Science and Technology Trends

Open Innovation Policies in Asian Countries

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Abstract

The present paper summarized open innovation policies of three countries—Korea, Japan, and China—based on the frame of analysis of open innovation policies proposed by Chesbrough and Vanhaverbeke (2011), which centers specifically on recent policies used since the 2000s. Literature analyses were basically used and interviews were used in a limited range.

In particular, from the viewpoint of knowledge production, distribution, and consumption, open innovation policies of the three countries were summarized and their characteristics were briefly compared. In addition, Asian countries' several misunderstandings of open innovation were elucidated. Asian countries' several particular misunderstandings of open innovation in contrast with Western countries grasped in the processes of literature analyses, interview analyses, and this authors' study of open innovation were described. Finally, based on the comparison and analysis of the three countries' open innovation policies and the elucidation of Asian countries' several misunderstandings of open innovation, several open innovation policies for Asian countries were proposed.

Keywords: Open Innovation Policy, Asian Countries, Open Innovation, Arrow Information Paradox

1. Introduction

"Open innovation" means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well (Chesbrough, 2003). This approach places external ideas and external paths to the market on the same level of importance as that reserved for internal ideas and paths to the market during the closed innovation era (Sridhar & Avinash, 2008). Eventually, open innovation means R&D without borders (Chesbrough, 2006).

Open innovation is a concept that integrates conceptually quite diverse present innovation and new economic phenomena. The sharing economy suggested by a group of economists, including Elinor Ostrom; the user innovation suggested by scholars, who use sociological approaches, such as Von Hippel; and "Wikinomics" suggested by Don Tapscottt and Anthony Williams and others are discussions presented on the other side of business administration to which open innovation is materially related. That is, all of sharing economy (Elinor, 1990) that takes notice of a new possibility of commons that may be achieved through negotiations or systems, Wikinomics (Tapscott & Williams, 2009) which is an economy based on many people's knowledge and technology surpassing individuals as with Wikipedia, and user innovation (Von Hippel, 2005), which is a phenomenon for individualized users' ideas and knowledge, are connected not only to existing products, but also to new product innovation in the times of knowledge-based economy, which surpassed industrial society, are different shapes of open innovation that are concretely

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realized through the utilization of knowledge and technology across the boundaries of enterprises.

The amount of knowledge has been explosively increasing to the extent that it is beyond the boundary of a certain business, country, or cluster and the speed of knowledge distribution has been increasing enormously based on the second IT revolution, no matter whether it is coded knowledge or tacit knowledge. As a result, the amount of knowledge and technology faced by an individual business, a certain cluster, or an individual country has become much larger than those produced by them (Yun & Mohan, 2012). Therefore, not only at the level of a country or a certain cluster, but also at the level of an individual business that efficient open innovation policies and strategies have become essential elements for the growth and development of the relevant country, cluster, or business. Therefore, as with open innovation strategies at the level of a business, which are essential for the growth and development of the relevant business, a certain country's open innovation policies are also very important for the relevant country's economic growth and development.

Open innovation policies refer to a series of policies implemented by a certain country in order to promote the open innovation of enterprises in that country that activate the production, distribution, and consumption of knowledge and technology across the boundaries of enterprises in that country, such as technology transfer policies, industry-academic-research cooperation promotion policies, technology transaction activation policies, and technology-mediating intermediary activation policies. Open innovation policies are under a concept of a new form of policies that goes beyond the scope of existing industrial policies, technology policies, or research and development policies. The present study was intended to define the scope of open innovation policies at the level of hypotheses and summarize open innovation policies of major Asian countries, in particular, those of Korea, Japan, and China, within this conceptual frame. Due to limited time and limitations in research resources, in the present paper, the characteristics of open innovation policies of major Asian countries were summarized through literature analyses. However, to grasp concrete reality of open innovation policies, from February 4 to 8, 2013, in-depth interviews were conducted with one related section manager of the Ministry of Education, Science and Technology of Korea, one related section manager of the Ministry of Knowledge Economy of Korea, one related section manager of the Presidential Council for Science and Technology, one related section manager of the Ministry of Strategy and Finance, and one related section manager of the Office of National Tax Administration for one to three hours each. In addition, during the same period, an interview was conducted with the councilor in charge of scientific technology at the Embassy of Japan in Korea and literature data on the newest trend of open innovation policies of Japan were received. In the same period, an interview with a person related to the Embassy of the People's Republic of China in Korea was attempted but the attempt failed. Therefore, situations in related sites in relation to the newest trend of open innovation policies of China were grasped through interviews with a responsible section manager of the Ministry of Education, Science and Technology of Korea dispatched to the Embassy of the Republic of Korea in the People's Republic of China and a researcher in the Science and Technology Policy Institute.

Next, several misunderstandings about open innovation strategies or policies by persons in charge of policies in Korea or in many Asian countries that this author has come to recognize in the process of reviewing Asian countries' open innovation policies or in the process of studies of open innovation were elucidated. Finally, the present paper is finishes with a proposal of directions of policies and strategies for the activation of open innovation in Asia.

2. Boundary of Open Innovation Policy

Open innovation policies are intended to promote production, distribution, and consumption of knowledge and technology across the boundaries of enterprises in the country and have different characteristics from those of existing industrial policies, scientific technology policies, and research and development policies. First, let us examine the differences between

industrial policies and open innovation policies. Industrial policies are diverse policies intended to promote the development of certain industries, which range from conventional industrial policies that correct market failure related to certain policies to activate the relevant industries to Schumpeterian industrial innovation policies that activate the innovation systems of the relevant industries to lead to enterprises' product innovation or process innovation. Open innovation policies are different from existing industrial policies in that they do not predefine industries or products per se and that they promote the production and distribution of protected knowledge as well as protectable knowledge instead of a certain sector.

