KISTEP
R&D and
Beyond
2015
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KISTEP R&D and Beyond 2015

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As we reflect on the year 2015, the past 12 months have been marked by noteworthy achievements of KISTEP. We recount the memories and achievements, wonder at the way time has flown, and indulge in self-reflection like no other time of the year.

KISTEP R&D and Beyond 2015 is, among other things, a compendium dedicated to the highlights of our achievements. In January, KISTEP selected 10 S&T policy issues based on major societal needs and announced them during the ‘KISTEP 10 S&T Policy Issue Forum.’ Based on the research on the selected policy issues, the ‘KISTEP Report on the Future of Korea’ was published in October. This report provided both microscopic and macroscopic understanding of how changes in S&T reconstruct economic, social and industrial landscapes. It also covered key issues for the socio-economic development of Korea while discovering new issues which will greatly impact our society in the near future.

This year, KISTEP continued its efforts to build a platform for international cooperation and strengthen ties among global S&T network.

The 1st Asian Innovation Forum (AIF) was held in August with a theme of ‘Towards Better Asia: Seeking New Possibilities of Innovation.’ This forum aimed to share innovation experiences and foster cooperation among Asian countries. The forum turned out to be a great success with more than 90 participants from 65 institutes and 21 countries. We hope that this forum will continue to promote innovation in the coming year by opening up the channels of communication and building networks between Asian innovators. During the AIF, the Asian STI Think Tanks Network (ASTN) was launched with 15 institutes from 11 countries as founding members. ASTN is expected to grow to become a representative body in the international arena on issues related to S&T policy and joint growth of Asian countries.

KISTEP also co-hosted the Gender Summit 6 Asia Pacific 2015 with the Center for Women in Science, Engineering and Technology (WISET) and National Research Foundation of Korea (NRF) in August. This Gender Summit was meaningful in that it was the first Gender Summit ever to be held in Asia-Pacific region and its emphasis was transition from gender balance to gendered innovation. The purpose of this summit was to support and advance effectiveness of research and innovation at all levels through the inclusion of gender. KISTEP will continue to support creating a sustainable science and technology ecosystem where both genders work more creatively in harmony by ensuring gender diversity in the science and technology field.

In November, KISTEP held the 7th KISTEP-ISTIC STI Training Program for High Level Policy Makers in Developing Countries with ISTIC (International Science, Technology and Innovation Centre for South-South Cooperation under the Auspices of UNESCO) in Seoul, Korea. This year, we were excited to have 7 countries that participate in the program for the first time. So far, 160 high level policy makers from 56 countries participated over 7 years. We hope to continue our assistance to developing countries in enhancing innovation capacities by sharing experiences of Korea in S&T innovation, while providing a network for seeking future collaboration opportunities.

With such a great year behind us, it is not without regret to see that it has so quickly drawn to a close. But indeed, an year’s end is just the beginning of another. Perhaps this duality, the simultaneous conclusion and dawn of another calendar year, is what fills our end-of-year celebrations with such excitement, promise and hope.

The next two years hold great significance in the history of science and technology in Korea. The year 2016 marks the 50th anniversary of the establishment of Korea Institute of Science and Technology (KIST) which has been considered as the start of advanced science and technology. In the following year of 2017, the Ministry of Science and Technology, which was the first ministerial-level agency responsible for promotion of science and technology, will also celebrate its 50th anniversary. In the 1960s, the Korean government reinforced S&T policies and strongly promoted the advancement of science and technology. As a result, Korea has undergone amazing transformation from a beneficiary with a per capita GDP of 67 USD to one of the wealthiest and most developed countries. In anticipation of a new turning point after the past 50 years, we published the ‘Moments of Innovation,’ sharing the interviews with the former ministers of science and technology. It was a great opportunity to hear stories behind the ground-breaking achievements in science and technology of Korea. Looking forward to 50 years ahead, KISTEP will put all efforts to become a global think tank in S&T policy and take the lead for a new takeoff to the future.

In this issue of KISTEP R&D and Beyond, you will discover the highlights of KISTEP’s activities, research articles, R&D statistics and interviews with internationally recognized experts. I hope you enjoy these glimpses into the year 2015 as much as we did putting them together.

Please enjoy KISTEP R&D and Beyond 2015 and we thank you for your continued interest and support.

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Science Diplomacy between South and North Korea

Chan-Mo Park | Chancellor, Pyongyang University of Science and Technology (PUST)  
Professor Emeritus, Pohang University of Science and Technology (POSTECH)

There are many things that need to be done to achieve the reunification of South Korea and North Korea, a long-time wish of over 70 million people of the two Koreas. Politicians have tried to come up with political solutions, while businessmen have tried to map out an economic plan to facilitate reunification. As a scientist, I have long been thinking about what the scientific community should do, and have come to the realization that science diplomacy between Seoul and Pyongyang is an important area.

I experienced the terrifying realities of war and the tragedy of our country being divided into the North and the South, as the Second World War took place when I was an elementary school student and the Korean War occurred when I was a middle school student. During the Korean War, I once survived three days of drinking only water under the rule of the Chinese army. I think most people of my age went through similar experiences. People who endured the adversities of the Korean War feel strongly about the importance of the peaceful co-existence and co-prosperity of the two Koreas, and believe that in order to realize peace in Northeast Asia and in the world, Seoul and Pyongyang should ease tensions, exchange people and technology, and collaborate with one another on various fronts.

Science diplomacy is important, as it breaks down the walls and lays bridges between countries and promotes the happiness and well-being of mankind, therefore contributing to the realization of world peace.

For one year starting in August of 1985, I taught the graduate courses at the West German campus of Boston University (USA). During my vacation, I took the train in West Germany to go to West Berlin via East Germany. Then I took a bus bound for East Berlin. The bus went through Charlie’s point, a place on the demarcation line between West and East Germany. At the time, I was able to make phone calls or write letters in East Berlin to friends in West Germany, and wished that people in the two Koreas could do those things. A few years later, the two Germanies became reunited. Though they already collaborated in the areas of science and technology before their reunification, they experienced a lot of difficulties after the reunification. In 1990, I had an opportunity to talk to a physicist working for the National Academy of Science of North Korea during the International Modern Physics Workshop held in Yanbian, China and I realized that the Information Technology (IT) gap between the two Koreas was wide. Through these experiences, I came to believe that for a smooth reunification, this gap should be narrowed, and envisioned an exchange and collaboration scheme through science diplomacy.

It is a well-known fact that science diplomacy plays an important role in world peace. Although there are political boundaries among the nations there are no national boundaries in science. Professor Abdus Salam, one of the founders of the International Center for Theoretical Physics (ICTP) declared that “Science is the common heritage of mankind.” This notion laid the groundwork for building the international collaboration system in science. In most cases, scientists in different countries form a good relationship among themselves regardless of religious, economical, or political boundaries. They maintain a good relationship through science diplomacy even when political diplomacy fails. “Science is great, because it is a common language of people from different cultures and regions.” said Dr. William Colglazier, who served as a science advisor to US Secretary of State Hillary Clinton from 2011. He also said, “Scientists can communicate and work together easily even when cooperation at the government level does not occur.”

Science diplomacy can be defined as a series of actions to improve the relations among countries through cross-border science and technology cooperation, such as exchanges of scientific information, joint studies, etc. Science diplomacy is important, as it breaks down the walls and lays bridges between countries and promotes the happiness and well-being of mankind, therefore contributing to the realization of world peace. The objective of science diplomacy is to resolve many global issues together, such as climate change, green growth, food shortage, disease elimination, nuclear security...
and so on. Scientists cooperate for the common goal, regardless of where they live. Thus, science diplomacy is regarded as one of the most innovative ways of achieving world peace. One typical example is the cooperation between civilian scientists of the US and the Soviet Union during the Cold War. Although there were no official diplomatic relations, the US and the Soviet Union issued visas to scientists from each country and allowed them to work on mutually important projects like the International Space Station. Similar efforts can be found in the joint declaration of the Korea-China-Japan Summit. The heads of state of the three countries decided to communicate and collaborate with one another to resolve the global challenges of climate change, financial crisis, energy and food security, public health, natural disaster, terror prevention, and weapons of mass destruction proliferation control, and work toward economic development, mutually beneficial outcomes, and win-win effects.

As we know very well, the prosperity of Northeast Asia depends on the peace and stability of the Korean Peninsula. Since the historic South-North Korea Summit in June of 2000, exchange and cooperation, especially in the Information Technology sector, has contributed to the peaceful coexistence of South and North Korea. I who conducted a study on the IT sector in North Korea with the support from the Ministry of Science and Technology starting from 1990, gave special lectures at Kim Chaek University of Technology and at the Pyongyang Informatics Center (PIC) in September 2000, and conducted a joint-study with PIC starting in April 2001, opening the floodgates to Inter-Korean science diplomacy. I visited Pyongyang many times, and through this process came to feel that we truly are people of the same nation, and that we could build mutual trust. Especially, in October 2002, when the North Korean economic delegation visited Pohang University of Science and Technology (POSTECH), President of the Kim Chaek University of Technology, Seoheon Hong, and I exchanged views on POSTECH’s digital library, which helped the North’s technology university to establish its digital library. Thanks to these efforts, in April 2006 the Inter-Korean Science and Technology Conference, which had previously been held in third countries such as China and Japan, was held at the People’s Palace of Culture in Pyongyang. Twenty people from the South, 150 people from the North, 10 people from China, 10 people from the US, and 1 person from Japan were present at the forum. At the conference, under the title of “Korean Conference on Science and Technology,” two keynote speeches were delivered and 47 papers from the IT, bio technology (BT), nano technology (NT), and environmental technology (ET) sectors were presented. In 2007, a symposium for the chemistry field was held in Pyongyang and about one hundred people from the South flew on a charter plane to the North’s capital to attend the meeting. However, the tensions between Seoul and Pyongyang increased due to the shooting and death of a tourist at Mt. Kumgang, the sinking of ROK’s Cheonan ship, and the bombardment of Yeonpyeong islands. Fortunately, science diplomacy did not stop and was continued thanks to Pyongyang University of Science and Technology (PUST). I believe this science diplomacy will help Seoul and Pyongyang to ease tensions and exist peacefully. In 2001, Seoul and Pyongyang gave approval to establish PUST. The construction was completed in September of 2009. In October of 2010, 150 undergraduate and graduate students were admitted into the newly-built university and started to take English classes. As all courses are taught in English, undergraduate and graduate students dedicate themselves to reading, writing, listening, and speaking in English for one year and for 6 months, respectively. Currently, about 400 undergraduate students and about 60 graduate students belonging to the School of Electrical and Computer Engineering, the School of Agriculture and Life Sciences and the School of International Finance and Management are taught by about 70 professors from 16 countries. In addition, a Medical School was established, and this year about 40 graduate students majoring in Public Health and Dentistry will be admitted, and more professors will come.
Science diplomacy is regarded as one of the most innovative ways of achieving world peace.

Since PUST started to admit students four years ago, it has held two international conferences and invited keynote speakers such as Professor Peter Agre, a Nobel prize winner; Lord David Alton, a member of the House of Lords; Professor Neil Scolding, a world-renowned stem cell scientist; and Dr. David Hilmers, a US medical professor who has been into space four times. Along with these four people, other prominent scientists from around the world, North Korean professors, and PUST students have attended the conferences, and by attending them, have participated in science diplomacy. In particular, Dr. Norman Neureiter, a US expert in science diplomacy, played an important role in the conference. Unfortunately, in 2013 when the second conference was held, South Korean scientists, despite the fact that they had visas to enter North Korea, could not attend due to the May 24th Measures, which were the South Korean government’s sanctions against North Korea. However, through the conferences, Western countries and North Korean scientists were able to build Human Networks, many foreign scientists recognized the merits of PUST graduate students and volunteered to guide the students in their research projects via the Internet, and attendees could resolve many of their misunderstandings about the Hermit Kingdom. In other words, PUST is doing its utmost to bridge the Western world and North Korea, and is contributing to the realization of world peace through science diplomacy.

It is due to science diplomacy that I can send this article via e-mail from PUST to Seoul. I look forward to the day when many South Korean scientists come to PUST and actively engage in science diplomacy for the two Koreas.

The United Nations Sustainable Development Summit 2015 was held from September 25 to 27 to launch the Sustainable Development Goals (SDGs) and a related action agenda for a transition into a global sustainable development system by 2030. It is no exaggeration to describe this as a historic attempt to adjust the trajectory of human civilization, as a giant community.

Human society has developed modern civilization over the 200 years that began with the Industrial Revolution in Europe in the early 19th century; developed countries have led its industrialization and economic growth. However, the number of people in absolute poverty and experiencing starvation reaches 1/7 of the world’s population, with many people even in developing countries suffering from disease and poverty. There is a structuralization of inequality,
As the UN has launched the SDGs system, the priorities of scientific and technological development in Korea should be realigned in accordance with the SDGs.

If one of the key methods for transformation is in the socially integrated innovation of the economy, another one would be newly developed technology. Technologies that destroy the environment should be gradually abolished and replaced by clean technologies.

As the UN has launched the SDGs system, the priorities of scientific and technological development in Korea should be realigned in accordance with the SDGs. The development and distribution of low-carbon technologies must be first priority and the Korean energy R&D institutes need to self-examine their attitudes towards related researches. The government, which has engaged in negotiations for reduction of national greenhouse gas emissions, can only be passive in these reduction efforts. It tends to only look at 2030 as a target year of reduction set in COP21 negotiations. However, researchers should study energy technology development and distribution plans with a strategy of developing competitive low-carbon technologies. They should set long-term low-carbon objectives to reduce greenhouse gas emissions consistently, and establish development plans. Researchers, at least, should study future low-carbon technologies more intensively than the government. The government-funded research institutes cannot transcend the short-term perspective of government, and has a tendency to neglect the long-term, in-depth research on low-carbon energy potential and its technologies. At the beginning of the era of sustainable development, researchers in science and technology should have long-term perspectives. Research strategies need to be realigned with a focus on SDGs, and become more creative and daring.
Researchers, Be Adventurous!

Min Seo | Professor, Dankook University

The number of parasites that live in the human body have significantly declined, but wild animals are still a paradise for parasites. As such, parasites are sometimes passed to humans from wild animals. Toxocara canis, which has recently emerged as an issue, is spread by dogs that are abandoned by their owners and become wild animals. And there is an elastic parasite living in the muscles of snakes, which is called sparganum. Unlike the parasites that used to live in the human body, these parasites live in other creatures and cause fatal symptoms when entering the human body. For example, toxocara canis can cause retinodialysis or meningitis, and sparganum attacks the brain or lead to mismatched testes.

One of the parasites that is spread through wild animals is Trichinella spiralis. This parasite enters the human body when we eat raw meat from wild animals such as wild boars. Trichinella spiralis has infected humans worldwide, and as such many countries have investigated to find out which wild animal could infect humans with the parasite. France investigated 2,000 wild boars, and Japan studied 1,000 racoons and 100 brown bears. Thailand, a trichinella-infected district, examined 0.35 million wild animals over 7 years. In contrast, the only country amongst the OECD member states that has never conducted any research into this parasite is our own, Korea. It is quite surprising considering that there have been a number of patients in Korea who were infected with the Trichinella spiralis. More specifically, more than 60 people have been infected over 8 times to date, mainly from wild boars. Under these circumstances, it is natural to wonder how many of our wild boars have the Trichinella spiralis. And this issue had to be solved by parasitologists.

In 2011, I stepped up to take the lead. I requested the national research foundation for a research grant of about 80 million won for a 2-year investigation into Korean wild boars. My request was accepted, presumably because of the consensus that the research should be conducted someday. But then, all of sudden, anxiety rose in my heart. “What if I did not find any Trichinella spiralis from the wild boars?” Trying to encourage myself that I could definitely find the trichina, I set off to Gangwon-do, where the majority of trichina infectees were found. There, I first looked for the Hunter’s Association in the province and asked them to provide me with some muscle tissue from wild boars after they caught them.

However, it was not easy to work with the muscles at all. When I received them, I cut them into small pieces with scissors, pounded them in a mortar, put in an artificial digestive juice, and stirred to separate larvae that might exist in the muscles. And then I pressed them with gauze, looking for any larvae. Whenever I went through all the steps, the dead of night would come so quickly, without my notice. However, it was not easy to work with the muscles at all. When I received them, I cut them into small pieces with scissors, pounded them in a mortar, put in an artificial digestive juice, and stirred to separate larvae that might exist in the muscles. And then I pressed them with gauze, looking for any larvae. Whenever I went through all the steps, the dead of night would come so quickly, without my notice. However, what I struggled with was not the physical labor. Cutting and pounding the muscles was not simple, but the great pity was that I couldn’t find trichina larvae in the wild boar tissue at all. Even though some parasites, observed from a few wild boars, had a similar shape to Trichinella spiralis, DNA
Even when research produces nothing, what if we were just to grant parasitologists additional research funds for 3 years, encouraging them by saying ‘You have worked hard and your research subject is definitely worthy of being studied, so keep up the great work for success.’ If this system could be established in our society, then we would be able to take a step ahead, and get closer to the Nobel Prize that still seems a long way off.

tests confirmed that they were different kinds. Eventually, my research ended up analyzing a total of 118 wild boars over 2 years, without any *Trichinella spiralis*. My fears had become reality. The upside, however, was that four of the wild boars confirmed a positive blood test for *Trichinella spiralis*. Yet, the blood test was just to measure antibodies in the blood. Actually, the existence of antibodies could be described as a shadow of the parasite. In other words, it did not signify that the four wild boars currently had *Trichinella spiralis* in their bodies, but only demonstrated that they had been infected with the parasite in the past. Indeed, the four wild boars did not even have a single trichina. Considering that my initial research plan was “If I find *Trichinella spiralis*, I will feed them to mice, breed the mice, and ultimately conduct a follow-up study using these mice, including the correct identification of trichina’s species,” my research was a desperate failure. Afterwards, when I made the study report for submission to the research foundation, I wrote C in the self-assessment section of the report, and worried that this self-assessment would be an obstacle to my future requests for a research grant. The only achievement from this research was an answer to the question, ‘Why has no one carried out this important research yet?’ All the laborious stages of the research were one of the reasons, but actually the fact that there were no countermeasures to be taken when the study produced nothing and turned out to be a failure must have been the primary rationale that made other researchers hesitant to jump into an investigation.

Most scholars are afraid of failure when they carry out research. In addition, they suffer from a compulsive belief that they need to attain satisfactory results within a limited time, the short research term stipulated when receiving a research grant. Accordingly, the majority of scholars opt to work on research areas that have been studied and have attained actual results to a certain degree, rather than try exploring new fields. This is so-called ‘safe research,’ which reduces the scholar’s agony over what to write in the study report. But, if this phenomenon is rife among scholars, the enterprising scholars who jump into new and creative research will not be produced. Let’s take the example of Ralph Steinman. One day, he found that a cell taken off of a mouse’s spleen played an essential role in the mouse’s immune system. When a pathogen entered the mouse’s body, the cell, which was named a dendritic cell after its twig-like shape, seemed to report this to the T cell that controlled the immune system. People did not have much interest in the dendritic cell when he found it in 1973. However, he continued his research into the cell, and after 20 years, at last, people began to acknowledge the importance of the cell in the immune system. When he was awarded the Nobel Prize in Physiology or Medicine in 2011, he said “I was lucky to have been given research grants for such a long time, over 20 years.” What if he had carried out this work in our country? Korean scientists would presume that in Korea, he would probably have had to frequently change his research subject to keep receiving research grants, and enduring this for 20 years would have been very difficult. To this thought, I want to add the following: he would not even have been able to think about requesting a research grant with such an unacknowledged subject.

Our country needs adventurous research. The same is true for parasitology. Sparganum is spread through snakes and water from mineral springs, but it has not been known what percentage of mineral springs contain sparganum. On top of this, there are a considerable number of studies that must be carried out by parasitologists for the nation’s health, such as what percent of sliced raw trout have bothriocephalisis larvae, and how many bovine livers, the source of toxocara canis infection, have toxocara canis.

Despite this, none of the parasitologists are applying for research grants on these subjects, because they know that from the moment their research turns out to be a failure, they will be driven into difficult circumstances. Even when research produces nothing, what if we just grant parasitologists additional research funds for 3 years, encouraging them by saying, ‘You have worked hard and your research subject is definitely worth studying, so keep up the great work for success.’ If this type of system could be more established in our society, then we would be able to take a step ahead, and get closer to the Nobel Prize that still seems a long way off.
Virtuous Circle: Soft Power and Korean Innovation

Jonathan McClory | Partner, Portland

It has been, in many ways, a hard year for soft power. In the Middle East and Africa, the spread of violence stands as a daily rebuke to those of us who argue for the growing primacy of diplomacy, persuasion and cultural attractiveness in achieving foreign policy ambitions. In Europe, the crisis over Greece has seen consensus replaced by division. Civil war in Ukraine has brought conflict to the continent’s borders. Tensions in Asia have also been rising, in the South China Sea and most recently on the Korean Peninsula. This has all given fresh ammunition to the critics of soft power who say it is, as ever, military force and economic might alone that matter. But it is not a view shared by more and more political leaders and governments. Indeed, the need to embrace soft power is increasingly urgent for countries that want to play an active and influential role in global affairs. However, the first step to a country’s effective use of soft power is understanding and quantifying what soft power that country actually has.

It is, of course, worth establishing a clear definition of soft power and exploring why it is increasingly important. Traditionally, power in international relations has been defined and assessed in easily quantifiable “hard” terms, often understood in the context of military capability and economic output. Hard power is the exercise of influence through coercion, relying on tactics like military intervention, coercive diplomacy, inducements of payment, and economic sanctions. Soft power, on the other hand, is the “ability to affect others to obtain preferred outcomes by the co-optive means of framing the agenda, persuasion and positive attraction.” Soft power strategies eschew the traditional foreign policy tools of the carrot and stick, working instead to persuade by using networks, developing and communicating compelling narratives, establishing international norms, building coalitions, and drawing on the key resources that endear one country to another. In simple terms, “hard power is push; soft power is pull.”

‘Soft power’ was first coined in 1990 by Harvard professor Joseph Nye, though Nye himself cites examples of soft power that go back centuries and span cultures. Soft power is neither new, nor is its use limited to the Western world. Nye used the term to describe the ability of a country to use attraction and persuasion in the pursuit of foreign policy objectives, as opposed to force or financial payments. The appeal of soft power rests in its promise to deliver key international objectives without the high costs associated with the exercise of hard power. As a result, savvier governments have latched onto the concept, hoping to use it to achieve foreign policy goals. They are right to do so. Indeed, the ability of a country to engage with and attract global audiences has never been so critical to prosperity, security, and international influence.

This has seen the concept of soft power make a swift transition from university lecture halls to the corridors of power. In the first half of this decade, the term

has come to populate news stories, op-ed pages, the speeches of world leaders, and foreign ministry strategy documents. Yet despite this familiarity, there remains a significant gap between the enthusiasm governments have displayed for soft power and their corresponding ability to leverage it effectively. There is good reason to believe that the old levers of hard power are no longer enough. Wherever we look, the old hierarchies and certainties are breaking down. Power has become much more diffuse – moving from West to East, from North to South, away from governments towards non-state actors and, through social media, increasingly from the elite to the universal. We see as well how challenges are now rarely constrained by national borders.

In this more complex world, countries have realised that Nye was right when he said ‘power with others can be more effective than power over others’. This power is best built and harnessed by attraction and persuasion so networks are forged and collaboration fostered. While there is a growing enthusiasm for soft power, it has not always been matched by a growing understanding of what it is or how it can be deployed successfully. Yet only with better knowledge can it be protected and used in a strategic, co-ordinated and, ultimately, effective way. The Soft Power 30 is a new, authoritative index, developed by Portland in collaboration with Facebook and ComRes, that aims to help governments and countries understand better the resources they have at their disposal. It ranks leading countries using 66 separate metrics to measure soft power covering categories such as government, culture, education, global engagement and enterprise.

Included for the first time, is specific analysis, developed with Facebook, of the reach of digital diplomacy. We have also made use of specially commissioned polling in 20 different nations to gauge the appeal of countries and their assets. I am confident it is the most comprehensive and up-to-date assessment of soft power yet.

So where does Korea stand in these global rankings? The Republic of Korea ranks in 20th place, which underscores the amazing transformation South Korea has undergone from the end of the Korean War to present day. Having started the second half of the 20th Century with a per capita GDP of just US$67, the Republic of Korea has transformed into a country that is now among the wealthiest and most advanced in the world.

