-Steers-Park, 1997: 83-87).

Chaebols were the main patent applicants during economic development period from 1960s to 1990s. However, patent application pattern has changed since 1997 Asian Economic Crisis. Patent applications of innovative venture enterprises, developed by government incentives, tax reductions and R&D supports, began to rise steadily.Korea Government offers 259 industrial researches, development and innovation programs for SME. Financial support for research and development programs offered by the government reaches 30% of all support programs. Others are 13% for technology transfer programs and 11% for human resource development programs (Chung, 2010:338).

Support policies of Korean government for SMEs caused establishments of many research centers. Korea had fewer than 60 research centers in the early 1980s and there were a few thousands before 1997 Asian Economic crisis. In 1998, just one year passed from crisis, there were 800 industrial research center in chaebols and nearly 3000 in SMEs. Nearly half of them was from electronics, machine and metals industries. Asian Economic Crisis was a turning point for the SMEs research and development efforts. As of 2011, there are 23.059 research centers in Korea, 1179 of them is operated by chaebols, and others are established by SMEs. Nearly 17000 of all research centers are specialized in electronics, machinery, information technologies, and chemical industries (Koita, 2011).

Korean holdings also established more than 60 R&D centers around the world. For example, Samsung electronics operates ten overseas centers around the world in addition more than 40 in Korea. LG electronics also established four research centers in China, 3 centers in USA, 2 centers in Japan. Hyundai Motors also operates five advanced technology and design centers, three of them is located in America (OECD, 2009:107).

One of the most important revolutions that changed the direction of Korean national innovation system in the late 1990s was the establishment of venture companies that can be defined as innovative SMEs. Venture companies is defined by a special law as: a) in which a venture capital firm has invested at least 10%, b) at least 5% R&D expenditure as of percentage of sales, c) whose business stems from high technology that should be approved by related government agency d) 50% of total sales are derived from patents or R&D. While venture firms grew rapidly in terms of total number, they have also shown higher growth on sales. For example venture firms have shown a sales grown rate of 35.2, chaebols have shown 16.7% and other SMEs sales growth rate was 12.5% in 2001 (Chung, 2007:31).

R&D expenditure of large corporations in 2010 has increased by 4,242.9 billion won (21.2%) from the previous year and reached 24,212.9 billion won. Share of R&D investment in large corporations has increased by 2.9 percentage point and reached 73.8 percent of the total R&D expenditure of business enterprises. R&D investment of small & medium-sized businesses and venture businesses were 4,850.3 billion won (14.8%) and 3,740.1 billion won (11.4%) respectively.

As it can be seen in Table 5, R&D expenditure of large corporations is increasing gradually but their share as a percentage of sales decreasing. However, both R&D investments in SMEs and venture business and their relative percentage as of sales is increasing gradually. It can be concluded that support policies of Korean governments since Asian crisis on SMEs and venture business is one of the reasons of such a development.

Table 5. R&D Expenditure and Distribution of Researchers in Korean Industries

	R&D Expenditure in 0.1 billion won (share in industry, %)						Researchers (share in industry, %)					
	2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009	2010
chaebols	146.429 (78.9)	160.217 (75.8)	175.119 (73.4)	187.13 9 (72)	199.699 (70.9)	242.129 (73.8)	91.514 (59.3)	99.029 (56.9)	102.473 (55.2)	106.007 (53.8)	108.136 (51.4)	120.105 (53.1)
SMEs	19.911 (10.7)	25.031 (11.8)	32.710 (13.7)	38.250 (14.7)	44.837 (15.9)	48.503 (14.8)	30.619 (20.9)	36.055 (22.3)	41.566 (22.4)	47.905 (24.3)	55.179 (26.2)	59.338(26.2)
venture	19.302 (10.4)	26.019 (12.3)	30.820 (12.9)	34.611 (13.3)	37.086 (13.2)	37.401 11.4()	32.173 (19.8)	38.820 (20.7)	41.594 (22.4)	43.111 (21.9)	46.988 (22.3)	46.725 (20.7)

Source: National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, (2010),

Number of researchers employed by large corporations has increased by 11,969 persons (11.1%) from the previous year and reached 120,105 persons. Share of researchers in large corporations has also increased by 1.7 percentage point and reached 53.1 percent. Number of researchers in small & medium sized corporations and venture businesses were 59,338 persons and 46,725 persons respectively. Share of researchers in small & medium sized corporations and venture corporations were 26.2 percent and 20.7 percent respectively in 2010. Numbers of researchers in all corporations are increasing gradually since 2005. This shows the increasing importance of research in Korean industries innovation system. Table 6 shows numbers of research centers both in SMEs and chaebols and their area of specialty.