Second, scientific technology policies focus on the activation of science bases in the country and the production of economically valuable technologies. Therefore, for the production of scientific and source technologies mainly by universities and the production of applied and developed technologies by government-funded research institutes or enterprises, not only the Ministry of Education, Science and Technology of Korea, but also almost all governmental departments become main agents of scientific technology policies, including individual departments in certain areas and the Ministry of Knowledge Economy focusing on applied and developed technologies. However, open innovation policies consider the distribution and consumption of knowledge and technology as importantly as the production of knowledge.

Third, research and development policies refer to various kinds of policies related to research and development investments necessary for the production of basic scientific and source technologies as well as various kinds of necessary applied technologies. That is, research and development policies focus on primary production of knowledge.

On the other hand, since open innovation policies aim at the promotion of the production, distribution, and consumption of knowledge across the boundaries of enterprises, encouraging enterprises to be equipped with the research and development capacities necessary for them to actively serve those functions as knowledge brokers in their areas should be included in important subjects of the policies.

Industrial innovation processes are becoming more open. The large, vertically integrated R&D laboratory system of the 20th century are giving way to more vertically disintegrated networks of innovation that connect numerous companies into ecosystems (Chesbrough & Vanhaverbeke, 2011). Based on the above discussion, the categories of open innovation policies are concretely presented in Table 1.

Open innovation policies are characterized by the fact that they focus on knowledge distribution and consumption in order to promote human and technology transfer and business start-ups based on the relevant technologies. In addition, knowledge production should definitely be included in concrete contents of open innovation policies, provided that, knowledge production policies, bearing knowledge distribution in mind, should be noticed in open innovation policies.

3. Review of Open Innovation Policy from Korea, Japan, and China.

3.1 Open Innovation Trends and Policies in Korea

First, in sectors of education and human capital development, in particular, the aspect of the mobility of researchers is mainly reviewed. As shown in Table 2, in the case of Korea, basically, manpower exchanges between university-/government-funded research institutes and enterprises are remarkably less frequent compared to those between university-/government-funded research institutes and other research institutes or universities. That is, currently, in Korea, compared to researcher circulation between universities and research institutes—between knowledge-creating organizations—researcher transfer between knowledge-creating organizations (universities and research institutes) and knowledge-utilizing-and-consuming organizations (enterprises) is quite limited

To examine the present state of researcher transfer from universities to enterprises, not only transfers, such as dispatch and employment/leave of absence, but also researcher transfers in research years that do not affect research institutes' manpower operation are shown to be rare. The reason for this is said to be that

Table 1 Concrete contents of open innovation policies

Concrete Contents of Open Innovation Presented by Chesbrough and Vanhaverbeke	Nature of the Relevant Policies, Knowledge Production, Distribution, or Consuming
1. Education and human capital development	
- increase meritocracy in research funding in the boundary	- production + distribution
- support the mobility of researchers among university, national laboratory, and companies	- distribution
2. Financing open innovation: the funding chain	
- increase the pool of funds available for VC investment.	- consuming
- support the formation of university spin-offs to commercialize research discoveries	- distribution + consuming
3. Adopt a balanced approach to intellectual property	
- reduce transaction costs for intellectual property	- distribution
- foster the growth of IP intermediaries.	- distribution + consuming
- rebalance university IP policies so broad diffusion of publicly funded research results is easier rather than focusing on royalty income alone.	- producing
4. Promote cooperation and competition	
- shift support from national champion toward SMEs and start-up companies.	- distribution +consuming
- promote spin-offs from large companies and universities	- consuming
- focus on innovation networks	
5. Expand open government	
- accelerate the publication of government data	- producing + distribution
- use open innovation processes in government procurement.	- producing + distribution
- support private commercialization of government-funded technology.	- distribution + consuming

Source: Chesbrough & Vanhaverbeke, (2011). Partially revised

Table 2 Present state of manpower exchanges between university-/government-funded research institutes and enterprises in Korea

(Unit: person)

Type of exchange	Division of Organizations	Total	Research Institute		University		Business	
			Subtotal	Average	Subtotal	Average	Subtotal	Average
	Subtotal	433	219	3.1	201	2.9	13	0.2
Dispatch	Korea Research Council of Fundamental Science and Technology	25	20	1.5	3	0.2	2	0.2
	Korea Research Council for Industrial Science and Technology	171	164	11.7	5	0.4	2	0.1
	Research centered universities	100	16	2.0	80	10.0	4	0.5
	Industry-university collaboration project receiving universities	137	19	0.5	113	3.2	5	0.1
	Subtotal	20	13	0.3	4	0.1	3	-
Employment and leave of absence	Korea Research Council of Fundamental Science and Technology	3	1	0.1	-	-	2	0.2
	Korea Research Council for Industrial Science and Technology	-	-	-	-	-	-	-
	Research centered universities	7	7	0.9	-	-	-	-
	Industry-university collaboration project receiving universities	10	5	0.1	4	0.1	1	-
	Subtotal	443	64	0.9	348	5.0	31	0.4
Research year	Korea Research Council of Fundamental Science and Technology	47	14	1.1	33	2.5	-	-
	Korea Research Council for Industrial Science and Technology	20	2	0.1	18	1.3	-	-
	Research-centered universities	142	30	3.8	106	13.3	6	0.8
	Industry-university collaboration project receiving universities	234	18	0.5	191	5.5	25	0.7

Source: National Science and Technology Commission (2012b).

incentives for working at enterprises are not sufficient to make researchers prefer working at enterprises to working at universities or research institutes. Next, to examine the present state of researcher transfers from government-funded research institutes to enterprises, although mid- to long-term transfers of experienced permanently employed researchers of government-funded research institutes are necessary to actually help enterprises, there are practical limitations due to regulations, such as prescribed numbers of employees. In other words, major reasons for inactive researcher transfers from government-funded research institutes to enterprises are government-funded research institutes' burdens for long-term transfers of permanently employed researchers due to limited prescribed numbers of employees and insufficient incentives for individual researchers.