Korea is the second highest-ranked Asian country in our index, finishing ahead of Singapore and China, which come in 21st and 30th place, respectively. Japan, which finished in 8th place, is the top-ranking Asian country in our soft power index. Korea’s strong performance in The Soft Power 30 rankings owes a great deal to the attractiveness and dynamism of its economic model, its capacity for innovation, and its commitment to fostering a free and open society. Breaking down our index by the six main categories, we see that Korea’s strongest assets are in Digital and Enterprise. This should come as no surprise. South Korea has not only become a consumer-electronics powerhouse, but it has invested heavily in building its human capital. Korea has six universities in the Global Top 200, as ranked by QS. It also leads the world in spending on R&D as a percentage of GDP.

Technology and enterprise, however, are not Korea’s only soft power assets. Our research shows that Korea has a number of diverse soft power assets, however, the most prominent ones are those that are linked to technology, innovation, and economic development. It is important to pursue a balanced approach to strengthening Korea’s soft power. However, it is sensible to play to Korea’s natural strengths – namely technology and innovation. Innovation and soft power are inherently linked. The greater a country’s capacity for innovation – developing new products and helping to solve global challenges with new technology – the more attractive a nation is to the international community. This leads to great soft power and an improved global reputation or ‘brand’.

KISTEP is well placed to play a leading role in building Korea’s soft power by continuing to create and foster international networks around science, technology and innovation.
As a result, a country is more likely to attract the inputs of innovation: increased foreign direct investment, international students, talented entrepreneurs, scientists and engineers. The wider effect of this phenomenon is greater global influence as well, allowing a country to have a greater impact on world affairs. In short, soft power and innovation have a symbiotic relationship, creating a positive feedback loop.

Korea would benefit from policies that make the best possible use of the innovation-soft power feedback loop. Such policies include: continuing to invest in human capital development; increasing support for ‘spin-off’ businesses from university research programmes; increasing international student exchanges and scholarships; encouraging Korean universities to establish global campuses; special ‘entrepreneurs visa’ to recruit global top-talent; and making innovation the cornerstone of Korea’s overseas development aid programme.

While policies and tangible assets are the bedrock of a nation’s soft power, the ability to develop and foster international networks is equally critical for global influence. Indeed, KISTEP’s own work in fostering international relationships is an important asset for Korean soft power. The inaugural Asian Innovation Forum, held in August 2015, is an excellent example of this. Bringing together experts, researchers, and policy makers from across Asia, Europe, and the Americas was essentially soft power in action. By bringing together individuals from across the world to share best practice, ideas, develop new links, and even identify opportunities for future collaboration, KISTEP made a direct contribution to Korea’s soft power. KISTEP is well placed to play a leading role in building Korea’s soft power by continuing to create and foster international networks around science, technology and innovation. Essentially this means developing a programme of science diplomacy. Korea’s soft power, and its subsequent global influence, would benefit from more of such efforts.

The widely agreed need to address Grand Societal Challenges requires new constellations and cooperation of actors, and is thus a site to explore such new constellations and their working. One can see such constellations emerging and can draw upon them for innovation policy purposes. Constellations can also be created (designed) intentionally. In practice, this will often require nudging and modulating of what is happening already. Public-private partnerships are an example of such emerging configurations.

Emerging constellations of new actors in science, technology and innovation policy

New constellations of actors in science, technology and innovation are emerging, as a patchwork of ongoing partial and contested transformations in society, industry and politics. The borders between science and society are opening up or being re-defined. We witness a “growing interest in strategic research and accompanying institutional changes, greater citizen involvement and science becoming more reflexive about its own role and impacts. Frictions and tensions
The widely agreed need to address Grand Societal Challenges will often entail the requirement of wider system transformation. In other words, more is necessary than technological and industrial innovation.

Grand Societal Challenges as sites to explore and experiment with new actor constellations
The widely agreed need to address Grand Societal Challenges will (often) entail the requirement of wider system transformations (Kuhlmann & Rip 2015). In other words, more is necessary than technological and industrial innovation as traditionally studied and stimulated: also novel ways of assembling and re-assembling heterogeneous bits of work (including traditional innovation) are asked for. Here we are moving away from a focus on government and its responsibilities to consider the possibility of challenges (Grand or otherwise) being taken up in the R&D and innovation system more generally. This is important because most of knowledge production and innovation take place outside the sphere of direct influence of government agencies.

To enable system transformation, new actor constellations are of crucial importance. For Grand Challenges, there are good reasons to include a larger variety of actors, and consider new roles for traditional actors. The approach required to address Grand Challenges is to ‘assemble’, to create a more inclusive, socio-technical system-oriented approach, embedding policy action in society. This can be achieved in several complementary ways. First, by making sure that key actors are involved, which implies that actor consortia should be public-private, including charitable or philanthropic foundations playing a key role because they are free to move, and tend to go for public interest goals. Second, combined economic and social issues and related changes are a key feature of addressing Grand Challenges, so social innovation must be included. Third, intermediary organisations and spaces they offer for interactions are important to enable and improve concerted action, without having a master plan. In the course of such developments, existing organisations may transform themselves. For example, research funding agencies may play more than their traditional role of funding research proposals, now adding reference to a Grand Challenge. They can adopt a central role in defining and/or managing a concerted action (there are precedents). Fourth, such a role will require new capacities and capabilities, so learning and transformation will be necessary. In short, a wider understanding and concept of innovation and system transformation is required which can draw on potentially constructive and productive interactions between heterogeneous actors.

To make such new actor constellations constructive and productive, concertation is needed. Typically, actors addressing Grand Societal Challenges find themselves in distributed, even disconnected situations. Still, concertation is possible to some extent, and there are interesting examples. One can think of road mapping, often a public-private undertaking. Road mapping exercises do require a prior definition of the goal to be reached, but the actual exercises tend to discuss the nature and values of these goals as well. Thus, road mapping might be useful to address Grand Challenges, not just to specify how to get there, but also to help to articulate what the Grand Challenge might be. An interesting example of spaces for concertation are the European Technology Platforms, some of them leading on to Joint Technology Initiatives. They were set up from 2004 onwards, building on existing networks and initiatives and stimulating new ones. Strategy documents would be created identifying challenges, coordination would occur, and – hopefully – action taken. The themes often show a technology supply orientation, but there are references to broader issues like sustainability. Particularly interesting because of its bottom-up dynamics is the European Nanoelectronics Initiative Advisory Council, led by the big incumbents in the sector, and through its members also coordinating with their North-American and East-Asian counterparts. In short, concertation will allow for and become effective through dedicated spaces, social as well as material spaces, with emerging boundaries and stabilising internal arrangements (Rip & Joly 2012), created by institutional and policy entrepreneurs, to foster constructive and productive interactions.
Concertation through tentative (meta-) governance

Since system transformation, even when recognized by major actors as important, will be demanding given the inertia of institutions and the multitude of interests involved, it will not be easy to address the governance challenge that Grand Challenges present: “the other Grand Challenge” [Kuhlmann & Rip 2015]. It is much easier to fall back on existing ST&I policies and instruments. Given the diverse, often even conflicting perspectives and interests of actors and the evolving nature of constellations (and of articulation of the substance of the Grand Challenges), tentative modes of governance are required: “Governance is ‘tentative’ when it is designed as a particularly dynamic process to manage interdependencies and contingencies in a non-finalizing way; rather prudent and preliminary than prescriptive and persistent. Tentative governance typically aims at creating spaces of openness, probing and learning instead of trying to limit options for actors, institutions and processes. It answers political and organizational complexities and uncertainties with explorative strategies, instead of relying only on orthodox or preservative means” [Kuhlmann et al. 2015].

Tentative governance would include a meta-governance dimension [Jessop 2002] addressing the ‘other Grand Challenge’ of transforming R&D and innovation systems. Meta-governance (‘governance of governance’) is visible in emerging modes of ‘social technologies’ of framing and facilitating articulation, contestation and negotiation of competing views of coping with innovation and transformation – social technologies working as a kind of ‘crash barrier’ guiding the ongoing ‘making’ of governance across the various domains of the research and innovation system effectively. The move towards concertation by bodies at arm’s length from central policy typically aims at creating spaces of openness, probing and learning instead of trying to limit options for actors, institutions and processes. It answers political and organizational complexities and uncertainties with explorative strategies, instead of relying only on orthodox or preservative means” [Kuhlmann et al. 2015].

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References


Looking to Future Trends in the next OECD STI Outlook

Governments must capitalise on the potential of science, technology and innovation [STI] if they are to manage transitions to ageing societies and low-carbon economies, as well as generate new jobs and foster inclusive growth. Faced with growing complexity and uncertainty, it is imperative to look beyond the short term and adopt a strategic approach in STI policy design and delivery. This is the starting point for the next edition of the OECD’s STI Outlook, which will incorporate a new forward-looking perspective.

The STI Outlook is a biennial OECD flagship publication that aims to inform policy makers on recent and possible changes in global STI patterns and their potential implications for national and international policies. It provides a comparative analysis of new policies and instruments used in OECD countries and a number of major emerging economies to boost the contribution of science and innovation to growth and to address global and social challenges.1)

The 2016 edition seeks to project current STI and policy trends into a 10 to 15-year future and identify challenges and implications for STI policy makers. It will do this by means of a dedicated “Forward Look” exercise the OECD is carrying out during 2015. The Forward Look approach is mainly desk-based, complemented by interviews and a small number of mini-workshops. Many
countries are contributing to the exercise, including Korea: at the outset, KISTEP provided an English summary of the findings of the most recent Korean technology foresight exercise; more recently, STEPI hosted a small workshop in support of the OECD exercise. Further workshops are planned in Washington, Beijing and Paris.

Megatrends
Large transformative forces are shaping the future of STI, for example, affecting universities’ and firms’ capacity to engage in research and innovation and changing the policy agenda. An initial list of these ‘megatrends’ is set out in Table 1. The Forward Look considers the implications of these megatrends for STI systems and policy.

Table 1. Megatrends list
- Demographic change
- Urbanisation
- International migration
- Societal change
- Growing richer but more unequal
- Health trends
- Global shifts in power
- Natural resources: competition and depletion
- Climate change
- Energy trends
- Globalisation
- Changes in economic structure, productivity and jobs
- Financialisation of everything
- Shifting roles of the State
- Technological change

Faced with growing complexity and uncertainty, it is imperative to look beyond the short term and adopt a strategic approach in STI policy design and delivery. This is the starting point for the next edition of the OECD’s STI Outlook, which will incorporate a new forward-looking perspective.
There is a growing array of policy instruments in use, with notable growth in demand side instruments and R&D tax incentives. Growing concerns over managing socio-technical risk and uncertainty are also driving renewed policy interest in technology assessment and “responsible research and innovation”.

- Research has become increasingly internationalised in terms of scientific cooperation, researcher mobility and sources of research funding
- There are growing pressures on research careers, particularly concerning contracts, dual labour markets, PhD skills, and reward mechanisms
- There are growing concerns around research integrity, including the reproducibility of research

Policy trends
STI policy also has its own trends deserving analysis. For example, there has been a broadening in the policy mission for STI policy, which has translated into more goals and more actors in the policy system. The sub- and supra-national levels have become increasingly active in complementing national STI policy, although this does not necessarily translate into more resources: fiscal consolidation and tight budgetary constraints will likely have major impacts on STI policy over the coming years. There is a growing array of policy instruments in use, with notable growth in demand side instruments and R&D tax incentives. Growing concerns over managing socio-technical risk and uncertainty are also driving renewed policy interest in technology assessment and “responsible research and innovation”.

People, communities and societies
This is a horizontal element of the Forward Look exercise that seeks to put the “human” factor at the heart of change in the STI landscape and its outlook. For further information on the Forward Look exercise, visit the project’s website.21

The 2014 edition can be viewed online at
https://www.innovationpolicyplatform.org/sti/e-outlook

21 https://www.innovationpolicyplatform.org/oe.cd-sti-outlook-forward-look

KISTEP
R&D and Beyond
2015

01. Policymaking with an Eye on the Future
Jim Dator, Professor at University of Hawaii at Manoa

02. Fostering Startup Ecosystem in Korea
Joon Chung, President of Korea Venture Business Association (KOVA)

03. Towards Unified Korea: Taking the Initiative through Science and Technology
Jong-wook Chung, Vice Chairman of the Presidential Committee for Unification Preparation

04. S&T Policy landscape in the UK
Sir Mark Walport, Government Chief Scientific Adviser at Government Office for Science in the UK
On April 9, Youngah Park, President of KISTEP, met with Jim Dator, professor and Director Emeritus of the Hawaii Research Center for Futures Studies, University of Hawaii at Manoa. The hour-long discussion overviewed strategies to incorporate futures research findings into practical policy.

Park --- Prof. Dator, you have shared your insight on Korea’s future, having visited the country several times. As a futurologist, could you share how you first became interested in Korea’s future or any recent developments that you would like to comment on?

Dator --- It's a long story, but I'll make it short. In Hawaii, there was a professor called Sam Lee. He organized a group of travel agencies so that Koreans would come to Hawaii and then go to the mainland. He ran a symposium for them and he asked me to speak every year. I watched the way in which the sophistication of those visiting Koreans got greater and greater. I also noticed that they were always women, and that they were always very smart. I became more and more interested in Korea, but I had never been to Korea. So he arranged a trip and we stayed at the Walker Hill Hotel, in 1981. I visited the Supreme Court, because I work with the judiciary and several other people. We went on an automobile trip to Busan, stopping at various places, and lecturing at universities. From that point on, I became interested and spent much more time trying to understand Korea. The next thing was the Korean wave. My question was, "Where did that come from?" Korea doesn’t have a deep history of popular culture like Japan, Hong Kong, or India. That's where the Dream Society came from. Korea had discovered that after agricultural society, industrial society, and the information society, the next is the Dream Society. That's what the Korean economy means to me as well. But there are also many problems that Korea and the world face; climate change, energy insufficiency, and an economy that doesn’t work. So I try to get people to see that the fifty-year miracle that happened in Korea will not drive the future. Something new is needed.

Park --- Korean people are also talking about innovation, a paradigm change, because we have spent the last fifty years on a track already passed by other countries.
The whole point is the human imagination, the human spirit, the desire to explore as we move into new environments. The Dream Society needs to have a technological base, but it needs to have a humanistic heart and soul.

**Futures studies for the government and policymaking**

Park --- You have carried out futures studies with the legislative and judicial branches, and have also participated in establishing public revenue plans during legislation processes. Could you comment on how futures studies can support the government, and what advice would you offer to Korea in utilizing foresight in policymaking and implementation?

Dator --- In the past we could make policy by solving current problems. The idea of lawmaking, instead of discovering law from the heavens or nature, is only around two hundred years old. But the pace of change is so rapid now. By the time legislature knows about these problems, it’s already past, or it’s beyond their solution. So legislation is slowly catching up. In administration, Korea has KISTEP and other government organizations that are very future-oriented. But I believe that the democratically elected branch of government needs to have an independent futures capability of one of two kinds. One is people who understand futures studies, and therefore know how to evaluate the material presented to them. These are people who may not be producing futures research, but are able to get it from many different sources, and inform the legislature. The other is an independent futures capability that the legislature can do on its own. If the separation of powers into executive, legislative and judicial is important, then each of the three branches needs their own futures research capability. The more different views there are about the future, the greater likelihood the policies that Korea make will be affected. Having only one view, and one future worked fifty years ago, but not now. You need to understand the many possibilities.

Park --- KISTEP has a foresight division in charge of predicting the future in S&T. Based on that foresight, we plan which areas should be invested for R&D. It is a small division, but I think we need to enlarge or strengthen these activities.

Dator --- I agree, and the idea is that each sector, not only science and technology, but also arts, humanities, women’s studies, and environment, carries out futures studies. The legislative futures research center might be able to bring that all together, to synthesize and harmonize the conflicts.

Revival of Confucianism

Park --- Yes, it is quite recent that the National Assembly became to realize the importance of futures studies.

Dator --- I heard the Secretary General speak, and the issues raised about climate change, global warming, energy, and economics. No one in the United States federal government thinks about these issues at all. So it is really inspiring to be here.

The Dream Society needs to have a technological base, but it needs to have a humanistic heart and soul.
Agriculture as the next Korean wave

Park --- You have identified agricultural produce as one of the major driving forces of the new Korean Wave. In Korea, younger generations working in the agricultural sector are diminishing, and in many cases rely heavily on imports. Although young and middle-aged generations suffer from unemployment and early mandatory retirement, the number of people working in the agricultural sector continues to decline. What were your reasons for identifying agricultural produce as one of the major driving forces of the Korean Wave? Also, what do you think are the necessary factors to overcome difficulties at home and abroad, to find solutions in the agricultural sector?

Dator --- The reference you make is to a talk I gave at a conference last year or the year before. But I’ve also participated in conferences on Foodpolis. Foodpolis in Jeonju is a new city venture. It’s extremely high-tech; high-tech material, high-tech food and heavily-processed food. I observed that some Korean food is very highly processed, even more than American food. I don’t think there’s a real potato in potato chips, and many other snacks are produced entirely chemically. That’s one thing that I see Korea already doing that some European countries are doing. It’s recognizing one of the biggest issues in the future—producing food to feed the growing world population. Korea wants to be able to move forward in that direction, without being held back by opposition to GMO or other things like that. Secondly, I go around the world telling every country “be self-sufficient in food.” In Hawaii, we are completely un-self-sufficient. Everything is imported. Korea is similar, and that’s extremely dangerous. For example, in Hawaii and maybe in Korea, many of the fruits and vegetables come from California. California agriculture is going down, because of the draught and tremendous water insufficiency. It’s important for Korea to think about food, which is a fundamental requirement, and water, and energy. They all go together. It will be a new kind of high-tech, one that involves a lot of old-fashioned farming, but on a high-tech and biotech basis. Korea can do that, and young people will want to gather. Some people want to get out of the city and farm, but others will see a way to use their science and technology for agriculture production.

Strategic foresight for Korea

Park --- From a foresight perspective, there appear to be a few points that make Korea unique. Geopolitically, Korea is surrounded by powerful nations, like China and Japan, and the issue of unification remains a strong variable. The influence of China on Korea has been growing in recent years, and the changes that are expected to follow unification seem to have changed from a “wild card” to a “megatrend.” Considering these unique characteristics, how should Korea foresee the future and prepare appropriate strategies?

Dator --- Well, I think one of the first things is to not rely too much on only the United States. I think the US will still be an important nation and hope that the countries will remain friends. But Korea also needs to continue engaging with China, and trying to normalize relations peacefully with North Korea. That’s the number one issue. And also with India. I think one of the most important things for Korea and much of the
rest of the world is to understand Islam, and the Muslim perspective. We still only understand Islam terrorists, and that’s not true. Islamic culture was much ahead than anywhere else in a certain period, and all the science and technology we do now came from Islamic cultures. They are going through a kind of a reformation. So I think improving understanding of and relations with Islamic countries is extremely important for Korea.

**Park** --- In Korea, the number of Muslims is increasing. There are also Islam mosques in Itaewon. Dator --- Just as many Christians pick phrases from the Bible to justify violence, or anti-scientific beliefs, you can also pick and choose things from the Koran and use it for violent purposes. But the religion itself fundamentally is not violent nor anti-women. I think we need in general to learn to respect it. I’m glad to hear that about Korea.

**Education for Dream Society**

**Park** --- You have emphasized Dream Society, in which the core driving forces are imagination and creativity. Along these lines, you have given a favorable evaluation of Korea’s creative economy. You have also emphasized the importance of education that can foster creativity and imagination. That leaves many people unemployed. That is an opportunity for the Creative Society, and for the Dream Society. Because people are free from labor, they are now able to be creative. The challenge is what to do with people when they are not needed to produce goods and services anymore. That’s the world now, and we’re moving more and more into that direction. That’s one of my basic premises. It’s not to create more jobs, but it’s to be part of the transition from a society based on identity through one’s work, self-creation, art and exhibit. It’s really as different from the information society, as the information society is different from the industrial society, or from the agricultural society. It’s a transformative new future that lies before us. One way to help move in that direction is to take STEM (science, technology, engineering and math), and add A and S (art and social sciences), so that it becomes STEAMS. I work at the International Space University (ISU) in Strasbourg, France, and almost all of the students are engineers and scientists, and they want to do STEM. Yes, we would not be able to go into space without the technology. But the whole point is the human imagination, the human spirit, the desire to explore as we move into new environments. So we need to not just have science and technology, but we also need to have the artistic, humanistic, ethical, social sciences and human relations part of it. So at ISU, I teach space humanities as a part of the overall curriculum that space scientists need to have. I think is really important for KISTEP to join with humanities, art, and philosophy. The Dream Society needs to have a technological base, but it needs to have a humanistic heart and soul.

**Park** --- I fully agree with you. You may have heard that the Korean government is planning a curriculum change in high school. The Korean government thinks that we don’t need to teach that much knowledge in high school. But university professors are saying that we need high school graduates to have some basic knowledge on physics, chemistry, and biology. What do you think about this issue?

**Dator** --- I think obviously they should be available for people who are scientifically, or technologically inclined, but I don’t think it’s necessary for everyone to learn calculus or advanced physics. It’s necessary to understand how science works so you learn the scientific method. But you don’t need everybody, or all the leaders to have deep science experience. The more important are the philosophical, ethical, and social sciences. For example, when I began as a young social scientist, there were no computers. If I wanted to do a survey research, it all had to be analyzed by hand. I did a big survey in Japan and IBM had a computer. I went down there and it was all paper tape. But if they gave me the wrong material, I had to calculate all the statistics by hand. I needed to know how the slide rule worked and things like that. Now that’s not really necessary. More and more in science, the important part is not all the details. They’re being done by machines, by the black box. What you need is to understand the principles and to creatively think about how to use science and technology for humanities. So I would put less emphasis on math, science, and engineering, and more on the humanities, philosophy and ethics.

**Advice for KISTEP as a leading institute in foresight studies**

**Park** --- Earlier on, you mentioned the importance of independent futures studies institutes including legislative, judicial, and administrative branches. KISTEP strives to be such an independent global think tank for science and technology. KISTEP performs foresight studies and establishes national S&T strategy for future development of the society at large. To function as a leading institute in foresight studies, what do you think are the necessary capacities and issues KISTEP should focus on?

**Dator** --- My general concern about foresight is that foresight is like a single flashlight in the darkness. It looks ahead, but all around is still darkness. What we need is a searchlight that sees everything. That’s what futures studies does. So foresight and futures studies need to be joined together. In my opinion, foresight is a technique for futures studies, and not a sufficient technique in itself. We need to bring together many different perspectives, and consider many alternative futures, but foresight encourages you to talk about the future. For example, I have never seen a population forecast that’s accurate. If we can’t understand something as simple as population growth or decline, how can we expect to predict accurately the much more complex? Futures studies does not predict. It forecasts a prediction that is intended to be an accurate statement. And we can’t make many of them. A forecast attempts to be a logical statement and a useful statement. We need foresight within each one of the alternative futures, not just foresight from projection of the best.

**Park** --- Indeed. Thank you for your time and the interesting insight into futures studies.
Fostering Startup Ecosystem in Korea

On June 30, Youngah Park, President of KISTEP, had an interview with Joon Chung, President of the Korea Venture Business Association (KOVA), about the future directions of Korean startup ecosystem and industry-academic-research cooperation.

Park --- It has been a little more than 100 days since you were inaugurated as the President of KOVA. During that time, you have worked hard in various ways to encourage vibrant startups. Congratulations on your inauguration, and I look forward to seeing the growth of Korean startups in the future thanks to your efforts.

Chung --- When I was a student, I never thought that I would run a business. The big issue for Korean startups is that we need to create a large number of large enterprises. Only one out of every nine previously NASDAQ-listed startup companies is still listed. And even that one company is not a major one due to low market capitalization. My goal is to help develop large startup companies.

Park --- It has been twenty years since the beginning of startup business in Korea.

Chung --- Yes, this is true according to KOVA. The Special Act on Venture Business was legislated temporarily in 1997, and then was extended for another ten years in 2007 until 2017. That means it will expire in two years. I’m not sure if it will be extended again. However, KOVA’s perspective is to continue to promote startup business by complementing and extending the Act.

Park --- It has been a meaningful time in terms of the growth in the quantity of startup companies despite the crisis. During that time, the number of certified startups has increased to 30,000, and based on the result of the corporate environment evaluation of business startups by the World Bank, Korea’s startup environment has improved, from 60th in 2010 to 17th last year. I wonder if you can sense this improvement in the field.