Table 6. Current Situation of R&D center in Korean Industries

	SMEs	**Chaebols**	**Total**
Electric/ Electronics/ IT	9,696	385	10,081
Machinery	4,296	276	4,572
Chemical industry	3,011	252	3,263
Engineering and construction	1,312	107	1,419
Food processing	468	55	523
Textile	355	21	326
others	2,742	83	2,825
Total R&D centers	21,880	1,179	23,059

Source: Korea Industrial Technology Association, http://www.koita.or.kr/eng/indicators/ (accessed at 24/07/2012)

Table 7. R&D Areas of Korean Industries

	2008		2009		2010	
	Expenditure	Rate	Expenditure	Rate	Expenditure	Rate
New product	128.349	49,4	134.184	47,6	153.847	46,9
Existing product	56.412	21,7	60.048	21,3	70.473	21,5
New process	41.843	16,1	51.393	18,2	60.292	18,4
Existed process improvement	33.396	12,8	36.033	12,8	43.421	13,2

Source: National Science and Technology Commission & Korea Institute of S&T Planning and Evaluation, (2010),

Korean business enterprises made the largest R&D investment in new product development in 2010. Investment in new product accounted for 46.9 percent of total R&D expenditure. R&D R&D investments for other areas were improvement of existing product (7,047.3 billion won, 21.5%), development of new process (6,029.2 billion won, 18.4%), and improvement of existing process (4,342.1 billion won, 13.2%).

4. Conclusion

The strength of Korean national innovations system come form the commitment of government to technology based national development and dedicated and entrepreunal industrty from the earlier years of republic. Korea changed its industry structre from a labour intensive light industry producer to capital-intensive chemical and heavy industry producer and lastly to high technology industries. Korea’s dedication gave its fruits in the form of patents, scientific papers, technology intensive products and highly qualified human resources. Korea increased its investment on R&D nearly to 3% since 1980s. Industry, mostly chaebols, had a share of more than 70 %, which is similar to developed nations industrial r&d investment ratio. International competition and Korean governments export oriented policies directed industrial sector to invest highlt on R&D and to become a technological frontier.an indication of industrial development is the patent registrations change from 1970s to 2000s. Number of patents registered by government patent office increased from 427 in 1978 to 56.732 in 2009.

As the country, developed and globalized government shifted its role from the sole policy maker and implementer to facilitator. Government adapted itself to become a conductor between innovation actors. Teaching oriented universities also have tried various efforts to develop their research capabilities with the help of government.Hovewer, increasing role of industrial research and university research eroded the roles of GRIs.Rather than GRIs, private company established research centers dominated country since 2000s.

Korean universities hire the largest pool of researchers but they account for only 10.1% of the gross national R&D, which is smaller than the share of GRIs (14.4) as of 2010. This directs many universities to become teaching oriented instititution rather than research orientation because of insufficient mechanism for research support. Naturally, university professors do not feel the pressure to conduct research. Once employed, they are almost automatically tenured especially in national universities. Necessary support mechanism for researcher in universities should be developed whether by government or university administrations.

Korean industry's share on national R&D expenditure is satisfactory (71.8/ 28). Dependence to industry so much on national R&D system may bring some dangeresous side effects. R&D is too sensitive to economical and financial structure of the company. In case of an economic crisis, the first department that could be laid of is R&D department. That was the case in 1997 Asian financial crisis.

Industry also focuses so much on applied search and new product development. Hovewer healthly development of a national innovation system is depend on the balanced focus on basic research and applied research at the same time. This means that universities and GRIs efforts to conduct basic research should be supported continuously.

Lastly, one important indication for operation triple helix model is the financial interactions between innovation actors. As it can be seen from the table 8, government research institutes are almost fully supported by government and the role of the industry is nearly negligible. Universites are greatly supported by government (87%) and then industry (12, 5%). Industry almost supported itself (93.4) in its research. It can be concluded that there are established links between innovation actors but those links should be strengthened. Especially interaction between GRIs and industry and university and industries should be increased more by establishing effective mechanisms.

As a policy advice it can be concluded that insufficient interactions between innovation actors makes the national innovation system weaker. Government support of universities and GRIs should be reduced and industry's burden of support of other actors should be increased.

Table 8. 2010 Flow of R&D Expenditures by Sector of Performance (Unit :%)

	Government Research Inst.		**Universities**		**Industry**		**Share in National R&D Expenditure**
Source of Fund	G.R.I.	G.Supported R.I.	National Unv.	Private Univ.	Gov. Invested. Companies	PrİvateCompany	
Goverment	99.5	95.9	90.1	87.0	25.0	6.5	28.0
Industry	0.5	3.9	9,6	12,5	74.9	93.4	71.8
Abroad	-	0.2	0.3	0.5	0.1	0.1	0.2
Total	100	100	100	100	100	100	100

Source: National Science & Technology Commission, Korea Institute of S&T Planning and Evaluation Report 2010.

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