In addition, incentives to attract researchers from enterprises to universities or government-funded research institutes are also insufficient. To conduct effective industry-academy-research institute joint research, not only researches of universities and government-funded research institutes should be transferred to enterprises, but also researchers of enterprises should be transferred to universities and government-funded research institutes with good research environments. However, although universities and government-funded research institutes have been supported with related facilities, such as business incubator centers, researchers for industry-academy-research institute joint researches have not been sufficiently secured. As of 2012, the Korean government has prepared diverse plans to activate researcher exchanges among industry, academy, and research institutes: these are the activation of transfers of university professors to enterprises using vacations and sabbaticals, plans to make dispatches of researchers of government-funded research institutes to small- and medium-sized enterprises substantial through giving incentives or separately operating prescribed numbers of permanent employees at the level of research institutes, and plans to install industry-academy-research institute joint research hubs in universities or government-funded research institutes to attract researchers of enterprises. On the other hand, universities have been reinforcing school-work links at the level of undergraduate studies by making contract departments and education programs that reflect market demands. In addition, universities have been successfully implementing policies to reinforce school-work links at the level of graduate school by making specialized graduate school systems centered on convergence technology for which the market requires specialized technologies. Nevertheless, the four subjects on in-depth interviews who are section managers of the Ministry of Knowledge Economy of Korea, the Presidential Council for Science and Technology, the Ministry of Education, Science and Technology of Korea, and the Ministry of Strategy and Finance commonly presented the insufficiency of researchers' fluidity among industry, academy, and research institutes as the most important problem that must be solved by open innovation policies of Korea.

Next, to adopt a balanced approach to intellectual property, the present state of the Korean government's policies for the distribution and consumption of knowledge and technology that would reduce transaction costs for intellectual properties is examined. Although diverse departments of the Korean government are operating diverse technology transfer information networks, as shown in Table 3, among others, no integrated online technology market at the level of the government has been systematically organized in Korea. That is, the diversity of information of NTB, which is a public technology integration network, is insufficient. For instance, NTB is just sharing some DBs with the Internet Patented Technology Mart under the Korean Intellectual Property Office that has the largest amount of information except for NTB on an annual interval. NTB shares only Meta information with information networks of departments other than the Korean Intellectual Property Office and thus integrated technology information searches are limited. As a result, there are considerable limitations for demanders to obtain desired technologies from NTB, which is an integrated site. Moreover, individual technology markets' information networks equipped with differentiated identities linked with related industries have not been activated either. Furthermore, the

Table 3 Present state of technology transfer information networks operated by diverse departments of Korea

Related department	Technology Transfer Information Network (year of establishment)	Operating Organization	Nature of Operating Organization	Number of DBs
Ministry for Food, Agriculture, Forestry and Fisheries (Rural Development Administration)	Outcome Yard (2010)	Korea Institute of Planning and Evaluation for Technology of Food, Agriculture, Forestry and Fisheries	Specialized research management organization	464
	Agricultural technology market place (2010)	Foundation of Agricultural Technology Commercialization and Transfer	Technology transacting organization	1,397
Defense Acquisition Program Administration	Private and military technology cooperation promotion center (Cyber technology exchange information yard, 2011)	Agency for Defense Development	National research institute	739
Ministry of Health and Welfare	Health Technology Transfer Center (2011)	Korea Health Industry Development Institute	Specialized research management organization	506
Ministry of Knowledge Economy	National Technology Business integrated information network (NTB, 1999)	Korea Institute for Advancement of Technology	Specialized research management organization	91,343
	Daedeok Innopolis Technology Commercialization Information System (DDIT, 2006)	Innopolis Foundation	Technology trust organization	9,330
Korean Intellectual Property Office	Internet Patented Technology Mart (IP-Mart, 1997)	Korea Invention Promotion Association	Technology transacting organization	54,815
Ministry of Environment	Korea National Environmental Technology Information Center (KONETIC, 2000)	Korea Environmental Industry and Technology Institute	Specialized research management organization	396

Source: National Science and Technology Commission, (2012a).

information on supplied technologies presented by NTB and the Internet Patented Technology Mart is inclined to formality and thus important technologies are omitted or added information to support price determination for technology transactions is insufficient so that the usefulness of NTB and the Internet Patented Technology Mart is very low.