Chung --- It certainly has improved in some ways. However, I do not put much emphasis on ranking. One organization may evaluate it as 17th but another ranks it
Education is essential. Entrepreneurship is a must to learn. In addition, because the possibility of failure in a startup is higher in reality, it will be very encouraging to have high rewards when a startup is successful. To do that, the right institutional strategy needs to be provided.
is that the number of these cases is too small. The government needs to provide an environment that creates a higher number of talented people. I think we need, not one or two, but 100 of these in ten years. I expect this can come true in the near future thanks to the efforts of many people.

Park --- You previously mentioned the issue of small markets and the difficulty in globalization. What would you advise Korean startups to aim at under the limited circumstances, and for the young, what should they focus on to build up global startups?

Chung --- It is necessary to educate young people to broaden their horizons towards the world instead of staying in Korea. Of course, learning language is important, too. Young people today have higher education and develop rapidly compared to the older generation. After all, the issue here is human resources. Whether it is research and development, sales, marketing or management, talented people are needed to win the competition. However, we are absolutely lacking these people. Fundamentally, it is essential to attract global leaders to startup companies.

Park --- I assume KOVA also has many concerns.

Chung --- You are right. That’s why KOVA operates the International Network of Korean Entrepreneurs (INKE). Its purpose is to build and support the networks between Korean businessmen working in the global market. In addition to these, INKE is endeavoring to send Korean startups in early stages to an overseas accelerator, which is the startup promotion institution, instead of to a Korean accelerator. This is to enable them to advance in that country from their foundation. By doing this, they can have a global perspective to approach their business plan from the beginning. This is really important and a must to-do, but is a difficult task.

Park --- When all these efforts pay off, the troublesome Death Valley issue may be resolved a bit. According to a recent report by Korea International Trade Association (KITAI), the survivability of Korean startups after three years from their foundation, the criterion for having passed the so-called ‘Death Valley’, is 44%. I thought this was very high, but it actually meant Korea had the lowest survivability among OECD members. People who criticize government policy say the reason for the low survivability is due to the large percentage of micro startups compared to innovative ones. What do you suggest KOVA and the government focus on for startups to survive?

Chung --- I didn’t think we were the bottom among OECD members. In fact, we are not the only one facing the Death Valley issue. The term is derived from Silicon Valley, the so-called best environment to start a company. This means Silicon Valley itself also has the Death Valley issue. It is not a problem for which a solution is sought, but a process that all startups have to experience. After all, the question is how to reduce the failure rate. We need to face Death Valley as it comes. I have already mentioned that we, at KOVA, are working hard to send Korean startups to overseas accelerators, and it is true that they have higher survivability when this is successful. Just by surviving overseas, a company can attract lots of attention internationally and this can guarantee good investment sources. At this point, another question is how to improve the quality of startups, but there is no brilliant answer to this question. Striving to create a better company is the only way that we have. We need to be aware there are failing businesses everywhere.

Park --- You have mentioned sending Korean companies to overseas accelerators several times. Do you think there are limits to what Korean startups can achieve through Korean accelerators?

Chung --- Actually, the number of accelerators is increasing in Korea, starting from Yeoksam-dong. Google also chose Korea as its third global market and established Google Campus Seoul. However, it is even more ideal for the successful first generation startups to EXIT (startup sets the wheels moving, sells it, collects fund and creates another ground for startup, resulting in virtuous cycle of startup ecosystem) and cultivate the younger generation, leading to another Tehran valley boom.

Park --- It already has been three years since the government’s promotion of the Creative Economy policy. Now, it is not easy anymore only with the governmental support. It is time for private sector to be actively involved. Please share your thoughts on ‘Creative Economy’ and the current policy?

Chung --- I think it is only an issue of whether to use that term or not. I doubt there is anyone against its concepts and content. The economic development model is not working anymore, and we need to try a new way. For this reason, we expect that the world will pay attention to our new approach. I think it is the right way, and we just named it ‘Creative Economy.’ I am sure there is a similar concept in other countries, under different terms.

Park --- I agree with you on that this is a global trend. Is there anything you consider to be a weakness of the Creative Economy policy so far?

Chung --- When the plan of the Creative Economy works well, private sector and markets will have a bigger role to play. However, it seems there is more work to do first. For one thing, laws and regulations need to be reformed to keep up with Creative Korea. For example, to talk about the infringement of patent in terms of Intellectual Property Rights (IPRs), the amount of compensation determined by the final decree in Korea is about 1/100th that of the United States. In the past, these laws and regulations benefited us when we had to grow our economy to catch up with other countries. We copied
advanced techniques from developed countries, and so we couldn’t really penalize overseas companies when they took legal action against Koreans. However, things are different now. Creative Economy itself provides opportunity to grow for businesses that possess intellectual property. The problem here is it is still difficult for this to be achieved under the current laws and regulations, which do not protect IPRs properly. The compensation amount needs to be increased to at least one-tenth of that of the United States. To do that, the government and the legal community need to start working.

Park --- That is a good point. So, what do you think is needed from private sector? Or is the government’s effort enough?

Chung --- I think the transformation of the general operational framework will increase investment and change many other things. In fact, private capital is attracted to anywhere money comes. There is a saying among businessmen that ‘We will go to the center of the desert as long as we can make money.’ That is, there is no use to invest in something that has good circumstances but does not provide an opportunity to create more income. The direction of Creative Economy is good but the government needs to reform laws and regulations and the general economic management plan. In terms of efforts from the private sector, I would like to talk about the philosophy of KOVA, which is widely shared within the association. We do not ask people to cut the pie into pieces. Instead, our approach is that we work hard to increase the size of pie itself. We constantly encourage ourselves to work towards protecting intellectual property, motivating and attracting the talented people, and innovate to increase the size of pie.

Park --- In this regard, although concepts such as corporate partnership and economic democratization have constantly been an important issue, the policy and philosophy of Korean government do not seem to have agreed with each other. A systematic approach may have not been discussed in depth, and there has been a lack of social discussions as well. For instance, in relation to the SME-appropriate business selection policy, many people had doubts regarding whether it truly was a win-win.

Chung --- Obviously, an SME-appropriate business selection policy is required in some areas. However, I think the reason that many people had doubts was due to a mistake of statistical population selection. SME policy also includes welfare and corporate policy in the bigger picture. In fact, there are various types of businesses under the category of SMEs. The Korea Federation of Small and Medium Business says there are 50,000 SMEs, and this figure includes self-employed businesses and innovative startups mixed together. On one hand, it is necessary for some businesses to benefit from the SME-appropriate business selection policy. On the other hand, this welfare type of protection may hinder some business. That is why I keep explaining there is no use in categorizing businesses by size, such as medium or small-to-medium enterprises. What we really need now is a refined classification policy.

Park --- Do you mean the classification of businesses as medium or small-to-medium enterprises is pointless?

Chung --- That is right. Businesses must be classified based on their properties instead of their size. There are 18,400 members of KOVA, and they all have different characteristics from each other. Some rely on a specific conglomerate for up to 99% of their sales, and some deal with general consumers. So-called first vendors of conglomerates and businesses with their own customers need different things. Actually, it may be right to calculate the sales of a conglomerate’s first vendor as the sales of that conglomerate. Because it is easy to compile statistics by considering similarly sized businesses as one group, it is difficult to draw a useful policy. Planning policy on human resources and budget allocation for these businesses in different sizes will only lead to controversy on how much budget to allocate where, and to what extent to increase the budget in how many years. In other words, the differentiation of businesses by size causes disputes regarding policy. For this reason, it is important to classify businesses by their properties and long-term plan for each group.

Park --- You have made a very good point. Does KOVA have any projects going on in this area, such as the classification of business property?

Chung --- At the moment, it is just a proposal. KOVA often makes suggestions. That is, making separate statistics for KOVA members as well as ingenious startups is needed. After this is done, it will be easier to find out what they really need. For an example of a survey, all SMEs’ CEOs say that funding is the most important issue, and innovative startups choose lack of human resources. This means the priorities are different. It is the same with the first vendor of large enterprises mentioned previously. This vendor falls into R&D budget allocation for SMEs due to its classification as an SME. It is fairly reasonable to consider it as budget allocated to support conglomerates. It is pity that discussions like these are lacking, probably due to political aspects of the SME sector.

Park --- The recently announced R&D innovation plan also emphasizes the private sector’s efforts and human resources in research. It also includes plans to increase the budget for SMEs’ R&D. What is your view on this?

Chung --- Even if we exclude basic technology from the discussion, I think it is right to increase funds for industrial technology. It is same with human resource policy. Ideally, in terms of industrial technology, although it can be a somewhat radical argument, it is necessary to apply an exceptional strategy such as retirement guarantee only for ten years from employment to enhance exchange between government-funded research institute for industrial technology and industrial human resources. The capacity of researchers at government-funded research institute is very high, and actually is significantly higher than those in the industry. In addition to this, the commercialization of their research results is not highly feasible. On one hand, highly capable researchers work for the research...
institute, and it is natural that they want to do more useful research. On the other hand, the industry has a chronic issue with a lack of good quality workforce. Therefore, the plan is to transfer the master’s and doctorate level workers to industry after their ten-year employment, based on the idea that they start working at the institute in their late twenties and early thirties. Currently, there are only post doctorate researchers working in industry. I am aware that a large number of these researchers wish to be employed permanently by the institute. I cautiously suggest this plan so that the young researchers can show their capabilities in the industry while they are still young.

Park --- Your suggestion sounds similar to the existing human resource exchange system, but it is unique in a way. I look forward to seeing its positive impact after your explanation.

Chung --- The industry also prefers the long-term dispatch of research workforce since excellent researchers can teach people in the field, enhancing the research capacity of the industry dramatically. However, it may not be easy for the research institute to send their resources on a long-term basis due to the issues with the continuity of their projects, for example. What I am trying to say is human resources in the science and engineering field need to be spread evenly among universities, research institutes, large corporations, and SMEs. By doing this, industry-academic-research cooperation will work better.

Chung --- What I have just mentioned may deal more with industry-research cooperation. But in fact, I feel that industry-academic cooperation is lacking. Corporate funding of universities is the same as it was ten years ago. Nonetheless, the government funds universities hugely, enabling the improvement of industry-research cooperation. Of course, there still are some people who prefer a practical approach that continue to cooperate with businesses individually, but they have space for more funding. However, just because of that, it is not possible for corporations to reduce their research funds to universities. It is understandable that the university should play the role of conducting purely academic research. Despite this, a college of engineering can put more effort into encouraging cooperation with the enterprises. My wish is that a mid-to-long term plan be developed for industry-academic-research cooperation and government R&D funding.

Towards Unified Korea:
Taking the Initiative through Science and Technology

On September 11, Youngah Park, President of KISTEP, met with Jong-wook Chung, Vice Chairman of the Presidential Committee for Unification Preparation for an interview on the role of science and technology in unification of Korea.
It has been over a year since you were appointed as the Vice Chairman of the Presidential Committee for Unification Preparation. Would you like to give your impressions after the first year?

Chung --- The committee is made up of 20 government officials and 30 private sector experts from 4 departments. We also have 30 other specialists from different fields of expertise. All members have worked really hard since the committee’s launch. All of the private sector experts are unpaid for their work and our tasks are more like voluntary work. When I first took on this position, frankly speaking, it was a bit hazy. I was appointed on July 15th last year, and had the first meeting with the members on August 7th. I could not clearly picture what I was supposed to do. But through the efforts of many people, we now have a better-organized system. I can now clearly do. But through the efforts of many people, we now have a better-organized system. I can now clearly picture where we are heading after running about 20 projects. Many people think that this committee only works in relation to the Ministry of Unification. Well, this is not true. We work in all areas, encompassing economic, social and cultural aspects. Eight of the 20 governmental members are incumbent members from the Ministry of Foreign Affairs, Ministry of Unification, Ministry of Strategy and Finance, Ministry of Culture, Sports and Tourism, Ministry of Land, Infrastructure and Transport, Ministry of Justice, and Office of Government Policy Coordination. This shows that the preparations for unification are not only limited to foreign affairs; science and technology is also a part. We have one expert in science and technology in our economy department. This may be insufficient considering the significance of the field, but the total size of the committee is limited to 50 by presidential decree. There is always a need for more members, but to expand the committee, we would need to request a revision of the decree. However, the number of experts is not limited by the decree. We can autonomously decide to appoint as many experts as we need. Recently, we invited one expert to reinforce our committee in the area of gender issues. We can autonomously decide to appoint as many experts as we need. Recently, we invited one expert to reinforce our committee in the area of gender issues.

Chung --- Who would not wish to improve the inter-Korea relations? Not just through family reunions, but people expect improved ties between the two authorities. In this regard, the agreement reached on August 25th marks a milestone in history. But the question of how to move forward is more important, of course. It is not much to say that the recent agreement is an achievement from ‘Trust-building Process’ on the Korean Peninsula, as President Park Geun-hye has been emphasizing. The inter-Korea relations had ups and downs and it sometimes does not pan out well. But with this agreement, we have laid the foundation to move toward enhanced inter-Korea relations. As the relations are not always going to be optimistic, we need to carefully approach. We have made an agreement to arrange the reunions of separated families and exchange their lists, and to stop any actions escalating tension. North Korea has expressed regret over some actions, and promised to prevent recurrence. Most importantly, the authorities in the South and the North have agreed to hold talks to improve the ties. Once it is agreed, the talks will be held at an early date. Taking this opportunity as momentum, we can proceed with issues such as reopening tours to Mt. Kumgang or any problems that have accumulated after the sinking of ROKS Cheonan.

Park --- When you took up the post as Vice Chairman last year, it was reported that you would flesh out the vision of the President for unification. Could you tell us the activities that the committee has been involved in since its launch, describe the concrete vision of unification you hope for as a result of such activities; and tell us what your top priority project is for inter-Korea cooperation?

Chung --- We have carried out about 20 projects in the last year. There are more sub-projects under the 20 projects, mostly in the economic field. Some include humanitarian development projects in social and cultural areas, but the economy represents the
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President Park Geun-hye said that peaceful unification is an unprecedented path on which we must choose to walk. To this end, the President asked the committee to become a ‘smart navigator’ to set out on a unification quest. The people of Korea have an indomitable spirit. I believe we can achieve peaceful unification.

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largest part of many projects. The 20 projects were chosen based on the Dresden Declaration made by President Park last year. But I am afraid that many people have a mistaken belief that the aim with these projects is to absorb the North. Looking at the details, however, it is clear that the projects can bring synergies both to the South and the North. These projects are a refinement of the plans proposed in Dresden. The projects can be categorized into three areas: the first deals with humanitarian outreach, including family reunions. The second one is to build infrastructures such as railroads that North Korea needs. The last one is about integration. The South and the North have become alienated in many areas. We have been striving to integrate the social and cultural aspects between us. Let me give you some examples. There are about 50,000 North Korean employees in Daesung Industrial Complex and most of them are female. In this regard, we are trying to address health issues for female employees, and to introduce mother and child care. We can immediately execute those projects once the South and North agree. President Park proposed a symbolic business (as part of her pledge) of a ‘World Eco-Peace Park’ in the Demilitarized Zone (DMZ). The DMZ is about 250 km long and 4 km wide. A park in this massive area may be small in terms of size, but would have a high symbolic meaning. The park will represent universal humanitarian values such as peace, environmental protection and cultural conservation. This zone, unvisited for more than 70 years, preserves abundant cultural heritages. The committee had a series of discussions not only with the Ministry of Unification and Ministry of Land, Infrastructure and Transport, but with the local government as well. The plan is almost finalized. Of course, we need to reach a consensus with North Korea on this issue, as the South cannot do it alone. We have already discussed the issue with the UN. Another part of the project is planting trees in North Korea. We will provide seedlings and pass on the knowledge needed to grow healthy plants. For agricultural development, we will send experts to selected pilot areas and provide education on how to tend crops, rather than just supply fertilizer or seeds. Our projects also describe how we will pass on management skills. According to reports, there is a growing number of markets in North Korea. It is estimated that there are about 400 markets, most of which deal with Chinese products. The low price will be helpful to North Koreans; but what could be better is to North Korea to build and operate factories to supply daily necessities so that residents of North Korea can enjoy higher quality products. It would not take much time for us to launch such project if the North agrees. It is better for us to cooperate rather than to work with China.

Park --- You have been responsible for some great achievements in diplomacy. As a senior secretary for foreign affairs and national security to President Kim Young-sam, you amicably settled the North Korean nuclear crisis in tandem with the US. And as a Korean ambassador in China in 1997, you were in practical control of the defection of Hwang Jang-yup, the North Korean politician. Would you like to share your philosophy on North Korean issues and unification?

Chung --- I left Seoul National University in 1993 and became a government official. I went to China after two years of struggling against nuclear issues. At that moment, I realized that the next generation should not live in a divided country. Yet the atmosphere has not much improved; we were on the brink of war in 1994 due to the North’s provocation of threatening Seoul with “a sea of fire.” The United States wanted to attack the North, which meant war in the Korean Peninsula. We had to stop that. Thankfully, the nuclear deal was made and former US President Jimmy Carter visited Pyongyang and negotiated a deal with Kim Il-sung in June 1994. Military tension can explode anytime. My view is unchanged: we must prevent such hostility. I believe unification is a must to prevent possible war. Talking about ways of unification, the unification by absorption or force, or unification under communism are practically impossible, and if it happens, it will be the scourge of our times. There was a strong presumption that the North had nuclear weapons. Peaceful unification is the only answer. Both Koreas need to openly discuss and cooperate in this regard. I disagree with people who believe that peaceful unification causes upheaval. Korea is the only country in the world that has been divided for more than 70 years. We need to achieve peaceful unification through communication. There are various stages we must go through to achieve peaceful unification. The day will not come right away. The first step is to weaken the threat of war through robust cooperation between the South and the North. The next step is to institutionalize our cooperation. The last step is to inaugurate the unified Korean government. These three steps should be intimately connected to one another, which will require a lengthy period of time. The day of unification may not come soon, but it surely will and it must come. President Park said that peaceful unification is an unprecedented path on which we must choose to walk. But instead of following the models of Germany and Vietnam, we need to make our own way forward for Korea’s unification. To this end, the President asked the committee to become a ‘smart navigator’ to set out on a unification quest. The people of Korea have an indomitable spirit. I believe we can achieve peaceful unification.

Park --- Since 2007, the Institute for Peace and Unification Studies (IPUS) of Seoul National University has been conducting an annual survey on views on unification. According to the latest survey results published in 2014, the demographic group with the highest rate of recognizing North Korea as a ‘hostile’ country was Koreans in their 20s, at 41.1 percent. Also, only 41.5 percent of them responded that they appreciate the North as a ‘cooperative’ partner, which was the lowest rate among age groups. In Gallup Korea’s survey in 2013, 48% of Koreans in their 20s answered that North Korea would be ‘highly likely to trigger a war.’ This shows that the young generation considers the North more hostile and intimidating than older generations. As our youth are the generation that will lead the united Korean peninsula, it is important to raise their awareness of the necessity and value of unification. How do you plan to address this issue?
KISTEP emphasized the importance of science and technology for unification. In this sense, KISTEP seeks changes in the traditional educational system, such as introducing business studies as a part of educational reform that can go along with capitalism. Park --- We look forward to the future plans of the committee and the future of South and North Korea. Do you have any plans for activities or ultimate goal of the committee?

Chung --- We are going to draw up policies from various ideas developed from last year. From now on, we will take more action and rely less on words and research. So far, our studies have shown that the benefits of unification would be like hitting the ‘jackpot,’ and now it is time for us to tell the nation that this ‘jackpot’ is not an empty pledge. We will cooperate with North Korea. There are many possible projects that can be handled together. I hope the barrier between us will be reduced as the private sector strengthens cooperation, and as talks are held between the two authorities. We will take action with what we have prepared, and form a strong bond. The countries in our neighborhood may interrupt and be hostile toward a united Korea. The research we conducted reaffirmed that unification benefits not just the Korean Peninsula, but the neighboring countries. But without their help, it is extremely difficult to achieve peaceful unification. We will be engaged in international activities this year.

Chung --- In fact, the committee needs to work on the science and technology field. We have only one expert specialized in science and technology working with the economy department. Considering its significance, the committee must work harder to embrace the science and technology field in the unification process. We will explore areas where the economy department of the committee and KISTEP can cooperate together.
On October 8, Youngah Park, President of KISTEP, met with Sir Mark Walport, Government Chief Scientific Adviser at Government Office for Science in the UK and discussed strategies to prepare the future by foresight in S&T policy.

Sir Mark Walport

- Government Chief Scientific Adviser at Government Office for Science (2013-)
- Director of Wellcome Trust (2003 - 2013)
- Elected as a Fellow of The Royal Society (2011)
- Knighted in the 2009 New Year Honours list for services to medical research (2009)
- A member of the Prime Minister’s Council for Science and Technology (2004-)
- Professor of Medicine at Imperial College London (1991 - 2003)

S&T Policy landscape in the UK

On October 8, Youngah Park, President of KISTEP, met with Sir Mark Walport, Government Chief Scientific Adviser at Government Office for Science in the UK and discussed strategies to prepare the future by foresight in S&T policy.

In the UK, S&T policy matters have always been significant. The context of science and technology policy is a crucial and strategic element in the development of a country’s economic and social progress. It is an area that is often at the intersection of science, technology, policy, and society, and it requires a holistic and dynamic approach to address the complex challenges of our time.

Park --- Sir Mark Walport, your career experiences are unique as you have worked across diverse fields. You were a professor of Medicine at Imperial College London. Then, you served as the Director of the Wellcome Trust where you’ve led the funding of research projects on the human genome. In 2013, you were appointed as the Government Chief Scientific Adviser (GCSA). Could you comment on what made you become interested in building your career in science policy in the UK?

Walport --- It was never a part of the plan to move from Imperial College, where I was a professor of Medicine, to the Wellcome Trust and to the Government. I suppose that as a young academic, I was interested in how to get things done most effectively. The opportunity came to me to get involved in ethics committees and in planning around academic activities, which allowed me to become interested in it. I spent over 20 years at Imperial College. I got involved in research administrations, so I chaired research committees of, firstly the Arthritis Research Campaign (ARC) as it was at the time. I became involved in Wellcome Trust and joined one of their funding committees. Then I became a chairman of the molecular and solar panel, and in 2000 I was interviewed and asked to become one of Trustees of the Wellcome Trust which I did for a couple of years and then the director job became vacant. Thus, I thought this would be an interesting challenge, moving from a campus where I worked in particular, rheumatic diseases, immunology and genetics. I then moved to Wellcome Trust where we had about £700 million a year, so it's a very large foundation, one of the largest in the world and there I became further interested in breadth of science policy, but particularly across biomedicine. I was appointed to the Prime Minister’s Council of Science and Technology in 2004. After 10 years at the Wellcome Trust, the opportunity came up to apply to be a Government Chief Scientific Adviser.
Park --- I think it’s very interesting that you applied for the position. In Korea, some important positions should be applied, but some are just appointed. For example, Jang Moo Lee, who is a chairman of the National Science & Technology Council, was appointed.

Walport --- It varies in the UK, some positions are appointed, but they tend to be non-executive positions rather than executive positions, so this job is a very full time job. I applied but I was detoured interviewed and I was appointed. The breath of my scientific advices is extremely broad. What I am saying is that there are two things: firstly the skills of science enable you to look very broadly. So, the method of science is very similar whether you are physical scientists or biological scientists. Any scientists can have only one area of deep expertise, but it sometimes describes as scientists with a t-shape who are interested in science policy, so deep science in one area and a breath of interest across. My job really is to find the best scientist in whatever area of science government needs advice. Therefore, I describe myself to the communities as the transmission mechanism between the outside world of science and the inside world of government. That takes me back to my medical skills because a lot of work I do is actually communications but it was not a planned career.

Walport --- It is a committee which is half inside government and half outside government. By that I mean there are two co-chairs. I am one of the co-chairs and then my counterpart is Dame Nancy Rothwell who is the President of Manchester University. The job is to advise the Prime Minister and the government on science, engineering and technology. It is a mixture of academics and people from industries as well with a very wide range of skills, so from technology to engineering to the biological sciences.

Park --- How many members do you have inside Prime Minister’s Council for Science and Technology? Do you have a regular meeting with the Prime Minister?

Walport --- We have roughly twelve to fifteen members at any one time, and the membership includes ex-officio, the presidents of UK national academies, so the presidents to the Royal Society, the presidents to Academy of Engineering, the presidents to British Academy which does humanities and social sciences, the presidents to Academy of Medical Sciences. We tend to meet the Prime Minister once or twice a year not as often as appropriate. We also advise other ministers as well therefore the government. We discuss our work program with officials across government. About half of our work is asked to government another half of our work we decide ourselves. We typically write letters to government, depending on what the topic is, we would copy it to a relevant minister. For example, recently we have written on the subject of autonomous vehicle to the Prime Minister, and to the transport sectors. The challenge of communicating to government is to communicate effectively and that means communicating briefly and very clearly. When the foresight program started, we used to produce volumes and volumes of material; we still produce quite a lot, but the summary reports are very brief, because policy makers are extra busy. So, I realized a while ago that if you want to have the maximum impact, then you need to have maximum clarity and brevity.

The UK S&T systems

Park --- Can you explain the concept for Prime Minister’s Council for Science and Technology (CST) in the UK? How does that operate? How is it effective to advice Prime Minister in the UK?

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How the UK foresight evolved

Park --- I heard that the UK foresight activities have evolved over three cycles. The cycle started with the UK foresight establishing priorities across the entire area of the science and technology base. However, your current foresight activities focus on emerging issues for future policy actions. Could you explain how your foresight activities were evolved?

Walport --- As a young academic at Imperial college I was involved in the very first runs of foresight and in those days it was a very bottom up activity driven to large extent by the academic unity who came forward with ideas for what might be interesting to look into the future. But it has evolved very much and I think the thing about foresight is that it’s about looking into the future and of course it is impossible to predict the future as we know it’s hard enough to predict the past let alone the future. But it’s with a view to informing the present, in other words you look into the future and you can see there are different scenarios for what the future might look like in any particular area and some of those might look more desirable than others. The question then is presented to policy-makers on how to increase or decrease the chances of that outcome, so I think for foresight to be relevant, it has to tell them something about here and now. I think the other good things about the foresight approach is that it looks quite a long way ahead; it takes policy-makers directly to the challenges at the present which allows them to look to a world which is 20, 30, 40 years ahead and that again is quite a good way of taking policy-makers beyond their immediate. However, given that this is an activity conducted within government it’s important that it is relevant to government now.

Park --- Some economists tend to predict everything including the science and technology foresight. What do you think about economists’ foresight of the future society?
Walport --- Foresight involves a very broad range of different communities essentially. That is the issue for foresight. You want to get together people with diverse skills who can look at it from different perspectives. As long as one recognizes that foresight is inevitably speculative, anything that looks into the future cannot be completely precise. On the other hand, there are some trends where we can be much more confident. For example, in the climate sciences, it is actually clear the direction in which planetary energy system is going if we continue to emit the amount of carbon emissions, we are emitting at the moment. It’s easier to be, if not precise, fairly accurate about the direction of travel in some areas rather than others. My PhD supervisor who was a very wise man used to distinguish between two types of questions. He called these pollable questions, in other words, questions in which you can vote on the answers and non-pollable question in which there is ultimately a right answer. Now field of economics, largely in the area of pollable questions there is not a single right answer. For example, in the area of climate science, the questions are non-pollable. In other words, it doesn’t matter what your opinion is on the human contribution to climate change. There is a right answer. As Moynihan⁷ said you can have opinion but not your facts.

How the UK employs the foresight in S&T policy

Park --- We believe that foresight in the UK strengthens strategic policy making in Government. Could you comment on how the outputs of foresight work are employed in policy formulation, planning and decision making in the UK?

Walport --- It varies according to the area of different programs from fairly short pieces of work looking typically at technologies through much longer piece of work which may last for 2 years and they affect policies in different ways. For example, we have produced reports on technology, on 'internet of things', and on 'financial technologies'. These are all available publically on our government of science website. They have fairly specific actions and government takes quite a lot of interest of them. Our broader projects and we have two at the moment on 'ageing' which is a problem facing all countries around the world and it is certainly a challenge in the UK. We all are living longer healthier lives, and that’s a very good news, but the question is how much mobility, how long people are ill for and how we manage that. In addition, the question is how do we make sure that people are able to contribute actively to the society for as long as possible, so that’s one area that we are working on. Another area is around future city, again very interesting around the world. People talk about smart cities, but of course city cannot be smart; city is just how we make people use the cities in a smart way so, smart city is really about smart people and how we use technology to help people; those are the projects we are doing at the moment.

Park --- The Government Office for Science published the foresight report on the future of manufacturing in 2013. We believe that future manufacturing will affect issues such as ‘low economic growth’, ‘low fertility and the ageing population’ in both the UK and Korea.

Walport --- Our foresight report, horizon scanning work, is not only directed at government, its interest is directed at industry itself. To some extent, what we are doing is we are looking broadly across things like the future manufacturing and the way that industries and others will be able to look at as well. In fact, conclusions in many ways are similar to the conclusions of the work done in Germany Industry 4.0, and I think that everyone recognizes that manufacturing is likely to change very dramatically and it already is. Manufacturing is going to become much more distributed, much more personalized. People are going to have much more resources and care for the resources. So, there is a whole concept of remanufacturing and recycling. I think for both government and industry to understand the direction of manufacturing is very important when it comes to policy; a lot of policies are manufacturing and at end of the day they are up to individual private companies and how they choose to evolve, but those manufacturing companies don’t evolve as times change are likely to find that the competition is very severe.

Emerging issues in Korea and the UK

Park --- This year KISTEP conducted the project that analyzed emerging issues for the next 10 years. We found that ‘Low Fertility & Super-Aging Society’, ‘Social Inequality’, ‘Unstable Life of Future Generations’, and ‘Job Insecurity’ are important issues for Korean people in the next 10 years. Would you share what issues are most concerning to people in the UK?

Walport --- These are very similar issues if you look across the world. That is a non-pollable question. We are much more globalized, and the internet and information technology metaphorically made the world smaller, but there is no substitute when it comes to social networking. Regarding low fertility, the fertility is actually not low but people are making choices to have fewer children. Of course, if people choose to have fewer children and they live longer, this creates an economic change and makes very important...
question about the future of work where they are staying in work for longer because pensions have to be afforded somehow. And so these are challenges that our countries share. The other obvious question is how work will change and again it’s quite difficult to predict the future, but we know that during the first industrial revolution, when people learn how to harness the power or fossil fuels that changed the way how things could be manufactured. It enabled people to live in cities and that had a dramatic change on working practices. We are now going through a further industrial revolution of information technology and we are really at the start of that as we know that machine intelligence is something which is going to develop. It will change the way almost every job is carried out, for example in medicine. I look forward to the world where if I am in clinical practice, artificial intelligence machine can help me to make better diagnosis. New jobs will emerge; new services will emerge of course going back to manufacturing. Manufacturing is increasingly distributed activity where you can have a factory in really quite small spaces, but producing highly volumes of important, highly technological pieces of equipment.

Trend of the UK science: education, gender and communication in science

Park --- The UK has a long history of this modern science after at least from Newton, but Korea only has very short modern science history. For our science and technology sector, it has around 50 years of history after the establishment of KIST (Korea Institute of Science and Technology) back in 1966, the first national institute, followed by establishment of the Ministry of Science and Technology in 1967. KISTEP has conducted a very interesting survey in September on how Korean people feel about science and technology. The interesting thing is that around 80% of the people are thinking that this remarkable economic growth of Korea was achieved thanks to science and technology. Also, around 70% of people consider as a parent or as a student they would like to major in science. However, scientists and engineers are not treated as well as they used to be. Do you have the similar trend in the UK?

Walport --- I think that brings up three important issues. Firstly, the issues of science education where in the UK, science education starts in elementary school effectivity where we have to have a strong focus, making sure to have good teachers with science expertise. The second is that we have to get better at communicating science to the public and people are naturally fascinated by science. Science is intrinsically very interesting, for example, when the Higgs’s Boson was discovered in a large head drone collider, there was enormous fascination even if people didn’t really understand what Higg’s Boson actually is. One of the things we have in UK is that we have a science media center. That’s an independent organization but actually brings together excellent scientists with science journalists and it acts as a forum for communications which can operate very well in an international or a national emergency. Then I think the third issue is diversity, gender in particular, which is the low representation of women in science. We are losing potentially up to half our talent and that doesn’t make sense. I think we have to all work on each of these issues.

Science is a very long term enterprise and it takes a long while from discovery by the scientists for it to be recognized as a groundbreaking piece of research. Science is also a global enterprise. Therefore, global collaboration is very important.

Park --- In August 2015, we hosted the Gender Summit 6 Asia Pacific in Seoul. As a female physicist I have had experiences of gender related issues. When I was in high school, I told people that I would like to major in Physics. This surprised those around me and they asked ‘Why are you majoring in Physics?’ as it was very odd for the society in those days. After entering Seoul National University, people thought that I was strange to major Physics as a female even amongst my colleagues from science. The problem I faced when I finished my PhD degree in 1987 was that it was very difficult to find a job as a female scientist. I was told that many universities in Seoul avoided reviewing female candidates. However, after the Fourth World Conference on Women in Beijing (1995), people recognized that we have to boost women’s power in science and technology.

Walport --- So, we all have somewhere to go. In the UK, women essentially take part in about 7% which is really short of 50%, and it’s certainly a problem in more senior positions. I have three daughters, one of them is an academic chemist and one is civil engineer and the other is a material scientist, where none of them were inhibited by anything at all. I think it is about encouraging all people that there is a great potential and opportunity in science engineering and technology but I think the other side of the coin is that we need to make sure careers have the flexibility that people from all backgrounds become scientist. I think that is one of the challenges because we need to make sure scientists can work part time for periods of time. It is about providing flexibility at the work place that would be necessary to fully achieve equality in a sort of diverse areas and our most precious asset is our talented people.

Park --- In the last decade, science education in Korean school has become less of importance. What about the situation of science education in the UK?

Walport --- I think it is improving all the time actually. More people are doing science in schools, but in mathematics we have a long way to go. Too few people continue with mathematics after the age of sixteen which is a problem so I think we are complacent about science and mathematical education. However, it is something successful government pays a lot of attention to. Science education is recognized as a very important area and I think the biggest challenge is actually making sure that we have very strong teachers because teachers make all the difference. The curriculum is important but the most important thing of all is the quality of the teachers. Jobs have to depend on
competence and I think one of the important things in all of the professions is to make sure you continue your professional development. There needs to be opportunities for the professionals to do continuous development as well. For example, we have a science learning and teaching center; there is a national network which provides professional development, and there is the association of science educators; so there are various forums which science teachers can have a refresh of their professional skills.

Towards collaboration between the UK and Korea

Park --- You may be aware that Korea is investing a lot on R&D. Although, the budget for the Korean government and private R&D is around 60 billion dollars, we are not producing results efficiently. We realize that it’s due to the lack of strategic design concept and technology as we have short history of science perhaps. Would you like to comment on this issue?

Walport --- Science is a very long term enterprise and it takes a long while from discovery by the scientists for it to be recognized as a groundbreaking piece of research. Science is also a global enterprise. Therefore, global collaboration is very important. The UK has always had very open and collaborative research environment so our scientists have traveled the world and scientists from other countries come to the UK. Therefore, we always have many students from countries around the world and when you look in the indices of the best universities in the world, British universities are always very strongly representative in the top 10 and top 20 universities in the world. So, the academic environment is a strong one and the strength of the British university is that it really teaches people to think. If you’re going to have the best science, you have to encourage creativity, originality and students to challenge. It’s about arguing and because it is the most independent scientist that discover the most original things. I think those are all very important points and that’s why I am pleased to be here because there clearly are opportunities for collaboration between Korea and the UK.

Park --- It’s been a great pleasure discussing these with you and I think we should start with building strong relations between KISTEP and UK government especially the Prime Ministers council for science and technology. Thank you for your time!

Walport --- Thank you!
I. Introduction

In the midst of a prolonged period of global low growth and low inflation, stagnation in developing countries and increasing debts have resulted in sustained economic uncertainty. In fact, according to the World Economic Outlook (WEO) updated in July 2015 by the International Monetary Fund (IMF), global growth for 2014 to 2016 is projected at 3.4~3.8 percent, and the growth of developed countries—at 1.8~2.4 percent—is expected to be lower. In this context, many countries are attempting to overcome a prolonged recession by fostering the engines for economic growth that will create jobs. In particular, the economic and industrial role of science and technology is being highlighted with the aim of fostering new growth engines. In the United States, scientific discovery and technological innovation are considered as essential factors to address the challenges of the 21st century, and national priority fields such as cutting edge manufacturing technology and clean energy are being prioritized. The EU is setting a ‘Horizon 2020’ strategy for economic recovery, and focusing its investments on industrial leadership in order to achieve a creative economy and secure new growth engines. Forming a startup ecosystem and fostering creative human resources are a part of our attempts to realize the creative economy. In addition, the government has increased its investments in future growth sectors, such as 5G networks and smart cars, with the aim of creating new industries.

With these attempts, both the quantity and quality of S&T (Science and Technology) accomplishments are increasing. In fact, the number of SCI papers written by Korean scientists has increased 35.3 percent, from 37,742 in 2009 to 51,051 in 2013, and the share of SCI-listed papers written by Korean scientists has also increased, from 2.5 percent to 2.73 percent. The number of patents has increased by 36.6 percent, from 9,604 in 2010 to 13,117 in 2014. Korea ranked 10th in 2011 and 5th in 2015 in the Composite Science and Technology Innovation Index (COSTII), an index that represents competitiveness in science and technology. However, the indicators for potential growth also show the problems Korea must address. The deficit of technology balance of payments continues, and in 14 out of the 65 items for which Korea has the top global export market share, China is close behind, with a difference in market share of less than 5 percent. The yearly growth (’10~’14) of Chinese PCT patents is 20.1 percent, more than double of Korea’s (8.1 percent).

Considering these factors, if Korea is to become more competitive than China and other developing countries, it must increase its potential growth through a constant investment in R&D. However, due to the continuous uncertainty of the global economy and the need to ensure fiscal sustainability, it is impossible to maintain the same rate of growth in R&D budgets. As shown in Table 1, under the National Fiscal Management Plan the average annual growth rate of R&D budget keeps decreasing.
The government allotted 19,094,200 million won for its 2016 R&D budget, which is 1.1 percent higher than the previous year. Considering that the 2014 and 2015 budgets had increases of 5.1 and 6.2 percent, respectively, this is a relatively lower increase. This is a result of a sustained budget deficit, and shows the government’s goal of focusing on ensuring internal stability by promoting efficient spending, rather than expanding the R&D budget.

Looking at the 2016 R&D budget by ministries, the Ministry of Science, ICT and Future Planning received the largest amount, 6,557,100 million won followed by the Ministry of Trade, Industry and Energy (3,407,300 million won), Defense Acquisition Program Administration (2,557,100 million won), the Ministry of Education (1,739,700 million won) and the Small and Medium Business Administration (956,300 million won). The government cut the budget for the Small and Medium Business Administration by 3.4 percent (33,600 million won), in areas where it overlapped with the portfolio of the Ministry of Trade, Industry and Energy.
In terms of policy, the government allocated the highest amount, 5,868,600 million won, for science and technology, followed by small and medium businesses, industry and energy (4,404,800 million won), national defense (2,598,100 million won), and education (1,845,100 million won). As a result of this increased support, including the customized education of human resources, industry-university-research institute collaboration human resources, and female human resources, the budget for education was increased by 5.6 percent (97,600 million won) from the previous year.

Of 9 technology fields, biotechnology was given the biggest R&D budget, 2,794,800 million won, followed by information and electronics (2,498,100 million won), and aerospace, aviation, and ocean engineering (2,050,400 million won). Since the proportion of private investment in biotechnology is low, and the size of the investment is much smaller compared with that of developed countries, the government allocated an increased budget in order to foster it as a future growth engine. When it comes to the information and electronics fields, which receive more in the way of private R&D investments, fields with high potential, such as Internet of Things, big data, etc. received higher investments. The government continued funding the aerospace and aviation fields to gain technology competitiveness and strengthen Korea’s industrial capacity in that field.

### III. Investment Direction of 2016 Government R&D

The objective of 2016 government R&D budget can be summarized into three major investment goals: promotion of an innovative economy, improvement of gross national happiness and innovation based on science and technology. First, to promote an innovative economy, the government raised R&D funding for the improvement of major industries, the fostering of future growth engines, and the enhanced commercialization of research findings. Then, the government aimed to improve the gross national happiness by increasing its investment in public-sector R&D and food, water resources, and security R&D, which are closely connected with the nation’s quality of life. Finally, they aimed to promote innovation based on science and technology by expanding basic and convergence research, reinforcing the foundation of science and technology, and promoting open collaboration.
is a focus on strengthening soft power innovations of the manufacturing industry, such as engineering and design. This is being done, for example, by developing advanced smart factory technology, at a level similar to that of the national small- and medium-sized business. Moreover, the government has planned to foster core design technology and support capability improvement via enhancing design innovation capability, which will promote the global competitiveness of domestic small- and medium-sized businesses. Similarly, the government has reinforced connection and cooperation between local support organizations, and continued to fund the related projects to boost R&D for local demand. For example, the government supports start-ups of local small-medium enterprises affiliated with industry, academia and research institutes by providing matching technologies and business models, meeting the demand of small-medium enterprises clarified by the creative economy and innovation center, and is targeting the enterprises educated through the “6-month challenge platform” program.

1) Promotion of innovative economy

1) Improvement in major industries

In the 2016 R&D budget, the government is angling for a breakthrough in the core industries in order to solidify the economic base. In addition, it has increased investments in small- and medium-sized businesses so that the businesses can take a key role in innovative economy. The government expanded investments in the foundations of small- and medium-sized businesses and projects to strengthen their research capabilities. As a result, the budget for small- and medium-sized business in 2016 will represent 18 percent of the total R&D budget. Fostering technology for startup growth, convergence and integration technology, and the abilities of industry experts are representative examples of small and medium-sized business support. In addition, the government is focused on funding manufacturing innovation, with the aim of creating added value in the manufacturing industries by implementing cutting-edge technology, such as ICT. At the same time, there

<table>
<thead>
<tr>
<th>Objective</th>
<th>To proactively address the needs of the dynamic and innovative economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Promotion of innovative economy</td>
<td>Achieve improvements in core industries to build a strong economy</td>
</tr>
<tr>
<td>2. Improvement of the gross national happiness</td>
<td>Create a clean and sound society in which all citizens are satisfied</td>
</tr>
<tr>
<td>3. Innovation based on science and technology</td>
<td>Expand creative basic research and convergence research</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major investment sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small- and Medium-sized Enterprises</td>
<td>Development of technology for startup growth</td>
<td>1,624</td>
<td>1,888</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>Convergence and integration technology for small and medium enterprises</td>
<td>685</td>
<td>906</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Enhancement of industrial experts’ capability</td>
<td>648</td>
<td>524</td>
<td>54</td>
</tr>
<tr>
<td>Innovation in Manufacturing Industry</td>
<td>Development of high technology for smart factories</td>
<td>50</td>
<td>99</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Enhancement of design innovation capability</td>
<td>366</td>
<td>420</td>
<td>54</td>
</tr>
<tr>
<td>Affiliation with Creative Economy and Innovation Center</td>
<td>Support for local small-medium enterprise start-ups affiliated with industry, universities and institutes</td>
<td>120</td>
<td>120</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 5. Investment direction of 2016 government R&D
Expansion of investments in future growth engines

The government increased its investment in the area of future growth engines, which is expected to bring about economic growth and create new jobs. In particular, it invested heavily in sectors with a relatively high chance of early commercialization, such as 5G networks and smart cars.

Table 6  Change in future growth engines by sector
(单位: one hundred million won, %)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future growth engines</td>
<td>10,810</td>
<td>11,807</td>
<td>997</td>
<td>9.2</td>
</tr>
<tr>
<td>Smart cars</td>
<td>368</td>
<td>619</td>
<td>251</td>
<td>68.2</td>
</tr>
<tr>
<td>5G network</td>
<td>859</td>
<td>1,142</td>
<td>283</td>
<td>33.0</td>
</tr>
<tr>
<td>Customized wellness care</td>
<td>399</td>
<td>446</td>
<td>47</td>
<td>11.7</td>
</tr>
<tr>
<td>Smart-emergency and safety management system</td>
<td>252</td>
<td>360</td>
<td>108</td>
<td>42.7</td>
</tr>
<tr>
<td>Hybrid systems for new and renewable energy</td>
<td>80</td>
<td>154</td>
<td>74</td>
<td>92.5</td>
</tr>
<tr>
<td>Internet of Things</td>
<td>286</td>
<td>336</td>
<td>52</td>
<td>18.1</td>
</tr>
</tbody>
</table>

In addition to future growth engines, the government has expanded its investment in new industries, such as the new energy industries, digital culture and service industries, and new bio-technology industries. As well, to enhance the competitiveness of traditional industries, agriculture and fisheries, the government has increased funding to develop agriculture and fisheries technology and introduce ICT.

Commercialization of research results

In an attempt to transform research results into a real business, the government expanded supports for commercialization in various forms. Also, to develop technology that reflects the actual demand, companies are selected first and then matched with public institutions. For example, the government offers vouchers to small- and medium-sized enterprises so that the corporations can receive technological support from government-contributed research institutes and universities. As part of the research equipment joint use project, vouchers that allow them to use the equipment of universities and institutions are also provided.

The government has expedited the consumer-oriented unification of the technology commercialization programs and expanded support for the commercialization activities of universities and government-contributed research institutes, with the aim of enabling the convenient transfer of technology. As an example of customer-oriented unification, the R&D rediscovery project from the Ministry of Trade, Industry and Energy, whose objective and contents were similar to those of the project from the Small and Medium Business Administration to develop commercialization technology [transfer technology] for small medium-sized enterprises, was integrated with the program from SMB [Small and Medium Business] Administration.

Table 7  Examples of research result commercialization
(单位: one hundred million won, %)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selecting Companies before Matching Public Institutes</td>
<td>ICT promising technology development</td>
<td>310</td>
<td>360</td>
<td>50</td>
<td>16.1</td>
</tr>
<tr>
<td>Support for Technology Commercialization</td>
<td>Research equipment joint use project</td>
<td>165</td>
<td>187</td>
<td>21</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>R&amp;D rediscovery project</td>
<td>110</td>
<td>285</td>
<td>175</td>
<td>159.3</td>
</tr>
</tbody>
</table>

2) Improvement of the gross national happiness

A healthy society

The government expanded its support for public-sector R&D, which is closely connected with the well-being of citizens. First of all, in the area of food safety, it strengthened support for food and drug safety and evaluation technology. In addition, in order to extend healthy years of life, it expanded the support for a smart health care system based on BT IT convergence technology, and continued to develop corrective measures against pollution to preserve a clean environment.

Specifically, the government extended the safety management programs, such as drug safety, provided support for developing an evaluation management technology for drugs, herbal medicines, cosmetics and sanitary aids to
ensure national healthcare, and continued investing in the development of medical equipment and technology with the aim of fostering medical industries as core industries with high added-value. Also, through the program for the development of life-friendly environment health technology, the government aimed to prevent an environmental crisis by eliminating hazards to the public health.

Table 8 Examples of R&D programs related to a healthy society  

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Safety</td>
<td>Safety management of drugs and others</td>
<td>200</td>
<td>224</td>
<td>24</td>
<td>12.0</td>
</tr>
<tr>
<td>Medical Equipment R&amp;D</td>
<td>Development of technology for medical equipment</td>
<td>216</td>
<td>216</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Improvement of Living Environment</td>
<td>Project for the development of life-friendly environment and health technology</td>
<td>126</td>
<td>148</td>
<td>22</td>
<td>17.8</td>
</tr>
</tbody>
</table>

➏ A sustainable society

The government increased its investment in R&D programs for building a sustainable society. The budget for corrective actions to address future crises, such as aging, as well as measures for food security and securing water resources, was strategically invested. For example, by increasing investments in experimental crops research, the government planned to supply an abundant amount of foods through developing crop production technology, and aimed to produce value-added crops. In order to take preemptive actions against climate change, such as global warming, the government increased the budget for acting on climate change, which will contribute to cultivating original technologies in fields that benefit significantly from carbon offset and the creation of new growth engines.