In addition, currently in Korea, the level of both online and offline technology brokerage markets for technology transfer is remarkably lower compared to the level of national research and development investments or universities and industries. This can be sufficiently identified from the fact that, in 2010, although national research and development tasks in which enterprises participated accounted for 48% of all national research and development tasks, the records of commercialization of those tasks were only 19% of the records commercialization of all national research and development tasks. The evidence can also be identified from the fact that the productivity of technology transfer per case (royalty/number of cases of transfer) of national research institutes in Korea country is very low to the extent that 1/17 of it is in the USA and 1/3 of it is in Europe. The biggest reasons for this are that market leading type enterprises or experts specialized in technology transfers are not activated in Korea. The infantility of technology-mediating industry in Korea can be estimated from the attitudes of the Korean research world and industrial world that regarded global technology-mediating enterprises, such as Intellectual Ventures and InnoCentive, as patent trolls when these technology-mediating enterprises entered Korea. In addition, currently, the share participation type technology transfer method that will enable universities or government-funded research institutes to receive a part of technology royalties as stocks instead of cash when they have transferred patents to enterprises is restricted, deactivating active technology transfers. Although approximately 160 organizations dedicated to technology transfers (Technology Liaison Office) were made by universities and government-funded research institutes in Korea in 2010 pursuant to the law, most of them are very small and have no base for self-reliance. In the case

of Korea, not only linkages between the outcomes of national research and development projects and technology commercialization support projects are insufficient, but also systems to reflect market demand when planning national research and development projects have not been organized. The largest task of the Korean government's open innovation policies for enhancing the fluidity of knowledge and technology among industry, academy, and research institutes can be said to be eventually the activation of knowledge and technology-mediating markets. This activation of technology-mediating markets can lead to the activation of merger and acquisition channels as important technology or knowledge supply sources for the growth of medium enterprises in Korea. External channels for securing new technologies for medium enterprises are urgently necessary for both the project World Class 300 currently implemented by the Ministry of Knowledge Economy in 2013, which is intended to foster 300 global level medium enterprises and the project for fostering 3,000 medium enterprises which is a policy objective presented by the same department in 2012 and is now pursued. The external channels can be obtained only by activating technology-mediating enterprises.

3.2 Open Innovation Trends and Policy in Japan

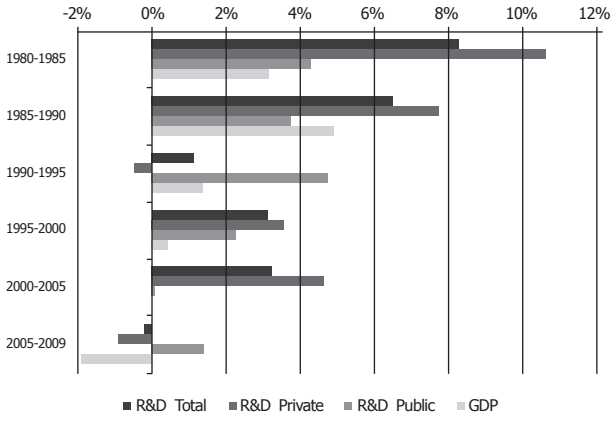
Man has described Japan's system of innovation as being in-house oriented and mainly driven by large corporations but external collaboration in R&D has been picking up in Japan since around the year 2000 (Motohashi, 2011). Conducting all required R&D internally is nearly impossible in mainly high-tech industries, such as electronics and pharmaceuticals, so shifting to an open innovation model is becoming a hot issue for Japanese companies. A report by the Research Institute of Economy, Trade and Industry shows that open-innovation activities, such as R&D collaboration with other firms and universities, have increased over time, and this trend is prominent particularly among small and young firms (Research Institute of Economy, Trade, and Industry, 2004).

As shown in Figure 1, in Japan, as enterprises' investments in research and development have decreased since the middle of the 2000s along with minus growth of GDP, overall research and development investments have decreased despite that the increase, small it may be, in government's research and development investments. In this situation, it is true that open innovation to secure new knowledge and technologies from the outside is becoming more and more important than ever.

Japanese enterprises' open innovation was reviewed as of the time when Japanese economy was recovered before the Lehman matter, as shown in Figure 2. Enterprises concentrated their energy on the development of their own core technologies and cooperated with universities for basic science or technology frontier projects and with SMEs for new areas of R&D.

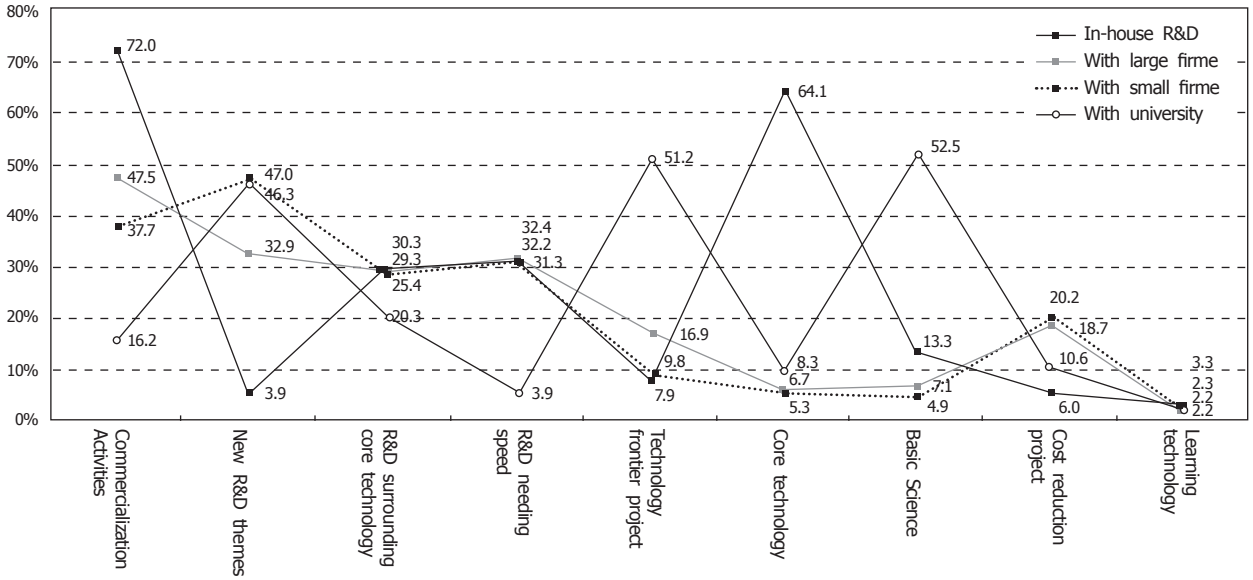
According to a comparative analysis of innovation activities by Japanese, U.S., and European firms in China, (1) foreign branches of Japanese firms are characteristically viewed as local branches of the home research facility, (2) foreign branches of U.S. and European firms conduct activities independently and actively collaborate with local universities and research facilities, and (3) the profit margins of Chinese branches of Japanese firms as a whole (Motohashi, 2010).