Table 9 Examples of R&D programs for a sustainable society  

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Security</td>
<td>Experimental crops research</td>
<td>416</td>
<td>442</td>
<td>26</td>
<td>6.3</td>
</tr>
<tr>
<td>Response to Climate Change</td>
<td>Developing countermeasures to climate change</td>
<td>465</td>
<td>528</td>
<td>63</td>
<td>13.6</td>
</tr>
<tr>
<td>Preparation for Aging Society</td>
<td>Product R&amp;D targeting 100-year lifespan</td>
<td>40</td>
<td>42</td>
<td>2</td>
<td>5.2</td>
</tr>
</tbody>
</table>

❼ A safe society

In order to establish a safe society in which citizens can feel secure, the government raised funding for certain sectors, such as information security, strong social safety, etc. For example, it expanded support for the development of core original technologies in the area of information security to obtain online security through basic technology and new threat-responsive technology. In addition, it also expanded the budget for security science in order to pursue effective actions against sophisticated and intelligent crimes.

Table 10 Examples of R&D programs for a safe society  

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Security</td>
<td>Development of new technology for information and communication security</td>
<td>299</td>
<td>412</td>
<td>113</td>
<td>37.8</td>
</tr>
<tr>
<td>Social Safety</td>
<td>Technology R&amp;D to maintain public order and security</td>
<td>22</td>
<td>51</td>
<td>29</td>
<td>132.1</td>
</tr>
</tbody>
</table>

❼ Innovation based on science and technology

The government expanded creative basic research and targeted convergence research. As it aims to increase the basic research budget by 40 percent of the investment until 2017, it is strategically increasing funds for basic research. Accordingly, the government also expanded its budget to support individual and group research and the Institute for Basic Science. It has allotted convergence research businesses an increased budget to promote problem-solving and object-oriented convergence research, and continued to support STEAM research to create new growth engines based on technologies that combine culture, tradition and science.

Table 11 Examples of R&D programs related to basic and convergence research  

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Research</td>
<td>Support for individual researchers</td>
<td>5,875</td>
<td>6,075</td>
<td>200</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>Support for research groups</td>
<td>1,489</td>
<td>1,552</td>
<td>63</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Support for Institute for Basic Science</td>
<td>2,046</td>
<td>2,155</td>
<td>109</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Enhancing the infrastructure for science and technology

When allocating the 2016 R&D budget, the government focused on enhancing the infrastructure for science and technology to enable achievements at a global level. To enhance the infrastructure, they expanded support for creative convergence human resources, and increased investment in big S&T infrastructure, such as heavy ion accelerator, the fourth generation synchrotron radiation, etc. Also, the government expanded its investments in aerospace R&D, such as moon exploration programs, development of the Korea Space Launch Vehicle, etc., and is aiming to conduct independent aerospace R&D.

Enhancing the infrastructure for science and technology

Support for International Cooperation

Multi-ministerial R&D Programs

Civil-military R&D Cooperation

Examples of open-collaboration R&D programs

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big &amp; Technology</td>
<td>International Science Business Belt</td>
<td>2,170</td>
<td>2,446</td>
<td>296</td>
<td>13.6</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Support for Joint use of Synchrotron Radiation</td>
<td>329</td>
<td>396</td>
<td>178</td>
<td>54.3</td>
</tr>
<tr>
<td>Aerospace</td>
<td>Korean Space Launch Vehicle</td>
<td>2,505</td>
<td>2,470</td>
<td>145</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Strengthening open-collaboration research capacity

Finally, the government planned to strengthen research capacity in Korea through open-collaboration. Specifically, it attempted to strengthen civil-military cooperation by expanding investments in civil-military technology transfer and joint use, and increased the budget for the implementation of multi-ministerial R&D Programs, such as trans-governmental whole-cycle new medicine development projects. In addition, the government made strategic investments in international cooperative research in order to bring about global technology innovation and establish a cooperative system.

Strengthening open-collaboration research capacity

<table>
<thead>
<tr>
<th>Sector</th>
<th>Program</th>
<th>2015 (A)</th>
<th>2016 (B)</th>
<th>Variation (B-A)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil-military R&amp;D Cooperation</td>
<td>Developing civil-military technology</td>
<td>174</td>
<td>307</td>
<td>133</td>
<td>76</td>
</tr>
<tr>
<td>Multi-ministerial R&amp;D Programs</td>
<td>Trans-governmental whole-cycle new medicine development</td>
<td>281</td>
<td>303</td>
<td>22</td>
<td>7.9</td>
</tr>
<tr>
<td>Support for International Cooperation</td>
<td>International joint-research program for energy</td>
<td>86</td>
<td>94</td>
<td>8</td>
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<tr>
<td></td>
<td>International exchange of research manpower</td>
<td>47</td>
<td>81</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

IV. Enhancing the Efficiency of Government R&D Investment and Improvement of System

What needs to be focused on in the 2016 R&D budget planning process is that the government is aiming to maximize the efficiency of its investment through effective investment and the improvement of related systems. The government has cut budgets by enhancing the efficiency of traditional budgeting, and intends to use these savings to invest in economy innovation and the creation of future growth engines.

As a part of its efforts to enhance investment efficiency, the government reviewed the R&D programs from square one: it strengthened the performance evaluation of R&D investments, implemented a sunset provision on long-term programs, managed similar and overlapping R&D programs, and promoted the efficiency of regional R&D programs. In addition, it has attempted to enhance the transparency of fiscal management through multidirectional modification of the R&D management system, including the systematized management of research equipment, research fund reform, and management of non-R&D programs.

1) Improving evaluation system for R&D investment

Evaluation of government R&D investments consists of a mid-term evaluation, follow-up evaluation, in-depth evaluation, etc. The evaluation is conducted each year in accordance with strict standards and impartial indicators, where its effectiveness has been highlighted. Therefore, when allocating 2016 government R&D budget, the government incorporated the evaluation results more strictly than ever. Significantly, for programs graded lower than "insufficient" for 3 years (’13–’15), the government budget was rejected, and reduced the budgets for ongoing tasks by over 10 percent from its 2015 budget.

In response to criticisms that evaluations are too generous, the government reduced the budgets for ongoing tasks by over 10 percent from its 2015 budget.

2) Implementing sunset provision for long-term programs

Despite continuous increases in government R&D funding, traditional budgeting for long-term programs thwarts efficient fiscal management. In fact, 594 out of 750 R&D programs were continued without termination. For
those programs, the government implemented a sunset provision instantly, by determining whether to continue support or apply the provision. Of the long-term programs, programs for which setting a program period does not bring about actual benefits, such as basic research, fostering manpower, support for institutes, etc. are determined to be supported continuously. The programs that can be finished during a certain period and programs that call for examination and evaluation were classified as ‘sunset programs’, and the termination date was set. When the ministry in charge of the programs calls for an extension, the government reviews whether the extension is appropriate.

3) Management of similar and overlapping R&D programs

The National Assembly and National Science & Technology Council have been presenting problems with similar and overlapping R&D programs. Even though there is a guideline for R&D programs to support small and medium-sized business, which specifies the role of the Ministry of Trade, Industry and Energy and Small and Medium Business Administration, the problem of similar and overlapping programs has been occurring. To prevent the same problems, when allocating the 2016 budget, the government comprehensively considered the distinct role of each Ministry, the objective of the programs, size of the task and its field, and determined the most appropriate department. There was a particular focus on coordinating the programs to support small-medium businesses; programs to foster small-medium business are supported by the Small and Medium Business Administration, and programs to foster each industry are supported by each department, such as the Ministry of Trade, Industry and Energy, Ministry of Science, ICT and Future Planning, etc. In addition, small-sized programs are supported by SMBA, bigger-sized programs are supported by MSIP or MOTIE, where MSIP is firstly suggested for programs of IT/SW fields. In addition to the programs to support small- and medium-sized enterprises, other similar and overlapping programs in each department were rearranged to enhance the efficient promotion of programs.

4) Efficiency of regional R&D programs

As regional programs began in earnest after 2000, programs to establish a research center and equipment to support local R&D programs flourished. Local branches, research centers and equipment were built indiscriminately, without sufficient consideration, which resulted in a weakened sense of responsibility for the local government and insufficient growth. To address these problems, the government reformed the process of establishing local R&D centers and improved supporting standards in order to strengthen the responsibility of local governments and promote projects more efficiently. In particular, for local branches of government-affiliated research institutes, the government managed the excessive government spending, and forced the launch of pilot projects before local branches could be installed. All feasibility studies were conducted by KDI to ensure public confidence. Originally, when it came to general regional R&D centers, there were no standards for government spending on each item. However, by specifying government spending of less than 70 percent for equipment purchase, it was planned to reduce government expenditure and strengthen the responsibility of local governments.

5) Systemized management of research equipments

As the science and technology industry grow and the S&T convergence trend continues, each department has expanded its budget for research facilities and equipments. Accordingly, over the last 5 years (’09~’13), investments in research facilities and equipments have reached 6.4 trillion won, which is 10.1 percent of the total R&D budget. However, oversight of the research facilities and equipments has been inconsistent, budget overruns are frequent, and unused and less-used equipments are not appropriately utilized. To address these problems, the government established an integrated review system of each department, with the aim of improving feasibility and effectiveness. In addition, it offered integrated information on the facilities and equipments, and built an equipment utilization service system to enhance the usage. By checking the records of equipment utilization, the government was able to relocate or transfer unused and less-used equipments, promoting the reuse of equipment.
6) Research funds and R&D expenditure reform

Originally, the R&D budget was divided into research funds and R&D budget, which led to a confusion in terms of fiscal management. Similarly, the ambiguous classification of research funds and R&D expenditure made it impossible for the government to grasp the exact budget trends, and highlighted the need for expenditure reform. Accordingly, when allocating the 2016 budget, the government arranged expenditure items systematically, and subdivided the research funds with the aim of achieving transparent fiscal management. In particular, it changed the R&D budget into R&D expenditure, and subdivided it into two categories. Research funds were divided into general funds and R&D funds, and the R&D funds were subdivided into 5 categories, aiming to enhance transparency and responsibility in budget spending.

7) Non-R&D program maintenance

As non-R&D programs that do not meet OECD standards are counted as R&D programs, some have pointed out that budgets for R&D programs are overestimated, which impedes effective management. Therefore, when allocating budgets, the government transferred the sectors not directly related to R&D, such as education and training, and support service activities, but to non-R&D programs, and planned to enhance R&D budget management.

8) Total cost control in R&D programs

Until now, R&D sectors were not subjected to total cost control, which led to concerns over a lack of transparency and responsibility. Recently, in the area of R&D, the total cost of programs to build large facilities, such as aerospace (space vehicles and moon exploration) and accelerators, has changed frequently, which highlights the need for a close review of increases in total cost and extension of period. As a result, the government revised standards for total cost and preliminary feasibility studies. Through this procedure, the government planned to enhance efficiency in spending by arranging and managing total costs of R&D programs, to establish a research foundation for each promotion process.

V. Future R&D Investment Direction

In a prolonged economic recession both inside and outside of the country, it is necessary to enhance future growth engines. However, because of fiscal conditions, it is hard to expand R&D investments continuously; effective investment is a prerequisite. Considering these factors, the government adjusted the size of the R&D investment in the 2015–2019 National Fiscal Management Plans.

<table>
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<th>’15</th>
<th>’16</th>
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<th>’18</th>
<th>’19</th>
<th>average annual increase</th>
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<td>19.3</td>
<td>19.7</td>
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</table>

Data: Korean government, National fiscal management plan, each year

The government plans to expand the size of R&D investment (government and private investment) to 5 percent of GDP, until 2017. Specifically, the government aims to increase the proportion of the basic research by 40 percent in 2017 from 37.1 percent in 2014, and to increase support for small- and medium-sized enterprises by 18 percent in 2016 from 16.8 percent in 2014.

The government has the goals of achieving qualitative growth, creating future growth engines through expanded R&D investment, and continuing to creating new businesses by launching ICT and promoting technology transfer. Furthermore, by increasing R&D that is focused on public convenience, the government will address social problems and promote the well-being of nations. In addition, as a strategy to ensure internal stability, the government will continue to improve its efficiency of budget deployment through innovation in R&D investment planning and management, performance-oriented R&D business supporting systems, and the management of similar and overlapping programs.
China has grown remarkably, from ‘the world’s factory’ to the ‘world’s market,’ to the extent that it is called Super China by some. Although Japan has suffered from a long-term slump, a ‘lost two decades,’ it is still advanced compared to South Korea. Concerns about the “nutcracker” situation of South Korea, where South Korea has difficulties stuck between China and Japan, have also increased in competition with Japan that South Korea hardly keeps up and with China catching up rapidly.

With the ‘new three lows (low growth, low interest rates, low exchange rate)’ having recently become the norm, South Korea is making every effort to find a new growth engine, but has failed so far to secure a new growth industry. Lee Myung-bak Lee administration’s “Low Carbon, Green Growth” and Park Geun-hye government’s “Creative Economy” are also the results of seeking new growth engines. Such efforts and attempts should be continued without a break. Most of all, as the unemployment issues Korea has experienced since...
1990 are associated with the low birth rate and aging issues, job creation has also been a key topic in South Korea. Considering those circumstances, this analysis studies the competitiveness and technological competitiveness trends of South Korea, China and Japan, and in particular points out which problems have to be addressed in South Korea in terms of technology and innovation.

To this end, this analysis examines various competitiveness indicators, and attempts to derive policy implications.

II. Major Competitiveness Indicators

Various organizations and institutions around the world have performed competitive assessments, developing and applying a wide range of indicators to measure the competitiveness of each country and have tried to predict the future.

The World Competitiveness Yearbook published by IMD (International Institute for Management Development in Switzerland) is the most widely known of the competitiveness indicators. In addition, there are The Global Competitiveness Report published by WEF (World Economic Forum), German Innovation Index released by five institutions including the Deutsche Telekom Foundation, the German Cartel, the Fraunhofer system, European Economic Research, and United Nations University Innovation/Technology Research, and Global Innovation Index released by INSEAD of France and World Business.

South Korea has the Composite Science and Technology Innovation Index (COSTII) published by KISTEP, but its target is confined to 30 OECD countries. China was excluded from this analysis since it has been dealing only with in-depth analysis of items for the past two years, so time series analysis was not possible.

This analysis investigates major competitive indicators with a long history and China as an indicator: World Competitiveness Yearbook of IMD, The Global Competitiveness Report of WEF and German Innovation Index.

A model to measure national competitiveness and the competitiveness of science and technology is a composite index that includes quantitative and qualitative measures about a series of observed facts. Therefore, each model will show differences to some degree depending on the composition, investigation and calculation of each sub-index. It is difficult to say that those indicators reflect absolute and objective facts, but they are preferred by policy-makers and have been widely used because they provide figures that are easy to understand.

In this regard, the WEF has mentioned there is a strong correlation between The Global Competitiveness Index (GCI), which estimates the figures of 143 countries, and the amount of GDP per capita (PPP $).(Figure 1)

The competitiveness evaluation index not only ranks the countries, but also focuses on analyzing the key factors affecting competitiveness. In the early 1900s, Max Weber described the relationship between culture and economic development. Ultimately, countries are competing for education and value system as well as products and services. IMD focuses on each country’s Value System as a key factor to determine the competitiveness of countries. IMD described the Value System as evolving from Hard work (capital) → Wealth → Social participation → Self-achievement as a country develops. South Korea is one of the typical Hard work countries in the System, and most East Asian countries are in a similar position. The competitiveness of the East Asian countries is the result of labor, loyalty, discipline, saving and education based on Confucian values. On the other hand, Japan is moving from Social participation to Self-achievement. Thus, in the case of Japan, the political, social and economic system needs to be reorganized depending on the change in the Value System from the community to the individual. Examples of “Self-achievement” countries include the United States and European Union. (Figure 2)

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2) IMD, 2014, IMD World Competitiveness Yearbook 2014

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Figure 1: Correlation Between GCI and GDP (per capita) of 143 Countries

* Source: World Economic Form; IMF World Economic Outlook Database, April 2014

The competitiveness evaluation index not only ranks the countries, but also focuses on analyzing the key factors affecting competitiveness. In the early 1900s, Max Weber described the relationship between culture and economic development. Ultimately, countries are competing for education and value system as well as products and services. IMD focuses on each country’s Value System as a key factor to determine the competitiveness of countries. IMD described the Value System as evolving from Hard work (capital) → Wealth → Social participation → Self-achievement as a country develops. South Korea is one of the typical Hard work countries in the System, and most East Asian countries are in a similar position. The competitiveness of the East Asian countries is the result of labor, loyalty, discipline, saving and education based on Confucian values. On the other hand, Japan is moving from Social participation to Self-achievement. Thus, in the case of Japan, the political, social and economic system needs to be reorganized depending on the change in the Value System from the community to the individual. Examples of “Self-achievement” countries include the United States and European Union. (Figure 2)
Most science and technology or innovation indicators are very important in the competitiveness evaluation index. Ikcheon Um et al.\(^4\) analyze key reports about science and technology competitiveness and point out that there is a high positive correlation between science and technology competitiveness and national competitiveness. For example, by analyzing IMD’s competitiveness rankings, science infrastructure rankings, national competitiveness rankings and technology infrastructure rankings with Spearman Correlation Coefficients, each correlation coefficient was 0.69 (p <0.001) and 0.84 (p <0.001), and there was statistical significance. The three competitiveness indicators used in this analysis are as follows.

The IMD World Competitiveness Yearbook\(^5\) has been published annually since 1989, and at the time of its first publication it ranked 26 OECD countries and 20 other emerging countries. The 2014 yearbook benchmarks the performance of 60 countries based on 338 criteria and calculates the composite index with 253 indicators in total, where 85 indicators are used as references. The IMD competitiveness evaluation index is composed of 20 sub-sectors in a total of four categories: achievement of economic management, efficiency of government administration, efficiency of business management, and infrastructure development. It includes 118 survey indicators for quantifying business management practices, labor-management relations, corruption, and environmental issues, which are hard to quantitatively measure. The survey’s indicators have been somewhat controversial, and there have been disagreements on the reliability of its measurements because it reflects the subjective views of respondents. Nevertheless, the IMD World Competitiveness Yearbook is still recognized as a key indicator with significant influences. Fields related to science and technology in the sub-sectors of the IMD competitiveness index are ‘technology infrastructure’ and ‘science infrastructure,’ as sub-sectors of ‘infrastructure development.’

The WEF Global Competitiveness Report\(^6\), which came from the report called “The Competitiveness of European Industries” in 1979, became an important factor to study and benchmark. WEF had published World Competitiveness Yearbook with IMD from 1989 to 1995, and it has published a separate report about competitiveness since 1996. The ‘World Competitiveness Index’ has been used since 2006 as an updated version of ‘Growth Competitiveness Index.’ WEF defines a country’s competitiveness as “policy, system and various elements that enable sustained economic growth and long-term prosperity.” The WEF Competitiveness Index is composed of three criteria, 12 sectors, and 112 indicators: 80 survey indicators and 32 quantitative indicators. WEF has a relatively small number of indicators compared to the IMD, whose proportion of survey indicators is high. Fields related to science and technology in the sub-sectors of WEF are ‘technological readiness’ and ‘innovation.’ The fact that it reviews an education indicator such as ‘health and primary education’ and ‘higher education and training’ by separating it into primary and higher education and deals with various diseases (e.g. malaria) and mortality in the health-related item is remarkable in sub-sectors of WEF.

Lastly, the German Innovation Index is differentiated from IMD and WEF because it partially contains indicators related to economy and education, but most indicators are related to science and technology. The German Innovation Index was published for the first time in 2005, and it has been investigated by the consortium including Fraunhofer Structure and Innovation Research Institute (ISI) in Karlsruhe, Mannheim European Economic Research Centre (ZEW), and Maastricht University Economic and Social Research for Innovation and Technology and Training Center (MERIT). The number of target countries was increased to 35, and it was analyzed on the basis of 38 indicators in 2014. Next, we analyze the rankings and features of South Korea, China and Japan using those competitiveness indicators.

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\(^1\) Ikcheon Um et al., 2014, A Synthetic Analysis for Comparing the Science and Technology Field of Main Competitiveness Reports in FY 2014, KISTEP

\(^2\) Hyunsong Cho et al., 2014, Analysis of IMD World Competitiveness Yearbook in 2014: Focusing on Science and Technology Infrastructure, KISTEP

Looking at the comprehensive competitiveness trend of countries in the past 10 years, China’s national competitiveness, which ranked lower than South Korea’s in 2005, has been ahead of South Korea since 2006. Japan, which historically had dominated South Korea, lagged behind between 2010 and 2013, but overtook South Korea in 2014. Hong Kong has overwhelmingly maintained a high national competitiveness regardless of the performance of South Korea, China or Japan.

IMD annually presents the current issues that each country has to find solutions for. The issues for China in 2014 were serious environmental pollution, the need to accelerate economic growth with boosting domestic demand, the need to control the financial crisis and real estate bubbles, communication between the government and the market, and the need to improve the quality of urbanization. For Japan, the need to accelerate its economic reform, enhance its fiscal soundness, promote cooperation and integration with the global economy, utilize its human resources, and transform into a problem-solving developed country were suggested. For South Korea, the need to maintain its growth potential by activating investment and domestic consumption, to restrain income inequality by job creation, to promote communication with North Korea, improve the environment for the creative economy, and correspond on various regional trade agreements in East Asia were highlighted.

As mentioned above, fields related to science and technology in the sub-sectors of IMD are ‘technology infrastructure’ and ‘science infrastructure.’ Figure 4 shows South Korea has maintained a higher ranking than China and Japan in terms of technology infrastructure, while Hong Kong has dominated the three countries in this area, as expected. Overall, the competitiveness of China’s technology infrastructure over the past 10 years has continued to increase, while Japan, which hardly rallied, has fluctuated since its competitiveness of technology infrastructure fell sharply in 2007. On the other hand, the science infrastructure competitiveness of Hong Kong is significantly lower than that of South Korea, China, or Japan. While Japan maintains the dominant position in the science infrastructure, the science infrastructure competitiveness of Korea has tended to increase slightly, and China is chasing South Korea closely.

Although South Korea still has higher competitiveness than China in terms of its technology and science infrastructure, it is expected that China will overtake South Korea soon. Japan has been ranked second for 10 years and it shows its relevant capacity is stable. Overall, Korea’s national competitiveness ranking is low, but Korea holds a significant competitive advantage in the technology infrastructure. There is a typical nutcracker effect among the three countries in the science infrastructure.
Fields related to science and technology in the sub-sectors of the WEF Global Competitiveness Report are ‘technological readiness’ and ‘innovation.’ Korea’s competitiveness in the area of technological readiness had ranked lower than Hong Kong and higher than Japan and China, but has dropped lower than Japan since 2012. Technological readiness sectors of WEF have elements similar to the technology infrastructure indicators of IMD, and Korea’s high competitiveness in the technological readiness of WEF corresponds to its high competitiveness in the technology infrastructure of IMD. However, a difference between WEF and IMD is that there is a big gap between South Korea and China in the competitiveness assessment. According to the index system of WEF, Korea still holds a dominant position in technological readiness compared with China.

In the competitiveness trends of the innovation sector, the fact that South Korea is located between China and Japan reflects trends that show the competitiveness of China has risen. However, the gap between the countries in WEF is considerably greater than IMD for the competitiveness of science infrastructure, and the innovation competitiveness of Hong Kong was ranked higher than IMD.

In the national comprehensive competitiveness and competitiveness of technological readiness and innovation of WEF, Korea in 2014 showed a similar pattern in that it is located between China and Japan and held a relatively high competitiveness in technological readiness.
In the evaluation results of the German Innovation Index for the three countries, more interesting trends can be found. While the innovation ranking of South Korea was stable, Japan had dropped and China had climbed. It is estimated that South Korea had the highest competitiveness. Although the relative superiority of South Korea was the result of the decline in Japan’s competitiveness, the fact that it maintained its position in the comparison of the three countries has great implications for South Korea. Of course, South Korea should find a long-term strategy for East Asia – including South Korea-China-Japan – to become the center of world innovation.

According to the German Innovation Index, expanding investments in studies and research and converting the input of increased future innovations into distinct output still must be a priority for most of the Asian countries. Output as well as input increased absolutely in all areas, but the composite index did not have any effect on improving rankings. On the input side, the center of innovation has not yet moved to Asia. However, when viewed in terms of economic investment in research and development, Korea and Japan are classified as world leaders. The Index points out that input for the whole innovation system including input of economy has significantly increased over the past few years in China. The German Innovation Index evaluates that Korea and Japan have already been industrialized countries for decades and are recognized as countries with research/innovation-oriented economy, but it did not have an effect on other Asian countries thus did not make the areas become active. This was because Korea and Japan targeted the market of North America intensively while they only targeted the market of Europe partially. The fact that markets of high-tech products in Asia did not exist even just a few years ago is one of the backgrounds for this strategy. However, the proportion of applications for European Patents from South Korea, Japan and China also has increased recently, so the gap between patent applications for US and Europe has decreased. This is because the importance of Europe for Chinese technology companies has grown.

The rankings of South Korea and Japan in the German Innovation Index evaluation are slightly lower than the IMD and WEF. However, German Innovation Index admits that South Korea, China and Japan are very competitive in Asia, and that China is particularly attractive as a future market. It pointed out that foreign companies were very interested in the Chinese market for high-tech products, as the number of patents filed by Japanese firms and Chinese inventors had increased more than 6-fold from 2006 to 2011, while increasing 8-fold for Taiwan, and 12-fold for Singapore.
The goal in assessing the competitiveness of countries around the world is to understand the strengths and weaknesses in order to find the best solution rather than to determine the current position and ranking.

In this analysis, the competitiveness of South Korea, China and Japan was compared and reviewed through an evaluation of three competitiveness reports: the World Competitiveness Yearbook by IMD, the Global Competitiveness Report by WEF, and the German Innovation Index. As mentioned above, competitiveness indexes show differences depending on their sub-factors and investigation methods, and the three competitiveness reports cited in this analysis also show differences. However, there are significant implications that can be gained through this comparison to grasp the overall competitiveness flow of the three countries, and the similarities between respective indicators.

In terms of comprehensive national competitiveness, IMD assesses that South Korea has lower competitiveness than Japan and China, and WEF evaluates Japan as having maintained the dominant position, with a significant gap. South Korea ranked two levels higher than China (26th and 28th in 2014), but this is not a great difference. Thus, it is a common opinion that China has raised its status rapidly, and that the competitiveness of South Korea does not show a big lead over China. Hong Kong is evaluated separately by both IMD and WEF, which see it as having remained very high competitive. Under the conditions for South Korea-China-Japan to be related closely with each other, to encourage mutual growth, and to compete, South Korea should prepare for the future.

The technology competitiveness of Korea in the technology infrastructure was rated highly by IMD, while WEF rated it highly for technological readiness. IMD estimated that South Korea’s competitiveness in the area of technology infrastructure was the highest of the three countries, and WEF assessed that South Korea maintained a significant gap with China even though it ranked lower than Japan. South Korea needs to pay attention to the trend that the competitiveness in the WEF evaluation of technology acceptance had been higher than Japan from 2006 to 2011 and has started to lag behind Japan again recently.

South Korea was ranked in the middle of Japan, South Korea and China for science infrastructure by IMD and for innovation by WEF. While there was a significant gap between countries in the WEF, IMD indicated that China and South Korea ranked 6th and 7th, and were chasing Japan closely. Both reports concluded that the competitiveness of China has risen rapidly. South Korea needs to be concerned with its ranking for innovation competitiveness in WEF, which has fallen steadily.

Examining the analysis of competitiveness in IMD and WEF, which divide and assess technology and science (innovation), Korea has a technical advantage among the three countries, but its science (innovation) sector is a concern. This results from the lack of basic and source technology, an issue which has been discussed for a long time in South Korea, and it must be one of the challenges to overcome in the long term.

The German Innovation Index can be explained as encompassing the science and technology related indicators of IMD and WEF. It is noted that it assesses that the competitiveness of Japan has reduced recently, and that Korea has led Japan. South Korea may provide a breakthrough in spite of the situation being worse than before to maintain higher competitiveness than Japan and China through hard work.

The competitiveness of a country does not last forever or remain unchanged. Even if competitiveness is based on natural resources, we have learned throughout history that resources also cannot last forever. The sources of competitiveness in each country are different, and they also vary even within the same country. South Korea depends to a large extent on people and was evaluated as a representative Hard Work country in IMD, its science and technology competitiveness is more important than it is for any other country. It should be noted for future generations that South Korea must strive to improve its technological competitiveness to realize high added value with its manpower and solve the low birthrate problem at the same time. Recently, its capabilities in the area of basic and source technology have expanded slightly, but interest and effort are still required for the future.
Suggestions to Mitigate R&D Workforce Shortage at Regional Small and Medium Enterprises

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Jinyong Kim  
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KISTEP

I. Introduction

Small and Medium-sized Enterprises (SMEs), which are considered by many to be Korea’s industrial keystone and the core of the creative economy, are having difficulty strengthening their competitiveness through technology innovation due to their perennial shortage of R&D workforce. Korea has the highest number of science majors per 100,000 people among OECD member states, and the rate of researchers who work for enterprises is quite high, but SMEs have been experiencing difficulties securing adequate R&D workforce.

In particular, regional SMEs have even greater difficulties in the supply of labor owing to two factors, ‘regional’ and ‘small and medium enterprises’. This is why there is a ‘mismatch’ occurring between demand and supply. Job applicants are all struggling to find employment, while SMEs have difficulties

References

1) This report is based on ‘Study on Regional R&D System for Strengthening Regional Capability and Accountability’ published by Ministry of Science, ICT and Future Planning and KISTEP.
2) The term ‘regional’ in this proposal refers to the 17 metropolitan cities and provinces excluding the capital area.

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IMD, 2006, IMD World Competitiveness Yearbook 2006
IMD, 2005, IMD World Competitiveness Yearbook 2005
filling the large number of vacancies arising. Worse, new regional workforce and the existing workforce often transfer their jobs to the capital area, looking for a better environment. This gravitation of regional workforce toward the capital serves to exacerbate the regional workforce shortage. This report attempts to analyse the R&D workforce shortage at SMEs from various angles, and to explore solutions that may ease the problem.

II. Current status and problem

1. R&D workforce shortage at regional SMEs

A great deal of research indicates that there has been a perennial shortage of R&D workforce at regional SMEs in Korea. In 2011, a survey on industrial technical workforce by business size revealed that SMEs (more than 10 employees – less than 299 employees) have a higher rate of shortage of workforce with master’s or doctoral degrees in R&D field than large enterprises (more than 300 employees).

The 2011 surveys on industrial technical workforce shortage at enterprises by metropolitan cities and provinces demonstrate that when the capital area is excluded, the lack of workforce with a master’s or doctoral degree is even more severe.

<table>
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<td>1.7</td>
<td>373</td>
<td>2.3</td>
</tr>
<tr>
<td>Gangwon</td>
<td>25</td>
<td>92</td>
<td>3.8</td>
<td>63</td>
<td>1.1</td>
</tr>
<tr>
<td>Chungbuk</td>
<td>200</td>
<td>155</td>
<td>1.8</td>
<td>21</td>
<td>1.2</td>
</tr>
<tr>
<td>Chungnam</td>
<td>201</td>
<td>314</td>
<td>1.7</td>
<td>63</td>
<td>0.7</td>
</tr>
<tr>
<td>Jeonbuk</td>
<td>153</td>
<td>225</td>
<td>4.4</td>
<td>40</td>
<td>1.4</td>
</tr>
<tr>
<td>Jeonnam</td>
<td>179</td>
<td>327</td>
<td>5.5</td>
<td>179</td>
<td>10.0</td>
</tr>
<tr>
<td>Gyeongbuk</td>
<td>404</td>
<td>476</td>
<td>2.5</td>
<td>26</td>
<td>1.2</td>
</tr>
<tr>
<td>Gyeongnam</td>
<td>689</td>
<td>829</td>
<td>2.8</td>
<td>72</td>
<td>1.8</td>
</tr>
<tr>
<td>Jeju</td>
<td>20</td>
<td>36</td>
<td>0.9</td>
<td>9</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>7,033</td>
<td>13,977</td>
<td>3.5</td>
<td>3,620</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* Footnote: The shortage rate is [shortage number of employees] / [current number of employees - shortage number of employees] * 100.
Looking into this by area, we can see that the regions produced more science and engineering workforce with master’s or doctoral degrees, with a higher annual average increase (3.02%) than the capital area (2.31%) during the same period. Accordingly, the share of non-capital area science and engineering graduates with master’s or doctoral degrees also increased, from 46.7% in 2000 to 48.7% in 2012, which indicates that the center of R&D workforce cultivation has gradually shifted from the capital area to the regions.

* Footnote 1: Graduates of engineering, medical and natural science programs in ‘Employment Statistics by Year’ (published by Korea Education Development Institute) are aggregated as science and engineering graduates.

Table 3 Change in the number of science and engineering graduates with master’s or doctor’s degree by capital and non-capital area (unit: person, %)

<table>
<thead>
<tr>
<th></th>
<th>Capital area</th>
<th>Non-capital areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>13,794</td>
<td>12,063</td>
</tr>
<tr>
<td>2006</td>
<td>14,375</td>
<td>13,382</td>
</tr>
<tr>
<td>2012</td>
<td>18,141</td>
<td>17,249</td>
</tr>
<tr>
<td>Annual average rate (%)</td>
<td>2.31</td>
<td>3.02</td>
</tr>
</tbody>
</table>

* Footnote 2: This table does not include the outflow of domestic workforce into overseas nations.

Examine this by comparing the capital area with other areas, the capital area shows more inflow than outflow, whereas the non-capital areas show the opposite trend. The capital area appears to have a higher inflow than outflow of workforce with master’s or doctoral degrees, whereas nine regions such as Gwangju, Jeonbuk and Busan show the opposite trend.

Table 4 Outflow and inflow status of graduates with master’s and doctoral degree by metropolitan city and province from 2006 through 2009 (unit: person, %)

<table>
<thead>
<tr>
<th>Region</th>
<th>Outflow (A)</th>
<th>Inflow (B)</th>
<th>Inflow and outflow index (B/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>17,564</td>
<td>9,419</td>
<td>0.54</td>
</tr>
<tr>
<td>Busan</td>
<td>3,497</td>
<td>1,142</td>
<td>0.33</td>
</tr>
<tr>
<td>Daegu</td>
<td>2,003</td>
<td>1,703</td>
<td>0.85</td>
</tr>
<tr>
<td>Incheon</td>
<td>1,393</td>
<td>1,643</td>
<td>1.18</td>
</tr>
<tr>
<td>Gwangju</td>
<td>1,824</td>
<td>950</td>
<td>0.52</td>
</tr>
<tr>
<td>Daegu</td>
<td>1,937</td>
<td>3,341</td>
<td>1.72</td>
</tr>
<tr>
<td>Ulsan</td>
<td>799</td>
<td>750</td>
<td>0.95</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>4,007</td>
<td>14,903</td>
<td>3.72</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>3,159</td>
<td>946</td>
<td>0.71</td>
</tr>
<tr>
<td>Chunghui</td>
<td>2,637</td>
<td>1,156</td>
<td>0.48</td>
</tr>
<tr>
<td>Chungnam</td>
<td>1,674</td>
<td>2,375</td>
<td>1.38</td>
</tr>
<tr>
<td>Jeonbuk</td>
<td>1,773</td>
<td>582</td>
<td>0.33</td>
</tr>
<tr>
<td>Jeonnam</td>
<td>581</td>
<td>1,336</td>
<td>0.45</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>3,148</td>
<td>1,936</td>
<td>0.61</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>1,292</td>
<td>2,627</td>
<td>2.03</td>
</tr>
<tr>
<td>Jeju</td>
<td>105</td>
<td>216</td>
<td>2.04</td>
</tr>
</tbody>
</table>

* Footnote 1: ‘Outflow’ is cases in which the workforce with master’s or doctoral degrees from that region is employed in other regions’ companies, whereas ‘Inflow’ is when other regions’ workforce with master’s or doctoral degrees comes into the region for employment.

* Source: Employment Statistics by Year, Korea Education Development Institute

Table 5 Outflow and inflow status of graduates with master’s or doctoral degree by metropolitan city and province (by year)

<table>
<thead>
<tr>
<th>Region</th>
<th>Outflow (A)</th>
<th>Inflow (B)</th>
<th>Inflow and outflow index (B/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>17,564</td>
<td>9,419</td>
<td>0.54</td>
</tr>
<tr>
<td>Busan</td>
<td>3,497</td>
<td>1,142</td>
<td>0.33</td>
</tr>
<tr>
<td>Daegu</td>
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<td>1,703</td>
<td>0.85</td>
</tr>
<tr>
<td>Incheon</td>
<td>1,393</td>
<td>1,643</td>
<td>1.18</td>
</tr>
<tr>
<td>Gwangju</td>
<td>1,824</td>
<td>950</td>
<td>0.52</td>
</tr>
<tr>
<td>Daegu</td>
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<td>3,341</td>
<td>1.72</td>
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<td>750</td>
<td>0.95</td>
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<td>946</td>
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<td>1,336</td>
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<tr>
<td>Gyeongsang</td>
<td>1,292</td>
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<td>2.03</td>
</tr>
<tr>
<td>Jeju</td>
<td>105</td>
<td>216</td>
<td>2.04</td>
</tr>
</tbody>
</table>

* Footnote 1: ‘Outflow’ is cases in which the workforce with master’s or doctoral degrees is outflowing, whereas ‘Inflow’ is when other regions’ workforce with master’s or doctoral degrees is inflowing into the region for employment.

* Source: Employment Statistics by Year, Korea Education Development Institute

Despite the increase of regional workforce, there is still a so-called workforce outflow phenomenon, in which talent cultivated in the regions moves to other places around the capital area for employment, which means that the regions continue to suffer from a severe lack of R&D workforce. Analyzing ‘the outflow and inflow status of regional workforce with a master’s or doctoral degree from 2006 to 2009’ by metropolitan city and province, the workforce outflow seems to depend on industrial conditions. Seven regions including Gyeonggi, Jeonnam and Gyeongnam appear to have a higher inflow than outflow of workforce with master’s or doctoral degrees, whereas nine regions such as Gwangju, Jeonbuk and Busan show the opposite trend.

Table 6 Outflow and inflow status of graduates with master’s or doctoral degree by metropolitan city and province from 2006 through 2009 (unit: person, %)

<table>
<thead>
<tr>
<th>Region</th>
<th>Outflow (A)</th>
<th>Inflow (B)</th>
<th>Inflow and outflow index (B/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
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<td>9,419</td>
<td>0.54</td>
</tr>
<tr>
<td>Busan</td>
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<td>1,142</td>
<td>0.33</td>
</tr>
<tr>
<td>Daegu</td>
<td>2,003</td>
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</tr>
<tr>
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<td>1.18</td>
</tr>
<tr>
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<td>950</td>
<td>0.52</td>
</tr>
<tr>
<td>Daegu</td>
<td>1,937</td>
<td>3,341</td>
<td>1.72</td>
</tr>
<tr>
<td>Ulsan</td>
<td>799</td>
<td>750</td>
<td>0.95</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>4,007</td>
<td>14,903</td>
<td>3.72</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>3,159</td>
<td>946</td>
<td>0.71</td>
</tr>
<tr>
<td>Chunghui</td>
<td>2,637</td>
<td>1,156</td>
<td>0.48</td>
</tr>
<tr>
<td>Chungnam</td>
<td>1,674</td>
<td>2,375</td>
<td>1.38</td>
</tr>
<tr>
<td>Jeonbuk</td>
<td>1,773</td>
<td>582</td>
<td>0.33</td>
</tr>
<tr>
<td>Jeonnam</td>
<td>581</td>
<td>1,336</td>
<td>0.45</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>3,148</td>
<td>1,936</td>
<td>0.61</td>
</tr>
<tr>
<td>Gyeongsang</td>
<td>1,292</td>
<td>2,627</td>
<td>2.03</td>
</tr>
<tr>
<td>Jeju</td>
<td>105</td>
<td>216</td>
<td>2.04</td>
</tr>
</tbody>
</table>

* Footnote 1: ‘Outflow’ is cases in which the workforce with master’s or doctoral degrees of that region is employed in other regions’ companies, whereas ‘Inflow’ is when other regions’ workforce with master’s or doctoral degrees comes into the region for employment.

* Source: Employment Statistics by Year, Korea Education Development Institute

Examining this by comparing the capital area with other areas, the capital area shows more inflow than outflow, whereas the non-capital areas show the opposite trend. The capital area appears to have 1.13 times more inflow than outflow, while the non-capital areas have 1.12 times more outflow than inflow.
Table 5: Outflow and inflow status of graduates with master’s or doctoral degree by capital area and non-capital area from 2006 through 2009

<table>
<thead>
<tr>
<th>Area</th>
<th>Outflow (A)</th>
<th>Inflow (B)</th>
<th>Outflow and Inflow Index (B/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital area</td>
<td>22,894</td>
<td>25,965</td>
<td>1.13</td>
</tr>
<tr>
<td>Non-capital areas</td>
<td>22,410</td>
<td>18,613</td>
<td>0.83</td>
</tr>
</tbody>
</table>

* Footnote 1: ‘Outflow’ is the cases in which workforce with master’s or doctoral degrees of that region are employed in other regions’ companies, whereas ‘Inflow’ is when the other regions’ workforce with master’s or doctoral degrees come into the region for employment.

* Footnote 2: This table does not include the outflow of domestic workforce into overseas nations.

* Source: Employment Statistics by Year, Korea Education Development Institute

As described so far, in reality, the R&D workforce is deployed around the capital area. As of 2011, the total R&D workforce in Korea amounted to 530,000 researchers, of which 60% (318,512 people) were placed around the capital area, whereas 7.4% (39,556 people) were around Daejeon.

Figure 2: The status of R&D workforce by metropolitan city and province (by year)

Pre-R&D workforce such as graduate students taking master’s or doctoral courses and R&D employees in the field do not consider jobs at SMEs to be attractive positions. A survey on the workplace preferences of job applicants with a doctoral degree in engineering or natural science found that 80% preferred working at universities or research institutes to working at enterprises.

Figure 3: Results of survey on workplace preferences of job applicants with doctoral degrees

Another survey targeting incumbent R&D workforce at enterprises indicates that job satisfaction varies according to the scale of the workplace. Employees at small enterprises tend to have low job satisfaction and organizational commitment, but a high level of work stress when compared with those at larger enterprises.

* Source: Report on R&D Activities by Year, Ministry of Science, ICT and Future Planning

3) Unlike the other regions, Daejeon has a cluster of many government-funded research institutes, so there are a number of high quality R&D human resources residing there.
We need to take a closer look at the level of this ‘skill mismatch.’ In 2013, KISTEP carried out a survey to assess the level of differences existing between the requirements of enterprise institutes and new researcher’s actual skills, focusing on about 19 skills. The results of the survey highlight the fact that all respondents recognize the existence of differentials on those skills. The differential of ‘Ability to deliver scientific information to the general public’ is the smallest (16.8 points), whereas ‘Problem solving skill’ is the biggest (26.4 points).

2. Causes of R&D workforce shortage at regional SMEs: mismatch between skill and compensation

The ‘skill mismatch’ phenomenon, which occurs when educational institutions are unable to provide adequate workforce to meet the demands of SMEs, is one of the causes of the workforce shortage. When SMEs were asked about their difficulties filling research positions, ‘A lack of technical competencies among applicants’ is the most common reason they gave. More than a half (50.3% of small manufacturing firms and 66.1% of small knowledge-based industries) identified this as an issue.

Table 4: Results of survey on job satisfaction, organizational commitment and work stress by business scale (points: 1 to 5)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Business scale</th>
<th>Less than 299 employees</th>
<th>300-999 employees</th>
<th>1000-1999 employees</th>
<th>Over 2000 employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job satisfaction</td>
<td></td>
<td>3.80</td>
<td>3.86</td>
<td>3.82</td>
<td>4.01</td>
</tr>
<tr>
<td>Salary satisfaction</td>
<td></td>
<td>3.21</td>
<td>3.25</td>
<td>3.22</td>
<td>3.61</td>
</tr>
<tr>
<td>Interpersonal relationship satisfaction</td>
<td></td>
<td>3.66</td>
<td>3.88</td>
<td>3.87</td>
<td>4.07</td>
</tr>
<tr>
<td>I have no intention of changing my job</td>
<td></td>
<td>3.05</td>
<td>3.17</td>
<td>3.40</td>
<td>3.88</td>
</tr>
<tr>
<td>I regard my company’s problem as my own problem</td>
<td></td>
<td>3.44</td>
<td>3.71</td>
<td>3.87</td>
<td>3.98</td>
</tr>
<tr>
<td>Leaving the company would be a loss to me.</td>
<td></td>
<td>3.00</td>
<td>3.06</td>
<td>3.28</td>
<td>3.44</td>
</tr>
<tr>
<td>My company is worthy of my loyalty.</td>
<td></td>
<td>3.46</td>
<td>3.52</td>
<td>3.76</td>
<td>3.84</td>
</tr>
<tr>
<td>Organizational commitment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel helpless and fatigued when I come home from work</td>
<td></td>
<td>3.08</td>
<td>3.09</td>
<td>2.81</td>
<td>2.69</td>
</tr>
<tr>
<td>Level of tension</td>
<td></td>
<td>3.29</td>
<td>3.44</td>
<td>3.35</td>
<td>3.19</td>
</tr>
</tbody>
</table>

* Source: Analysis on Correlation between Job Satisfaction and Performance of R&D workforce at SMEs, 2013, Korea Institute of Intellectual Property

Table 5: Differentials between the requirements of enterprise institutes and new researcher’s actual skills

<table>
<thead>
<tr>
<th>Classification</th>
<th>Small manufacturing</th>
<th>Small knowledge-based industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of applicants</td>
<td></td>
<td>43.0</td>
</tr>
<tr>
<td>Lack of technical competencies among applicants</td>
<td></td>
<td>50.3</td>
</tr>
<tr>
<td>Poor working conditions (lack, working environment)</td>
<td></td>
<td>32.8</td>
</tr>
<tr>
<td>Lack of possibility of long-term front for the job or enterprise</td>
<td></td>
<td>4.9</td>
</tr>
<tr>
<td>Competition with other enterprises for workforce security</td>
<td></td>
<td>9.1</td>
</tr>
<tr>
<td>Lack of cultural and welfare facilities around enterprises</td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td>Lack of information on job applicants</td>
<td></td>
<td>9.4</td>
</tr>
<tr>
<td>Inconvenient commute</td>
<td></td>
<td>4.6</td>
</tr>
</tbody>
</table>

* Source: 2013 Survey on the Actual State of SMEs, 2013, Small and Medium Business Administration, Korea Federation of Small and Medium Business

4) A total of 1,000 superiors or immediate supervisors of new researchers in science and engineering fields, who served as mentors from enterprise institutes, founded in Korea after 2001, were questioned through visiting research (400 researchers) and online research (600 researchers). The target industries were ‘teamwork,’ ‘mentoring,’ ‘negotiation,’ ‘networking,’ ‘project schedule management,’ ‘career development planning,’ ‘knowledge of research methodology,’ ‘research ethics,’ ‘creativity,’ ‘abstract thinking,’ ‘problem solving skill,’ ‘research planning,’ ‘leadership,’ ‘teaching,’ ‘scientific policy decision,’ ‘entrepreneurial spirit,’ ‘innovative activity,’ and ‘technology (patent) transfer and commercialization.’
This ‘skill mismatch’ occurs when higher educational institutions such as universities do not provide adequate workforce to satisfy the demands of industrial settings. ‘Compensation mismatch’, which occurs when there is a differential between job applicants’ salary or benefit expectations and the actual salary or benefit that SMEs can provide is another main cause of SMEs’ workforce shortage. Examining the salary level of SMEs’ R&D workforce, which is regarded as representative of the current compensation, we can see that the average wage of R&D researchers working at SMEs is 45.6% that of large enterprises, while the annual starting salary of those with a master’s or doctoral degree is 63.1% that of large enterprises.

Compensation differentials give a sense of the relative deprivation of R&D workforce at SMEs. The 2013 research on the actual state of SMEs suggests that the primary reason why employees at small manufacturing firms change their jobs is the lack of compensation. 72.3% (dissatisfaction with wage: 48.0%, dissatisfaction with working environment: 24.3%) of the survey participants say that the primary reason why employees at small manufacturing firms change their jobs is the lack of compensation. 72.3% (dissatisfaction with wage: 48.0%, dissatisfaction with working environment: 24.3%) of the survey participants say that the compensation level is unsatisfactory.

This report suggests five measures to mitigate the two main causes of workforce shortage at regional SMEs, ‘skill mismatch’ and ‘compensation mismatch’.