The Japanese government's open innovation policies can be estimated through budget structures among others. In 2010, of the total S&T budget amount of 3.57 trillion yen of Japan, 65% was executed by



Source: Motohashi (2011)

Figure 1 Japan's annual growth rate of GDP and R&D



Source: Research Institute of Economy, Trade, and Industry (2004)

Figure 2 Japan's in-house and collaboration R&D in 2004

the Ministry of Education, Culture, Sports, Science and Technology (MEXT), 15.1% was executed by the Ministry of Education, Culture, Sports, Science and Technology (METI), 4.3% was executed by the Ministry of Agriculture, Forestry and Fishery (MHLW), and 3.5% was executed by the Ministry of Agriculture, Forestry and Fishery (MAFF). Whereas the MEXT is mainly in charge of investments in universities' research and development, the METI is in charge of organizing R&D programs for industrial innovation.

An R&D project by the METI is typically organized by a group of companies working on large-scale R&D projects. These projects are funded by the METI and public research institutions, such as Agency for Industrial Science and Technology (AIST). The Very Large Semiconductor Integrated Circuit (VLSI) project and a substantial number of such projects in the area of advanced materials, mechanical engineering, energy development and environmental technologies have been introduced as the METI R&D projects. However, due to the increase in technological complexity and because huge enterprises in Japan have been equipped with their own technological capabilities, most of the METI's existing research projects have not produced successful outcomes. As an alternative for this situation, the METI presumed specific social and policy needs, such as "healthier and longer life" and is organizing research and development projects aiming at satisfying the needs.

One of the METI's new research and development projects is promoting innovation at SMEs. SMEs that had been the subjects of assistant policies of large enterprises' research and development projects previously have become the source of entrepreneurship, innovation, and job creation. Now, SME innovation policies, such as the Japanese Small Business Innovation Research (SBIR) have become a top priority. The uptrend can be sufficiently presumed from the fact that the SBIR budget has been showing an increasing trend with an increase by at least four times in 10 years from 10 billion yen in 1999 to over 40 billion yen in 2010. According to a questionnaire survey on the characteristics of open innovation of enterprises recently conducted on Japanese SMEs, Japanese enterprises with high technology levels and activated organizational culture to cooperate with internal or external organizations are actively implementing diverse kinds of open innovation based on ICT (Idota et al., 2012).

According to the interview with the councilor

in charge of scientific technology at the Embassy of Japan in Korea, the Japanese government also recognizes that solutions for economic recession are effective preparation and implementation of open innovation policies and is preparing related policy alternatives. Among others, effectively developing national research and development projects reflecting social demand and effectively implementing the projects through industry-academy-research institute's manpower and space linking systems are important. In particular, he specified that activating small and medium enterprises' participation in national research and development to create new creative business and preparing global level technology systems and open innovation systems to continuously create new sustainable growth engines are tasks of Japan.

3.3 Open Innovation Trends and Policies in China

China's innovation policies are largely divided into open-door policies or market-based open innovation systems before 2006 and indigenous innovation policies thereafter (Liu & Lundin, 2006; Wei, 1993; Bichler, 2012). Whereas China pursued the development of manufacturing industries and various other industries based on foreign countries' technologies and knowledge until 2006 after opening its doors to the world market, Chinese government's policies bases have been greatly changed once more since 2006 in order to raise its innovation ability.

Since the 1980s, China launched its economic reform and open-door policy toward a market-oriented economy of great openness (Liu & Lundin, 2006). The Chinese national innovation system at this time is basically a market-based open innovation system. As shown in Table 4, in 1990, research and development investments in China consist of investments by government led research institutes accounting for 50%, investments by universities accounting for 12%, and investments by enterprises accounting for 25% of all research and development investments in the country. However, the ratios were completely reversed in only in 10 plus some more years so that in 2005, investments by research institutes accounted for 21%, investments by universities accounted for 10%, and investments by enterprises accounted for 68% of all investments.

Table 4 Changing of R&D expenditure ratio during key actors during open-door policy era (%)

	1990	1997	1999	2000	2002	2004	2005
Research institutes	50	43	39	29	27	23	21
University	12	12	9	9	10	10	10
Enterprises	27	43	50	60	61	67	68

Source: China Statistical Yearbook on Science and Technology 2004 (2006).