III. Mitigation measures for R&D workforce shortage at regional SMEs

Our own group interview with employees and students at research-focused universities who have master’s or doctoral degrees and are preparing to enter the job market shows similar results. All the interviewees, except for the employees of venture enterprises or SMEs, prefer large firms to venture enterprises or SMEs for the reason of employee treatment, job stability and company’s benefit.

Table 11   Results of group interview with employees and job seekers with master’s or doctoral degrees at a research-focused university

<table>
<thead>
<tr>
<th>Classification</th>
<th>Preference for large firms</th>
<th>Preference for venture enterprises or SMEs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Better working conditions such as treatment, job stability and benefit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Employment history at venture enterprises or SMEs is not considered as valuable experience in the labor market</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Firms’ vision, high potential of future compensation, horizontal and vertical organizational culture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- If there are basic infrastructure facilities such as education, medical treatment, culture, etc. Thus, it is believed that ‘working at large firms=working in a good living environment’</td>
<td></td>
</tr>
</tbody>
</table>

Table 12   The primary reason why employees at small manufacturing firms change their jobs

<table>
<thead>
<tr>
<th>Classification</th>
<th>Headhunting from large firms</th>
<th>Headhunting from other types of businesses</th>
<th>Entering school</th>
<th>Workforce reduction for administrative reason</th>
<th>Disatisfaction with working environment</th>
<th>Disatisfaction with salary level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1.6</td>
<td>10.5</td>
<td>26.0</td>
<td>1.3</td>
<td>9.5</td>
<td>26.3</td>
</tr>
<tr>
<td>Small firms</td>
<td>1.4</td>
<td>9.5</td>
<td>23.4</td>
<td>1.2</td>
<td>10.1</td>
<td>26.7</td>
</tr>
<tr>
<td>Medium firms</td>
<td>3.0</td>
<td>17.3</td>
<td>27.3</td>
<td>1.9</td>
<td>5.6</td>
<td>21.7</td>
</tr>
</tbody>
</table>

* Footnote: The total exceeds 100.0, as multiple responses were allowed

Figure 4   Measures to mitigate the main causes of workforce shortage at regional SMEs
1. Promote workforce development program involving regional SMEs

Despite an excess supply of workforce with natural science or engineering backgrounds, in reality, the industrial world has been complaining about a workforce shortage. However, there is an oversupply of workforce with degrees lower than the doctoral level, and this is projected to continue for another 10 years (Ministry of Science, ICT and Future Planning, KISTEP, 2013). With this oversupply of workforce, getting a job has become more difficult, and the employment rate is declining. Similarly, the industrial world is suffering from an inefficiency of the labor market that is caused by a vicious circle: poor level of workforce - increased expense for this workforce’s education and training - decline in productivity - growth recession - reduction of job creation capability.

The most fundamental reason for this phenomenon is that university education does not correspond to the demands of the private sector. An analysis of indicators to show the extent to which university education matches private sector needs (IMD) shows that while Korea’s level has improved from 4.00 points (52nd in the world) in 2005 to 4.93 points (41st in the world) in 2013, it still remains in the lower ranks. A panel survey on employment and education also suggests that university curriculums and teaching methods are not appropriate, and points out that graduates lack problem solving skills, communication skills and cooperation skills. Another reason for the workforce shortage is an information mismatch, which occurs when universities, the principal agent of workforce cultivation and supply, are disconnected from the industrial world, the main agent of workforce utilization and demand, especially from regional SMEs. However, this disconnection phenomenon is more noticeable at SMEs than at large firms, due to their weaker financial firepower and information strength on outstanding workforce.

Therefore, in order to change university education so that it corresponds to the demands of the economy and ease the skill mismatch and information mismatch between universities and industry, the government needs to promote a workforce development program in which SMEs can participate, with the government acting as a coordinator. To produce the workforce that can satisfy the needs of the regions, the innovation leaders such as universities, industry, government and local governments, triple helix for regional human resource for science and technology (HRST), should be unified, and share their values with each other.

This project aims to mitigate the workforce shortage at regional SMEs, and to improve the employment rate of graduates in science and engineering fields within the regions. The basic strategies to attain this goal are as follows: positively utilize consultative groups of human resources by industry and region; promote the involvement of SMEs by region and by industry; and develop an incentive mechanism to induce the participation of each main agent. Details of these strategies include the development of a new university curriculum that reflects the requirements of the regions and industries, participation of the industrial workforce in university education, introduction of internships (credit system) during university courses, establishment of a scholarship programme, and the provision of frequent field trips for students in science and engineering fields. Through this project, we expect to vitalize the participation of the industrial workforce in university education to continuously provide SMEs with information on outstanding workforce and the requirements of industry, and eventually, to mitigate the skill mismatch and information mismatch.

Table 12: Roles and participation mechanism of each institute involved in workforce development program including regional SMEs

<table>
<thead>
<tr>
<th>Role</th>
<th>Participation mechanism</th>
</tr>
</thead>
</table>
| Industry | - Curriculum planning and class participation  
- Joint scholarship programme creation  
- Improve information security on outstanding workforce  
- Ease the hiring of outstanding workforce  
- Reduce re-training expenses |
| Universities | - Curriculum planning and education provision  
- Improve reputation of universities  
- Encourage inflow of outstanding workforce |
| Consultative groups | - Bridge between industrial world and universities  
- Adjustment of requirements from industrial world and universities  
- Establishment of roles of sustainable consultative groups |
| Students | - Compulsory participation in internship programme before graduation  
- Frequent field trips and visits to enterprises |
| Government and local governments | - Provision of business operation expenses, development of incentive mechanism  
- Operational support for selected businesses (such as universities and SMEs by industry)  
- Overcome market failure by mitigating the workforce shortage at regional small and medium-sized firms and increasing the employment rate |

5) Employment rate of job applicants with bachelor’s degree declined from 67.3% in 2005 to 56.2% in 2012, while the employment rate of applicants with a master’s or doctoral degree declined from 81.9% in 2005 to 67.7% in 2012 (Employment Statistics by Year, Korea Education Development Institute).

6) Labor productivity of Korean employees is in the lower rankings, 23rd out of 34 OECD members (Ministry of Trade, Industry and Energy, Korea Productivity Center, 2013).

7) The internship should be made and agreed upon by academic advisors, enterprises and students in advance.
2. Improve workforce security for regional SMEs’ R&D departments through improving the technical research personnel system

The aim of the technical research personnel system is to have R&D workforce work at SMEs for many years. With this system, we can provide space to firms and an opportunity for workforce to establish a career; as such, we can consider this as an efficient measure for workforce supply to SMEs. Thus, we should consider improving this technical research personnel system to secure R&D workforce at SMEs.

Firstly, the SMEs’ student research group system supported by the government should be applied to local universities and SMEs. Since this system provides students in the science and engineering fields with a package programme consisting of workforce cultivation → employment → degree achievement → working as technical research personnel and R&D workforce, which is created by connecting the existing workforce support projects, it can induce R&D workforce to serve at SMEs for the long haul. Therefore, this is the first thing that we should introduce to regional SMEs according to priority.

Figure 5: Overview of SMEs’ student research group system

- Select third-year students in science/engineering fields and provide an opportunity to participate in job-connected and customized educational field trips, and enterprises projects in their fourth year
- Students earn their master’s degrees.

- Cultivate regional workforce and strengthen the competitiveness of regional SMEs by creating a specialized curriculum for the region’s industry
- SMEs hire the students who have finished the courses and support them while they work on their master’s degrees
- Operate conditional courses that guarantee the student’s employment as technical research personnel [small and medium business administration]
- Support college tuition for students taking these courses
- Allow them to work at the firms for three years as technical research personnel after earning their degree

Secondly, we should increase the proportion of technical research personnel at all enterprises, and specifically at regional enterprises. Even though R&D budgets have been gradually increasing throughout the private sector, the share of technical research personnel working at enterprises is declining. We should benchmark the alternative civilian service of Taiwan, a similar system to our substitute military service, considering that it has contributed to Taiwan achieving a high proportion of technical research personnel at enterprises, 70.3% (as of 2012).

Lastly, subject to the needs of regional SMEs, we should ease the current degree level required for technical research personnel to the bachelor’s degree level. As of 2013, the technical research personnel at SMEs only accounted for 39.3% of all technical research personnel, and segmenting this proportion by region, the capital area accounts for 84.1%, while non-capital areas account for 15.9%, which indicates that regional SMEs are facing difficulties employing technical research personnel. Thus, we need to ease the degree level of technical research personnel selection for regional SMEs to the minimum range, while remaining true to the original intent of the employment system.

3. Induce long-term incumbency of key R&D workforce at SMEs

To prevent a ‘hollowing out’ of the R&D capabilities of SMEs, we need to create favorable working conditions to enable researchers who have become key R&D workforce to stay at the enterprises for a longer time. One survey indicated that R&D workforce who have been working at SMEs for more than five years are more likely to stay at the firms for the long term, which implies that it is necessary to create advantageous conditions that will induce the long-term incumbency of workforce.

Table 12: Turnover of R&D workforce from SMEs by incumbency

<table>
<thead>
<tr>
<th>Turnover by incumbency</th>
<th>Less than 3 years</th>
<th>3 years ~ 5 years</th>
<th>5 years ~ 10 years</th>
<th>More than 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover by incumbency</td>
<td>13.1%</td>
<td>16.4%</td>
<td>5.8%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

* Source: Mitigation Plan for R&D workforce Shortage at SMEs, 2014, Relevant Ministry Cooperation

9) The number of technical research personnel assigned to enterprises was reduced from 1,695 in 2009 to 1,241 in 2013, of which the proportion that private enterprises account for is 29.1% in 2013 (Military Manpower Administration).

10) According to Minseon No (2014), 95.2% of SMEs claim that their greatest difficulty in utilizing the technical research personnel system is ‘employing technical research personnel’. 56.8% of them say that the degree criteria needs to be eased from ‘master’s degree or higher’ to ‘bachelor’s degree or higher’.
Above all, we should reinforce the support to connect SMEs’ technical research personnel system and key workforce’s performance compensation fund project (operated by SBC plan). For example, we may consider establishing a system to offer special treatment to personnel performing military service (technical research personnel) when they are assigned to SMEs under the technical research personnel system while registered in the key workforce’s performance compensation fund. Those who are registered in the key workforce’s performance compensation fund project are likely to work at the firms for more than five years without changing their job; thus, this would help to mitigate the workforce shortage at regional SMEs for at least five years. Also, to further invigorate this effort, we may consider that the government provides subsidies to technical research personnel who are assigned to regional SMEs while registered in the key workforce’s performance compensation fund project.

In addition, we suggest building and managing databases of regional SMEs’ key workforce registered in the key workforce’s performance compensation fund project. Using this data, we should produce policies that will prevent large firms from “poaching” the key workforce of regional SMEs. The new policies we may apply could include imposing expenses for education and training on large firms when they attempt an unreasonable employment of the key personnel of regional SMEs, forcing large firms to provide a certain amount of money to mutual-aid projects when they headhunt the key personnel of regional SMEs under cooperation of the SMEs, and introducing a human resources development programme (HRD) dedicated to key R&D workforce development for regional SMEs.

4. Create a working space for R&D workforce at knowledge-based regional SMEs

To promote regional knowledge-based industries, it is important to improve the working environments of regional SMEs to induce outstanding workforce to congregate and stay in the regions. Also, it is necessary to provide an appropriate office space and research space that is suitable for knowledge-based industries for regional SMEs, as well as those in the large cities or the capital area, because one of the reasons that workforce with master’s or doctoral degrees avoid the regional SMEs is the poor working environment, not to mention the uncertainty of working for a small enterprise itself.

Thus, first of all, we should consider providing, in a timely manner, the knowledge-based industry with public rental type buildings, in complexes that could tentatively be named ‘office parks,’ around the large cities that are not in the capital area, to be used as working spaces, because the industry, particularly the knowledge-based service industry, does not require large sites but the rapid provision of working space due to its short life cycle characteristics. As knowledge-based service industries usually tend to be located in the large cities, we should prepare these spaces around the large cities that are not in the capital area. In addition, new policies are required, such as providing the occupants of the ‘office park’ buildings with inexpensive rent, tax benefits and financial aid, and inducing them to actively participate in government-supported businesses for knowledge-based industry. Furthermore, it is also necessary to create living spaces, which could be tentatively named ‘research parks,’ for R&D workforce and enterprise institutes of knowledge-based SMEs around the transportation hubs such as the heart of small and medium-sized cities or express train stations. Given that, we should increase the sophistication of the industrial structure through the development of knowledge-based industries, utilizing adequate space in the small and medium-sized cities within the provinces, and in particular, promoting knowledge-based industrialization focusing on existing industrial complexes, should be pursued as soon as possible. Through this, we expect the supply of workforce with master’s or doctoral degrees for the research institutes of knowledge-based regional SMEs can be vitalized.

10) The SMEs’ key workforce performance compensation fund project is based on “Special Act on Support for Human Resources,” and enforced as of August 21, 2014, with the aim of encouraging the long-term incumbency of SMEs’ key workforce and the development of outstanding workforce. This is a mutual-aid project in which firms and their key workforce accumulate the fund together on the premise of an incumbency of more than five years, and repay the principal and interest to the key workforce upon the expiration of the term. Hence, this can be regarded as an incentive system for the key workforce’s long-term incumbency at SMEs.

11) A ‘knowledge-based industry center’ (old apartment-style factories) was built for manufacturing industries. But the offices in this area can be very expensive, since it was sold by private enterprises. Also, once tenant companies occupy the offices, they tend to stay for the long term, so the facility cannot flexibly respond to the frequent demands of knowledge-based industries.
5. Establish ‘regional creative and innovative agent system’

To cultivate and provide outstanding workforce to the regions, the government has pursued diversified policies and projects to date, but the disparity in R&D workforce between the regions has not yet been resolved. Therefore, to prevent outflow and induce the inflow of outstanding workforce for the regions, we should find differentiated approaches to workforce selection, management and utilization. As one of these measures, we propose that a ‘regional creative and innovative agent system’ (tentative name) be established, which is a workforce support system focusing on outstanding workforce development. The basic strategy of this plan is to shift from the traditional support provided by institutions or individual projects to new methods to polysynthetically select and manage outstanding workforce by regionally-operated task forces, with the government providing exceptional support for outstanding personnel who are willing to work at local firms.

Figure 7 Concept map of the task force’s functions for outstanding workforce security and management

IV. Conclusion

It is incontestable that SMEs, the backbone of regional industries, need to grow on the basis of ideas and technologies to achieve a creative economy in the regions. Although, as described in this paper, the difficulties that regional SMEs currently face, both internally and externally regarding R&D workforce, the origin of ideas and technologies, have been long-standing and persistent. Numerous obstacles, such as a lack of finance and information on outstanding workforce, poor work environments and settlement conditions, are tangled up and inter-related with each other, forming a net that is dragging down regional SMEs. In order to resolve these persistent problems, departments of the government need to cooperate with each other and promote various policies from different fields simultaneously. In particular, we should remember that these policies need to be pursued from the point of view of the demander, at the level of the SMEs.

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12) The government has legislated the Act on the Cultivation of Regional Universities and Human Resources (enforced in 2014) and is currently promoting a variety of projects for regional workforce development, including BK21+, reinforcement of university education capabilities (NURI) and industrial cooperative universities (LINC).
Empirical Study on Human Resources in Biotechnology: Focusing on Biopharmaceuticals and Medical Devices

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Juhae Ryu
Researcher
KISTEP

I. Introduction

South Korea is rapidly becoming a super-aged society. Due to the limitations of the “catch-up” economic strategies that have been promoted in Korea for the past 40 years, sustainable economic growth is reaching a limit. In order to overcome this phenomenon, the government has chosen biotechnology as high-value industry, and has developed and supported it for the last 30 years.

Due to continued investment by the government, certain external indicators such as the scale of the biotechnology [BT] market are growing rapidly, but a shortage of excellent biotechnology human resources is currently threatening the competitiveness of Korean biotechnology. However, as the statistical basis for developing policies to foster and use biotechnology human resources has been insufficient, it is hard to find what is the problem with biotechnology human resources when they enter the biotechnology industry.

II. Outline of Survey

A survey on human resources in biopharmaceuticals and medical devices sectors, which are subfields of biotechnology, was conducted to develop a statistical basis for fostering and using biotechnology human resources. The biopharmaceuticals and medical devices sectors were selected for the following reasons.

First, biopharmaceuticals, which accounted for the largest portion of the biotechnology market, is an appropriate for investigating the status of human resources of biotechnology in Korea. Biopharmaceuticals is also expected to be a promising sector to lead the next generation. At $2.34 billion, the scale of the Korean biopharmaceuticals industry accounted for about 0.2% of the world market in 2013. The total investment for research and development in the industry was $730 million and average investment per company was $2.3 million, the highest R&D investment of all the bio-industries.

The field of medical devices has become a prominent business item for global companies, as healthcare products have been developed actively with the development of information and communications technology and an increased interest in health. The Korean medical devices accounted for $3.95 billion and 1.2% of the world market in 2013 and it is growing rapidly every year. However, the performance of the sector is not yet satisfactory considering the level of support the government has provided to the medical devices industry.

Therefore, this study conducted a survey of businesses regarding human resources in the biopharmaceuticals and medical devices field, and will derive implications for the development of policies to foster and use biotechnology human resources.

Before setting the subjects of the human resources survey in biopharmaceuticals and medical devices, the biopharmaceuticals and medical device industry can be defined as follows.
Based on the definition, human resources in the biopharmaceuticals and medical devices sectors were defined as ‘staff having professional knowledge and skills related to biopharmaceuticals and medical devices, and engaged in related occupations of the industry.’ However, human resources related to general administration such as human resources, purchases, general affairs, accounting, etc. were excluded from the definition because they were not consistent with the research purposes.

Human resources in the biopharmaceuticals and medical devices sectors were classified into three categories: researchers (including R&D staff and clinical staff), production (including facility and quality managers), and sales/administration, etc. The outline of the survey about the status of human resources engaged in biopharmaceuticals and medical device is as follows.

### III. The Status of Human Resources Engaged in Biopharmaceuticals and Medical Devices

#### 1. Biopharmaceuticals

##### 1. Analysis of Subjects and the Scale of Human Resources

The biopharmaceuticals companies that responded mainly consisted of small businesses (36.0%) and medium-sized businesses (39.0%), and most of the respondents were independent companies (93.0%). 51.0% of companies responded that their capital was from 1 billion won to 10 billion won. Companies with annual sales of more than 10 billion won as of the end of 2013 represented 44.0% of the group, and there were 12 companies whose annual sales exceeded 100 billion won. The majority (56.0%) of respondents were located in Seoul and Gyeonggi.
37.0% of respondents answered that they had plans to expand in the future, of which 59.5% (22 companies) replied they planned to expand biopharmaceuticals continuously. Bio-food companies comprised 16.2% of the survey group (six companies), and the companies seeking to expand in bio-chemical and medical devices comprised 8.1% of respondents (three companies).

43.0% of respondents reported that they cooperate with other institutions. Companies that had made an ‘R&D cooperation contract’ and companies involved in ‘technical cooperation-licensing’ accounted for 68.1% (28 companies) and 51.2% (22 companies) of the group, respectively.

84.9% of independent companies (79 companies) and 100% of domestic group affiliates (4 companies) responded that they had their own research institutes, while all of the overseas group affiliates did not. With respect to scale, all of the independent mid-sized companies (10 companies) had their own institutes, while the majority of medium-sized businesses (94.9%, 37 companies) and small businesses (72.2%, 26 companies) had their own institutes.

As respondents mainly consisted of small and medium-sized companies, the number of employees was also quite small. Most companies had less than 100 employees; companies with 10 to 50 workers were the largest group at 36 companies, while 29 companies had more than 100 workers. The responded biopharmaceuticals had an average of 53.9% (94.5 employees) out of 175.3 employees as biotechnology human resources.

Regarding the type of work in biopharmaceuticals, production (40.2%, 38.0 employees) and sales, administration and other services (38.2%, 36.1 employees) both had more employees than research (21.6%, 20.5 employees). 54.0% (91.9 employees) of full-time employees per company were the biotechnology human resources and 97.2% of biotechnology human resources responded they are full-time employees.
There is a gap between the average number of biotechnology employees of companies having their own research institutes (average 108.5 employees) and companies without institutes (average 26.4 employees). Companies with their own research institutes have a relatively large number of biotechnology employees in all type of works compared to companies without institutes.

### Table 3: The Status of Biotechnology Human Resources among Biopharmaceutical Company Respondents (average)

<table>
<thead>
<tr>
<th>Total number of employees</th>
<th>Average</th>
<th>Rate</th>
<th>Research(a)</th>
<th>Production(b)</th>
<th>Sales: administration, etc. (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of employment</td>
<td></td>
<td></td>
<td>Total</td>
<td>Full-time</td>
<td>Part-time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Military Service</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Freelancer</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Contract worker</td>
<td>6.4</td>
<td>3.6</td>
<td>0.2</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Full-time</td>
<td>175.3</td>
<td>100.0</td>
<td>21.6</td>
<td>38.0</td>
<td>40.2</td>
</tr>
<tr>
<td>Part-time</td>
<td>170.1</td>
<td>100.0</td>
<td>20.0</td>
<td>34.5</td>
<td>35.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Rate</th>
<th>Average Rate</th>
<th>Average Rate</th>
<th>Average Rate</th>
<th>Average Rate</th>
<th>Average Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>174.5</td>
<td>108.5</td>
<td>23.4</td>
<td>43.0</td>
<td>42.1</td>
</tr>
<tr>
<td>With Company Research Institutes</td>
<td>174.5</td>
<td>108.5</td>
<td>23.4</td>
<td>43.0</td>
<td>42.1</td>
</tr>
<tr>
<td>Without Company Research Institutes</td>
<td>179.1</td>
<td>26.4</td>
<td>4.2</td>
<td>13.5</td>
<td>6.6</td>
</tr>
</tbody>
</table>

*Respondent Base: Pharmaceutical Manufacturing Companies (n=100)

Looking at biotechnology human resources by major academic degree, there are differences depending on the type of work. Academic degrees preferred differed depending on the type of work; in the research field, 10.8 employees (52.9%) were with Master’s degree, in production, 27.1 (71.1%) employees were with below Bachelor’s degree, and in sales, administration, etc., 29.7 (82.3%) employees were with Bachelor’s degree.

### Analysis of Employment and Prospects/Retraining

An average of 12.2 employees in biotechnology per company changed their jobs or retired in 2014. Sales, administration, etc. (average of 5.3 employees) recorded a higher turnover than production (average of 4.3 employees) and research (average of 2.6 employees). In particular, it was found that turnover/retirement of employees in biotechnology was higher among those with a career history of 2 years or less than among those with a career history from 3 years to 5 years (average of 1.6 persons) and those with a career history of more than 5 years (average of 1.6 persons). This suggests that the management of new employees is required.

The hiring prospects of biopharmaceutical companies for the next three years will decrease to 8.3 employees per company in 2015, 6.3 employees in 2016 and 6.6 employees in 2017. This was because there was a plan to recruit in 2015 when the survey was conducted, but the respondents applied a conservative forecast regarding subsequent employment plans. Respondents said that they preferred to hire candidates with a Bachelor’s degree, and preferred to hire in sales/administration. They also had a preference for new employees, preferred to hire full-time male employees.
Difficulties in Hiring New Applicants, by Academic Background

Degrees and majors are important factors in the standards of employment for new applicants, and work experience, professional knowledge and skills are important for experienced applicants. In the survey about difficulties in recruiting biotechnology human resources depending on academic background, while it is not difficult to hire applicants with a college degree or a Bachelor’s degree, finding candidates with a Master’s degree was rated as being of average difficulty or somewhat difficult, while finding candidates with a Doctoral degree was more difficult than finding candidates with a Master’s degree. It was reported that highly educated employees are more difficult to hire.

Table 5: Prospects on Employment of Biotechnology Human Resources in Biopharmaceuticals (average)

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Total Employment (prediction)</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below college degree</td>
<td>8.2</td>
<td>6.3</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Bachelor</td>
<td>2.6</td>
<td>1.9</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Master</td>
<td>3.4</td>
<td>2.5</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Doctor</td>
<td>1.9</td>
<td>1.6</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>0.6</td>
<td>0.3</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>2.6</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Sales/Administration, etc.</td>
<td>3.2</td>
<td>1.6</td>
<td>1.7</td>
<td></td>
</tr>
</tbody>
</table>

* Respondent Base: Pharmaceutical Manufacturing Companies (n=100)

Looking at the difficulty of hiring new applicants by academic background, the responses of ‘it is difficult to find people with the potential capacity, qualities and attitudes required’ and of ‘bio-technology personnel desired doesn’t apply because the working environments or conditions are poor’ were given relatively frequently.