In fact, since its opening in 1978, China switched its economic structure into a market-centered one. However the practice for government research institutes (GRIs) led basic research projects to account for the majority of research projects was maintained until the early part of the 1990s. In this respect, the Chinese government carried out a drastic change. Toward the end of 1998, the State Council decided to transform 242 GRIs at the national level into technology-based enterprises or technology service agencies (Liu & Lundin, 2006). As a result, enterprises' research and development investments become to exceed 50% of all research and development investments when the 2000s began.

Meanwhile, in China, a great gap existed between GRIs and universities, which are knowledge-creating organizations, and enterprises, which are knowledge-utilizing organizations, that the situation underwent a major change during the period of open-door policies. Among others, GRIs universities were allowed and encouraged to build up their own spin-offs so that they could commercialize their technology directly. According to Statistics of University's industry, after 2137 universities' spin-offs were made in 1999, universities' spin-offs have been actively and continuously created including 2447 created in 2003 and 2355 created in 2004. Furthermore, as universities activated contract research for the industrial sector, most of universities' research and development activities were switched to studies for enterprises to the extended that after the ratio of funds from industrial enterprises to the entire universities' research and development funds was recorded as 33.3% and the ratio of funds from the government was recorded

as 58.4% in 2000, the ratios were recorded as 38.9% and 53.8% in 2004.

Due to the open-door policies, in China, whereas market centered technologies rapidly developed in a short time, the composition or level of the technology in the period exposed the limitations as shown in Table 5. That is, the Chinese government placed emphasis not on patents based on creativity but on utility model patents or design patents centered on applications and improvement. In addition, whereas China recorded placed 26th in terms of the number of patent registrations in the U.S. in 2000 with 119 patents, Korea recorded placed 8th with 3,331 patents. Thereafter, whereas China took the placed 20th with 404 patients in 2004, Korea took placed 4th with 4590 patents. That is, in terms of quality and quantity of patents, China's records during the period open-door policies were not so great.

During the open-door policy era, both in the manufacturing sector and in high-tech industries, foreign direct investment (FDI) firms accounted for important parts of technology import, R&D expenditure, export, and employment. In the case of the manufacturing sector, whereas FDI firms accounted for 21% of research and development investments, 20% of technology import, 58% of technology export, and 14% of employment in 1998, they became to account for 29%, 48%, 76%, and 34%, respectively in 2004. In the case of high-tech industries, too, in the areas of pharmaceutical products, electronics and telecommunication, computer and office equipment, and medical equipment and instruments, FDI firms became to account for high ratios of tech import, export, employment, and R&D expenditures. In particular, FDI firms' shares of technology import and export became very high both in the manufacturing sector and in high-tech industries. During this period, although FDI firms' research and development investments and employment also increased, a stagnation phenomenon clearly appeared that the shares did not increased from the 20% zone and the 30% zone, respectively.

Table 5 The patents granted in China—By type of Patents in open-door policy era

(unit: piece)

	2000	2005
Total patents granted	105345	214003
Invention patent	12683	53305
Utility model patent	54743	79349
Design patent	37919	81349

Source: China Statistical Yearbook on Science and Technology 2004 (2006).

In this situation, China switched its policies into indigenous innovation policies in 2006. The "National Plan 2006–2020 for the Development of Science and Technology in the Medium- and Long-Term" is the current long-term S&T policy framework of China. The most interesting element of the new plan is the declared intention to strengthen "independent" or "indigenous" innovation (Liu & Lundin, 2006). The new innovation system maintains the central government, state-owned enterprises (SOEs), and universities and government-led research institutes as significant elements. They are now also developing innovation from private enterprises, multinational enterprises, and regional government with private enterprises significantly becoming the key players (Liu & Cheng, 2011). Its goal is to make China a globally significant innovative country through the implementation of this indigenous innovation strategy (Liu & Cheng, 2011). The current strategy of indigenous innovation has an intention to protect domestic enterprises from global competition while leveraging an exceptionally large domestic market to promote the diffusion of innovative products within China to some degree. By converting domestic enterprises from cost-limited to innovation-driven institutions, decreasing reliance on foreign technology, mastering cutting-edge industrial technology, and promoting economic and social development, the goal is to make China one of the world's recognized innovative countries (State Council of China, 2006). However, a problem is that the Chinese efforts in indigenous innovation are indispensably accompanied by the necessity to establish innovation networks that will have global impacts but the exceptionally large domestic market cannot accomplish this on its own.

Although China's per capita GDP was below $500 in 1978, it grew to a level close to approximately $3,500 by 2008. According to an evaluation from the outside, such as East-West Center, unfortunately,

despite this outstanding economic growth, China's capability for technologic innovation had not developed as successfully. The objective of the Chinese government's indigenous innovation strategy established in 2006 was to invest 2% of Chinese GDP in research and development by 2010 and 2.5% of Chinese GDP in research and development by 2020.

The Chinese government's research and development investments accounted for 1.34% of GDP with a total amount of USD 30.56 billion in 2005 but the percentage increased to 1.70% of GDP with a total amount of USD 86.60 billion in 2009. In 2007, the total amount of research and development investments of China already reached seventh place in the world in absolute value. Specifically targeted national science and technology programs, such as 973 basic research, key technologies research and development program, 863 high-tech program, national key experimental laboratories program, and innovation fund for small and medium enterprises (SMEs) established by the Ministry of Science and Technology (MOST).

The best means of new Chinese policies is the changes to government technology-procurement policies which follow from the lessons of the best practices of South Korea and the United States. In fact, previous Chinese government's purchase policies were cost minimization and were not indigenous innovation promoting. The key concept of these policies is to make use of public funding to promote the development of innovative domestic products: they have a Chinese brand, use Chinese intellectual property, and have at least 51% Chinese ownership. In addition, these policies also require that in the case of key projects given by governments too, made-in-Chinese equipment should account for at least 60% of all core equipment.

In the new innovation policy era, the Chinese government adopted a strategy to implement 16 mega-projects by organizing research consortia in which private enterprises play more important roles. For example, in the "high-performance digital machine tools mega-project, coordinated by Ministry of Industry and Information (MII), the main participants include: Beijing First Machine-Tool Group, China Academy of Machinery Science and Technology, and Xian Jiaotong University. Another good example is the mega-project developing next-generation telecommunications technology in which Huawei and ZTE, as well as China Mobile, are all key players in the consortia.

However, ironically, despite the indigenous innovation policy of China, the ratio of investments in basic research that had decreased because the opening did not increase. Out of Chinese investments in research and development in 1995, the ratios of investments in basic research, applied research, and experimental development were 5.18, 26.39, and 68.43, respectively. However, these respective values were shown to be 4.70, 12.6, and 82.7, in 2008. That is, the ratios of investments in basic research have been rather decreasing.

In China, usually only large SOEs have historically been able to maintain a large number of scientists and engineers as employees, but this trend changed dramatically after the indigenous innovation policy started. For instance, the ratio of research and development manpower employments by SOEs that had accounted for most of private employments of scientists and engineers rapidly from 48% in 2002 to 25.9% in 2007. Enterprises' research fund ratios also showed the same phenomenon. By 2007 non-SOEs accounted for 49.4% of all noted enterprise segments' research and development funding while SOEs accounted for only 22.6%.

The 2006 adoption of a Chinese indigenous innovation strategy has resulted in significant changes in the realities of innovation practices within China through establishing government-led research consortia and key government procurement policy tools; China's government was able to increase its control over the resources available for innovation.

According to a questionnaire survey based study on the present state of Chinese enterprises' open innovation conducted in 2012, when the enterprises were requested to give answers about the importance of information sources in innovation activities through questions to which overlapping answers were allowed, of the enterprises' answers, 41.7% were firm itself or its affiliated group, 52.5% were user of consumers, 10.0% were government or public R&D institutes, and 8.3% were universities (Fu & Xiong, 2011). To

questions regarding Chinese enterprises' sources of knowledge for open innovation, the answers indicated that the enterprises were actively implementing open innovation by obtaining knowledge from markets and research institutes beyond the inside of the enterprises, the most frequently from market information sources followed by internal sources and institution information sources in order of precedence.

3.4 Characteristics and Summary of Three Countries' Open Innovation Policy

Open innovation policies are related to knowledge production, distribution, and consumption policies as shown in Table 1. Among them, knowledge production policies are not implemented alone. The relevant policies can be said to be open innovation policies only when they are implemented together with knowledge distribution or consuming policies (Chesbrough & Vanhaverbeke, 2011). Korean open innovation policies are understood as being gradually changed from knowledge production centered policies to diverse methods of knowledge distribution centered policies. Examples of these changes may include the preparation of diverse policies to activate the dispatch of university professors or researchers to enterprises of the reinforcement of policies for school enterprises and research institute enterprises.

On the other hand, Japan is evaluated to currently reinforce knowledge production-centered open innovation policies involving knowledge distribution and consumption. Examples of those policies may include the development of social problem solving type large national research and development projects and the establishment of research and development hubs in which universities, enterprises and national research and development institutions are to be situated together for joint research and development. The policies can be characterized by the fact that they concentrate more on knowledge production that can be accompanied by knowledge distribution and consumption.

Finally, in the case of China, the base of policies is considered gradually changing from focusing on knowledge consuming to emphasizing knowledge production and distribution simultaneously. The indigenous innovation policy is not a strategy to change the existing open innovation policy into a closed innovation policy but a strategy to reinforce knowledge production capabilities further and reinforce knowledge distribution and consumption based on the reinforced knowledge production capabilities.

4. A Few Misunderstandings on Open Innovation in Asian Countries

4.1 Open Innovation as a Channel of Not Monopolizing Innovation but Democratizing Innovation

The innovation proposed by Schumpeter was innovation based on creative entrepreneurs' entrepreneurship at the beginning and the discussion was developed into innovation by groups of large enterprises later (Schumpeter, 1942). Thereafter, diverse innovation discussions were developed in Evolutionary economics and innovation studies and most of the discussions were centered on the theory of innovation systems. The theory of innovation systems is clearly more progressive that not only the Neoclassical theory, but also the Keynesian theory in that all of discussions of government's policies' intervention in System failure, National Innovation Systems, and Regional Innovation Systems have a theoretical basis of the government's more active intervention in markets. However, most Asian countries including not only Korea, but also Japan and China have characteristics distinguished from innovation studies in Europe or in the USA that are linked to political progressiveness in that they approach innovation policies from practical viewpoints. Therefore, the fact that the open innovation has an aspect of democratizing innovation as strong as user innovation should not be overlooked in that the open innovation becomes the basis of the innovation logics of SMEs or individual business founders based on creative ideas. That is, rather than having a value as an innovation strategy of large enterprises having sufficient research and development capabilities or a policy for the strategy, open innovation can be a strategy more suitable for SMEs that promote creative innovation and sustainable growth based on diverse external ideas. In addition, its value as a means of

the start-up of individuals' open innovation business models based on ideas and knowledge existing in the world as a means of sustainable economic and social growth should not be overlooked (Yun, 2010).

4.2 Open Innovation is Not "Not Unique" but "Very Unique"

Diverse discussions of which the logics are already connected to the theory of open innovation or the cores of the logics are similar to that of the theory of open innovation already exist in existing economic or business administration theories such as the discussion on external effects that took notice of the effect of external economy that surpasses existing economic effects in economic theories or customer relationship management that took notice of customers' demands, expectations, or opinions in business administration. However, the importance and value of the discussion on open innovation that explicitly took notice of enterprises' or diverse economic units' pursuit of new innovation based on external knowledge and technology that they did not create or their transfer to the outside or utilization of internal knowledge and technology that are not utilized cannot be overlooked. In particular, the fact that in Asia, where the Confucian tradition is strong, in the state where the importance of technology-based economy has been just established in economic systems, cultures that makes enterprises and economic units be unwilling to acknowledge or take notice of the value of open utilization of technologies and knowledge not created by them are overflowing cannot be denied. Whether another hidden reason Japanese economy that had been even expected to go beyond the economy of the USA fell into recession at the time when knowledge distribution and consumption became more important than internal production of knowledge is the culture in Japan, which is hostile to open innovation should be watched. Open innovation is a phenomenon having quite unique characteristics which enable enterprises or governments to obtain high economic profits only when they have invested considerable amounts of finances and strategic costs.

4.3 Open Innovation Needs, Not No-R&D Investment but Enough R&D Investment.

The paradigm of open innovation has come to appear following the advent of knowledge-based economy in which the amounts of knowledge and technology existing outside innovating bodies, such as enterprises, have become sufficiently large. In addition, in particular, open innovation has come to be watched as an innovation strategy when enterprises that have accumulated sufficient technology and knowledge on their own became to take notice of innovative external technologies or ideas not owned by them. In other words, only those enterprises and countries that have sufficient innovation capabilities on their own can be equipped with the insight and ability to realize the necessity of external knowledge and technologies and acquire the knowledge and technologies. This is the reason for the fact that the current core technology management strategies of global leading enterprises in the USA and in Europe are open innovation strategies. The reason Samsung recently established a large research institute in Silicon Valley and had the research institute take full charge of open innovation strategies is also based on this context. The reason technology-based global cutting-edge enterprises and countries where world class cutting-edge industries have developed are leading in open innovation strategies and policies is that only these enterprises and countries are equipped sufficient internal innovation capabilities based on sufficient research and development investments and became to pursue open innovation capabilities.

In other words, open innovation strategies and policies are not something for which internal research and development investments are unnecessary but are strategies and policies that must be pursued on the basis of sufficient internal research and development investments. Asian enterprises or countries that are just being equipped with their own research and development capabilities should never overlook the necessity of internal research and development investments as they face the open innovation strategies and policies pursued by Western advanced countries and cutting edge enterprises.

5. Policy Proposals for Activating Open Innovation in Asian Countries

Although China is in a little different situation, the reasons why open innovation has not been activated commonly in Korea and Japan appeared both in interviews with persons in charge of policies of the two countries and literature analysis. Among others, important reasons are that excellent researchers are concentrated on universities and that even if the researchers create excellent study outcomes with enormous economic performance, they would never move to enterprises or markets. That is, the lack of researchers' fluidity is the most serious hindrance factor for open innovation. Therefore, the first proposal for Asian countries' open innovation policies is that the countries should be equipped with diverse, stereoscopic, and practical policy systems that can enhance researchers' fluidity. Policies for enhancing researchers' fluidity, which coincide with the entire life cycles of technologies, should be prepared to enable university professors or researchers of national research institutes who created excellent study outcomes to willingly move to enterprises with the relevant technologies, stay there for the life cycle of products from the relevant technologies and come back to universities or enterprises to dedicate themselves to studies when necessary. These policies are more necessary because researchers in Asian countries where the Confucian tradition is strong have cultural traditions that make them avoid transfers from universities or research institutes to enterprises.

It is well known that the arrow information paradox exists in relation to knowledge and technology transactions (Chesbrough, 2003). The paradox is that demanders are not willing to pay prices unless the knowledge and technology which are the subjects of transactions are well known and when they have come to sufficiently know knowledge and technology, which are the subjects of transactions, they try to use the relevant knowledge free of charge without pay prices. An important base for overcoming this arrow information paradox is trust (Fukuyama, 1996). Unlike in Western society where the tradition of capitalism is strong, it is well known that in Asian countries, cultures for trust have not been sufficiently accumulated yet not only in transactions of tangible goods, but also in transactions of intangible knowledge and technology. In Western countries centering upon USA, diverse knowledge and technology-mediating enterprises appeared to overcome the arrow information paradox and activate technology transactions in diverse methods. Therefore, among others, Asian countries should prepare diverse stereoscopic cultural and institutional policies that can overcome the arrow information paradox in knowledge and technology transactions and activate knowledge and technology transactions. The activation of knowledge and technology transactions in markets is the most concrete open innovation activation policy. To this end, in the case of Asian countries in particular, technology and knowledge transaction activation policies should be established in comprehensive dimensions, including culture, systems, and policies.

The present paper summarized open innovation policies of Asian countries including Korea, Japan, and China at a limited level. Therefore, comparing open innovation policies of Asian countries, establishing analysis frames to compare and analyze open innovation policies of Asian countries and those of Europe or the USA, and precisely comparing and analyzing the open innovation policies from the viewpoint of the production, distribution, and consumption of knowledge and technology are left as tasks for follow-up studies.

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