On the other hand, in the difficulties of hiring experienced applicants by academic background, the response of ‘it is difficult to find people with skills and work experiences desired’ was given most frequently. This is because experienced applicants had not improved their work skills due to poor working conditions in their previous job, or could not be deployed easily because retraining programs were insufficient.

Figure 5: Difficulties in Hiring Biotechnology Human Resources in Biopharmaceuticals, by degree

* Respondent Base: Pharmaceutical Manufacturing Companies (n=100)

Note: ‘Not difficult at all’ is 1 point and ‘Very difficult’ is 5 points in the questionnaire.
57.0% of companies identified ‘work sharing with existing workforce’ as an alternative when hiring is difficult, while 16.0% cited ‘re-education and additional training of existing workforce.’ Most companies responded that they utilize their existing workforce when hiring is difficult.

90.0% of biopharmaceuticals companies participated in the survey were providing education and training to improve the business skills of biotechnology employees. A number of companies provided education from commissioned professional education institutions (73.3%, 66 companies), operated in-house education programs (52.2%, 47 companies) or provided education training with support for education (61.1%, 37 companies). For the education effects of biotechnology employees, they responded positively that ‘it was very effective’ (7.8%), or ‘it was somewhat effective’ (61.1%).

In terms of the difficulties of promoting biotechnology human resources or education and training, 55.6% of companies that provide education replied they have little time for developing human resources. OJT and retraining program are most preferred as the method of education and participating in domestic and international academic conferences is also used for one of the retraining options.

2. Medical Devices

1. Analysis of Subjects and the Scale of Human Resources

Medical device companies in the survey mainly consisted of smaller businesses than biopharmaceuticals: micro businesses (38.0%) and small businesses (49.7%). Companies that answered capital was from 100 million won to a billion won represented 61.0% (199 companies) of the group, and sales of 54.9% (179 companies) in all the respondents were from a billion to 10 billion won in the end of 2013. Like biopharmaceuticals companies, the majority (58.9%, 192 companies) of respondents were located in Seoul and Gyeonggi.
Only 35% (114 companies) of companies responded that they had a plan to expand their business, and the majority of companies replied they didn’t have a plan for business expansion. Medical devices companies cooperating with other institutions represented 40.8% (133 companies) of the group, of which 56.4% (75 companies) responded that they had ‘made an R&D cooperation contract,’ followed by 20.3% (27 firms) of companies that had conducted ‘domestic and abroad exchanges of technical human resources.’

75.0% (8 companies) of domestic group affiliates and 64.3% (200 companies) of independent companies have their own research institutes, while 28.6% (two companies) overseas group affiliates have their institutes. In terms of scale, while large and medium-sized businesses have recorded a high ratio of reservation as 100% (one company) and 91.9% (34 companies), only 48.4% (60 companies) of micro businesses have their own institutes.

As respondents in medical device fields mainly consist of micro and small business, the total number of employees is smaller than that of biopharmaceuticals companies. 87.7% (286 companies) of respondents have less than 50 employees, of which 127 companies have less than 10 employees. The average number of employees per company in the medical devices sector is 29.8 and of them 58.4% (17.4 employees) are biotechnology human resources.

Regarding type of work, production (46.4%, 8 employees) and sales, administration and other services (30.3%, 5.3 employees) used more biotechnology human resources than research (23.4%, 4.1 employees). An average of 58.5% (16.8 employees) of full-time employees per company are biotechnology human resources, of which 96.6% are full-time employees.

There is a gap between the average number of biotechnology employees at companies with their own research institutes (average 21.6 employees) and at companies without institutes (average 9.9 employees). It was found that companies with their own research institutes have a relatively large number of biotechnology employees compared to companies without institutes.

<table>
<thead>
<tr>
<th>Type of work</th>
<th>Total number of biotechnology human resources (on full-time)</th>
<th>Research (a)</th>
<th>Production (b)</th>
<th>Sales –administration, etc.(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>39.8</td>
<td>17.4</td>
<td>4.1</td>
<td>23.4</td>
</tr>
</tbody>
</table>

* Respondent Base: Medical Devices Manufacturing Companies (n=326)
Table 7  The status of Biotechnology Human Resources With/Without Company Research Institutes in Medical Devices (unit : person, %)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total Employees</th>
<th>Biotechnology Human Resources</th>
<th>Research</th>
<th>Production</th>
<th>Sales/ Administration, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Company Research Institutes</td>
<td>37.7</td>
<td>21.6</td>
<td>5.8</td>
<td>9.7</td>
<td>6.1</td>
</tr>
<tr>
<td>Without Company Research Institutes</td>
<td>15.8</td>
<td>9.9</td>
<td>1.0</td>
<td>5.1</td>
<td>3.8</td>
</tr>
</tbody>
</table>

* Respondent Base: Medical Devices Manufacturing Companies (n=326)

Investigating biotechnology human resources by major academic degree, there were differences found depending on the type of work in medical devices. Employees with a Bachelor’s (52.4%, 2.2 persons) or Master’s (23.8%, 1.0 person) degree were engaged in research, while employees with less than a college degree (86.4%, 7.0 persons) were mostly engaged in production. Employees with Bachelor’s degrees accounted for 63.5% (3.3 persons) of employees in sales, administration, etc.

An average of 3.1 employees per biotechnology company changed their jobs or retired in 2014. Production (average 1.3 persons) recorded a higher turnover than sales, administration, etc. (average 1.1 persons) or research (average 0.7 person), and it was found that the proportion of turnover/retirement (average 1.6 persons) of biotechnology employees with a career history of 2 years or less was relatively high. As in the biopharmaceuticals sector, the management of new employees in medical devices is required.

Analysis of Employment and Prospects/Retraining

Companies in the medical devices sector responded on average that they planned to hire 2.3 persons in 2015, 2.3 persons in 2016, and 2.4 persons in 2017. In the area of production, hiring candidates with Bachelor’s degrees was preferred. There was also a preference for new employees, full-time employees, male employees, and employees related with existing works in 2015.

Table 8  Prospects on Employment of Biotechnology Human Resources in Medical Devices (average)

<table>
<thead>
<tr>
<th>Prospects on Employment of Biotechnology Human Resources</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employment (prediction)</td>
<td>2.3</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below College Degree</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Bachelor</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Master</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Doctor</td>
<td>0.06</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Type of work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Production</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Sales/Administration and etc.</td>
<td>0.5</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Career</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Experienced</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Type of Employment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>2.3</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Part-time</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Female</td>
<td>0.8</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Type of Business</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing</td>
<td>2.0</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Expended</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* Respondent Base: Medical Devices Manufacturing Companies (n=326)

While attitude and personality, potential capacity/talent are important factors in determining hiring for new applicants, field experience and skills are important for experienced applicants. Through a survey on the difficulties in recruiting biotechnology human resources depending on academic background, employing new applicants with Doctoral degree and experienced applicants with Master’s/Doctoral degree is 3.7 points which is a higher figure than those in the case of other academic degrees. These results indicate that it was difficult to hire experienced highly educated candidates.
In relation to the difficulties in hiring new applicants according to academic background, ‘Biotechnology personnel do not apply because the working environments or conditions are poor’ was the most frequent response. This means that the relatively poor working environment of medical device companies inhibits their hiring. In particular, while they respond ‘Due to the gap between demand of industry and university curriculum, it is difficult to find people with the basic skills needed in the field’ for applicants with less than a college degree, the response for applicants with a Master’s/Doctoral degree is ‘It is difficult to find people with the potential capacity, talent and attitude required.’ Individual solutions are necessary according to the level of the academic degree.

In the difficulties in hiring experienced applicants according to academic background, the response ‘It is difficult to find people with the desired skills and work experience’ was highest in relation to applicants with less than a college degree, while for positions requiring a Master’s/Doctoral degree the response was ‘It is difficult to hire people due to the ‘poor working environment.’’ Individual solutions for employment are necessary according to the level of academic degree desired.

56.4% of companies cited ‘work sharing with existing employees’ as an alternative when it is difficult to hire new workers, while 17.8% mentioned ‘re-education and additional training of existing workforce.’ Most companies responded that they utilize the existing workforce when it is difficult to hire new workers. The mismatch of workers increases the work of existing employees.

As 72.2% of respondents are providing education and training to improve the business skills of biotechnology employees, the majority of the companies has been providing education and training. Most of the companies entrust this work to professional training institutions (48.1%, 114 firms) or operate an in-house training programs (47.7%, 113 firms). For the education effects of biotechnology employees, they responded positively that ‘it was very effective
(4.2%)", and ‘it was somewhat effective (54.4%)’ but 41.8% of companies responded that it was ‘average’.

On the difficulties of promoting biotechnology human resources or providing education and training, 37.6% of companies that provide education replied they have little time for developing human resources in reality, and 22.4% responded ‘there are few various and practice-oriented programs’. As in the biopharmaceuticals field, OJT is the most preferred method of supporting and improving the capacity of employees.

IV. Policy Direction for Improving Human Resources of Biopharmaceuticals and Medical Devices

1. Providing more job offerings through developing the biopharmaceuticals and medical devices industries

First, it is important to provide more jobs by developing the biopharmaceuticals and Medical devices industries.

As a high-value-added and knowledge-based industry, the bio-industry is characterized by high risk/high return and long-term investment. In other words, long term investment is necessary because investment capital is high and the payback period is quite long. High returns are guaranteed in the event of success, but there is substantial risk. A bio-industry requires over 800 million dollars for 20 years at least [Korea Biotechnology Industry Organization, 2013]. As a representative bio-industry, biopharmaceuticals has those characteristics.

The medical device industry is fused with disciplinary technology such as clinical medicine, electric, electronic and mechanical materials, and optics in the design and manufacture of products and occupies a wide spectrum from simple supplies to high-tech electronic medical devices. As a small quantity batch production industry, specialized small or medium-sized businesses lead the market in low-cost or a partial market and a handful of large companies take the lead in expensive high-value-added products. The companies that engage in continuous R&D are the ones that can survive in the market [Korea Health Industry Development Institute, 2013]

However, Korean companies seem to exist in contrast to the features of the industry. While an in-depth verification would be required, unlisted small and medium enterprises and companies with less than $10 billion in sales accounted for more than 50% of Korea’s biopharmaceuticals and medical devices companies. And in the structure of human resources, which shows R&D capacity, companies focus more on sales and production than R&D.

It should be a prerequisite to foster enterprises with research and industrial competitiveness by developing the biopharmaceuticals and medical devices industries. First of all, through an in-depth analysis of R&D investment, a system that supports and focuses on development stages should be built by analyzing the cost at each stage. For example, the biopharmaceuticals industry requires a road map for R&D investment to find and secure a pipeline with a high possibility of success in the areas of vaccines, recombinant drugs (biosimilars, antibody drugs, etc.), cell therapy (stem cell therapy, cell therapy, etc.), and gene therapy agents. Such a road map would analyze the cost of the final commercialization of the excavated pipeline, and differentiate and distribute the pipeline.

Second, in order to increase the sustainability of R&D and the possibility of commercialization and provide an environment in which companies can
survive, companies which enforce R&D, secure their pipeline, and continue to develop should be supported with tax and finance until they become profitable.

Third, with respect to the items with goals of global license acquisition and expansion of domestic developed biopharmaceuticals (biopharmaceuticals, bio-betters, bio-similar, cel/gene therapy agents), a system that supports the cost of R&D and collects profits after success should be introduced.

Fourth, by reforming the existing permit system for biopharmaceuticals and medical devices, we should build an updated system that counsels and supports companies in the area of licensing from the initial stages of development, and actively reviews and approves when companies apply for clinical testing and permits. It is also important to ensure reliability through the development of foreign license agreements with the certification authority.

Finally, the Creative Economic Innovation Center responsible for venture businesses should reinforce the development of innovative ventures in biopharmaceuticals and medical devices. The venture businesses supported by the Creative Economic Innovation Center have been concentrated on ICT rather than the bio sector. While biopharmaceuticals and medical devices are evaluated as the best in the industry due to their growth and profit potential, intensive interest and strategies are required because there is low capital investment for domestic ventures. To foster new venture businesses, the Creative Economic Innovation Center should build a system that connects domestic and foreign enterprises with bio-ventures and specialized ventures, and manage the strategic pipeline thereof.

2. Solving mismatch problems by improving wages and working conditions

The mismatch problem in the biopharmaceuticals and medical devices sector results from the gap between the wages or working conditions that unemployed or economically inactive young people want and that the market provides. Although biopharmaceuticals and medical devices are higher value-added industries with high future prospects, there are fewer jobs than expected and limits to the acceptance of highly educated applicants because of poor wages and working conditions. It is necessary to solve the mismatch problem by improving the wages and working environments of small and medium-sized enterprises. This appears in forecasting the mid-term and long-term supply and demand of the biotechnology workforce. The supply and demand forecasted for the biotechnology workforce in 2014–2023 are 23,533 and 17,552, respectively. When demand is simply subtracted from supply, excess supply is 5,981 people, and the excess supply rate is expected to reach 25.4%. It is forecasted that there is an excess supply of workforce, which can be broken down by education level as follows: 953 Doctoral degree holders, 1,536 Master’s degree holders and 3,491 Bachelor’s degree holders. Their excess supply rates are 19.9%, 20.5% and 31.1%, respectively (Jeongmin Shim, 2014).

In the results above, though supply and demand prospects confine the R&D workforce to graduates with higher qualification than a college diploma, there is a limit on the employment capacity of the bio-industry, including the biopharmaceuticals and medical devices sectors. This mismatch needs to be addressed to support the bio-industry.

Second, the government has introduced a compensation fund for long-
term workers to prevent high turnover since 2014. The government gives employees who have worked for 5 years at a small or medium-sized business a compensation fund paid by the business (1/3) and the individual (2/3) and a tax incentive. Those policies are encouraged in order to promote long-term employment in many small and medium-sized businesses in the medical devices sector.

Third, measures to attract highly educated applicants such as Master’s and Doctoral degree holders are needed. The continuous support of the government for R&D policy is necessary to promote an influx of highly-educated human resources with practical skills. It is desirable to promote human resources in conjunction with various projects such as personnel support programs to achieve parity with the wages paid by large companies.

Finally, the policies that aim to address this mismatch often cannot achieve the desired effects when they are only applied individually. The government is developing various policies to stimulate the biopharmaceuticals and medical devices sectors, but measures to foster and utilize human resources are insufficient because it has focused only on developing technologies. By making a plan to foster human resources in the bio-industry, including the biopharmaceuticals and medical devices sectors, a system in which projects and policies can be organically linked should be established.

3. Expansion of female workforce and retraining system

Among the science and engineering fields, biotechnology has a significant female workforce. However, this survey found female employees in the biopharmaceuticals and medical device companies are concentrated in production, and have qualifications below a college diploma. As companies expressed a preference for men that was two times higher than their preference for women when asked about future hires, it can be considered that companies are not actively seeking to use the female workforce. The small scale of biopharmaceuticals and medical device companies makes them a difficult employment environment for balancing work and family roles. Biopharmaceuticals and medical device companies should promote a culture of balancing work and family roles and the career management of female workers, and be aware that these are helpful in the long-term.

Second, the retraining system should be expanded to enhance the biopharmaceuticals and medical devices work force. It is necessary to reorganize a system of retraining within the enterprise in order to enhance the capabilities of medical devices personnel. Since the scale of business is small, there are limits on the capacity of companies to establish re-education systems by themselves. Issues related to the biopharmaceuticals and medical device sectors are managed by various ministries, including the Ministry of Science, ICT and Future Planning, the Ministry of Trade, Industry, and Energy, the Ministry of Food and Drug Safety, and the Ministry of Health and Welfare, etc. Retraining of the workforce of small and medium-sized businesses is also performed by a variety of institutes according to their needs. Master plans for retraining are necessary after identifying the actual situation on bio-personnel retraining and retraining needs of businesses. Systematic linkage and joint development of programs in each training institute or in regional retraining institutions are needed.

V. Conclusion

In South Korea, people are interested in policies to support the bio-industry and technology, but there is low interest in human resources policies that can lead the industry. In order to foster and use the bio-workforce, we would make the following suggestions.

First, it is necessary to establish a comprehensive inter-ministry plan to foster and use biotechnology human resources, including human resources in the biopharmaceuticals and medical devices sectors. Second, an objective and consistent survey of bio-technical personnel is required in order to establish a policy based on the evidence. Lastly, a variety of stakeholders, including the relevant ministries, research institutes, enterprises, universities, etc. should be actively involved in establishing the basis for policies, and individual interests should be left aside. We expect that such efforts could achieve results and make the bio-industry a critical part of South Korea’s future economy.
Applying new technologies developed through research and development (R&D) activities is an important factor in securing the competitiveness of individual companies and achieving the economic growth of the country. For this reason, many companies are investing heavily in R&D, while universities and public research institutes are engaging in numerous R&D activities with support from the government.

The results of the R&D activities of universities and public research institutes are receiving attention as a new resource to support economic growth. There are a couple of reasons for this phenomenon. First, while companies, with the exception of a few cases, tend to conduct research related to their specific businesses and focus mainly on the new application or optimization of existing technologies, public research institutes tend to develop general and original technologies, meaning that they can be used and commercialized by multiple
entities. Also, since the research results of public research institutes are the outputs of public budget, many entities hoping to use the technologies, rather than just one company, can use the results. Second, in many cases, public research institutes carry out studies that involve high economic risk, developing the next-generation original technologies that can power new economic growth. Moreover, as the open innovation paradigm spreads and success stories such as the successful commercialization of public technology in the US after the Bayh-Dole Act emerge, more and more countries are looking at the R&D results coming from universities and public research institutes as a new resource for economic growth.

In line with this trend, many efforts have been made domestically to spread and commercialize the achievements of public R&D. Since 2006, the Ministry of Trade, Industry, and Energy has supported leading technology licensing offices (TLOs), which have the role of granting licenses to companies to use the patented technologies of universities and public research institutes. Also, the Korean government has transformed administration-focused TLOs into ones with the strengthened ability of business development, and increased the number of technology transfers. Since 2010, the ministry has increased the number of technology transfers even more significantly by carrying out various business related R&D (R&BD) projects, in an attempt to respond to criticism that the low technology readiness level (TRL) of public study results is an obstacle to their commercialization. However, despite these efforts, the R&BD projects have not yet reaped great results, in terms of their potential for commercialization. The average ratio of revenue from technology transfer, or royalties, to the research budget of public research institutes supported by the government hovers at around 3%, and in the majority of cases, the revenue from technology transfer remains in the form of a fixed payment rather than a running royalty, indicating that commercialization is not achieved after technology transfer.

There are several ways to commercialize the results of studies done by universities and public research institutes. In Korea, three main ways are used: technology transfer, investing with a specific technology in a company newly established to commercialize the technology, or establishing a new company to commercialize the technology. Each of these three methods has its strengths and weaknesses. Technology transfer, the most favored means of commercialization, has the strength that the developer or holder of technology takes almost no risks. However, technology transfer is not easy.

II. The Need for Public Technology Incubators: Overcoming the Structural Problems of Technology Commercialization

According to the Association of University Technology Managers (AUTM) in the US, companies are very reluctant to get a license or buy a patented technology, except in some areas such as medicines and pesticides. Over 80% of companies use the contents of patents registered by universities or public research institutes in their R&D activities, but of these companies, less than 10% get licensed for or buy the patented technology. The other two methods, of investing in a newly-established company or establishing a company for the commercialization of a technology, have the advantage of allowing the developers to run the company as they wish and commercialize the technology, but also have high risks.

In order to overcome these limits and promote the commercialization of technologies, measures are needed to (1) minimize risks, as in technology transfer and (2) push ahead with the commercialization process without being affected by whether there are partner companies or not. Technology incubators, which specialize in the entire commercialization process, including selecting promising technologies, establishing business models, finding investors, organizing the structure of a company such as choosing a CEO, establishing a company and growing it, and designing an exit strategy, can take on this job.

This study first examines the need for technology incubators through an analysis of the structural problems involved in technology commercialization, and then discusses why these technology incubators should be run as public entities, by looking at the examples of past and present technology incubators.

It is generally said that technology commercialization is slow because (1) public research institutes lack ability in the area of commercialization due to their nature as public institutions; (2) public research institutes do not manage intellectual property (IP) well; and (3) the developed technologies are not for commercialization; all of which puts the blame on the technology suppliers or public research institutes. However, considering that the commercialization ability of public research institutes has risen significantly, IP has soared at least quantitatively, R&BD projects have raised the low TRL, and commercialization is slow even in the US which has higher ability, the poor record of commercialization is presumably due to factors other than the three reasons above. It is not desirable to find fault only with technology suppliers,
or universities and public research institutes, for the lackluster record of technology transfer or commercialization. It is more desirable to look at partners of technology suppliers or companies/founders of companies as well as technology suppliers in order to identify the problem. There is no data yet examining the responses of companies for a given chance of technology adoption from public sector, but we can presume that companies would react similarly to the opportunities for new business with different market risks and technology risks. When facing new business opportunities, companies tend to behave as follows. In the picture below, companies already participating in a given market are competing fiercely in an area with low market and technology risks (current business area, potential business area, and business opportunities of applying or simply improving the current-generation technologies). Companies in this area tend to react as follows; (1) if they have proper R&D ability of their own, they do not need to adopt new technologies at the cost of profitability; and (2) only if they do not have R&D ability of their own and regard the market as attractive, they want to introduce new technologies, but they do not want to pay royalties since royalty payments will weaken their profit in competing situations.

The next business area to consider is the exploratory business area, with low market risks and high technology risks. In this area, some companies which are accustomed to taking technology risks [i.e., pharmaceutical companies seeking for new drug candidates to develop novel drugs] push ahead with the introduction of technologies. In particular, Korean companies tend to attempt to overcome technology risks by doing government projects. If companies succeed in this area, they can reap significant rewards through the commercialization of technology. This is possible because they can have a monopoly on the technology (i.e., through the utilization of patents). However, the problem remains; there exists only a few companies that are accustomed to adopting technology in spite of high risk and have sufficient capacity to overcome this risk.

Finally, the adventurous business area and the other unexplored area have market risks that are too high for ordinary companies to make an investment. Particularly in the other area, in most cases, related products utilizing other competing technologies are already launched in the market are resulting in the difficulty in entering the market. So, not only technology transfer but also establishing a company is difficult. However, in the adventurous business area, in many cases the technology has not yet entered the market, so commercialization through establishing a company is still possible.

To sum up, cases in which the commercialization of technology can reap a reward are as follows.

(1) When technologies are transferred to companies that lack proper research ability but hope to enter the current-generation market;
(2) Technology transfer and commercialization can be achieved with companies that are accustomed to taking high technology risks and creating an exclusive blockbuster market, and that are open and innovation-oriented;
(3) A company is established in a business area with high technology risks/market risks.

Of these possibilities, the ones in which the desirable goals of technology commercialization can be attained are (2) and (3). The figure below shows the phenomena that can occur when a new technology enters the market. Figure 2(a) on the left is the case in which products made with a new technology simply replace existing products in the market. In this case, new products simply encroach on the market share of existing products, failing to increase the size of the whole market. In contrast, Figure 2(b) shows what happens in cases where products made with a new technology that do more than just...
replace existing products. They create new demand and increase the size of the whole market. Figure 2(a) may be desirable from the perspective of an individual company’s competitiveness. However, a public research institutes’ research goals should be to increase benefits for society as a whole, and induce the growth of the whole market as shown in Figure 2(b), rather than just creating a situation in which certain companies can gain financial benefits.

![Figure 2](image)

Of the cases in which technology commercialization can produce the result described above, (1) occurs when technology is transferred to companies which lack research ability. Technology demand from these companies is not future-oriented and market-creating, but mainly serves to replace competing products in the existing market. The pattern of market growth looks like Figure 2(a). Consequently, in order to attain the desirable goals of technology commercialization, public research institutes should, in spite of associated risks, focus on (2) and (3), which can create new markets. However, as discussed earlier, (2) has the problem that the number of companies that have the inclination to introduce new technologies and the capacity to overcome technology risks is very small, and (3) has the problem that companies must overcome high risks associated with both the technology and corresponding markets.

In order to resolve these problems, we can consider the following. For technologies belonging to category (2), the solution can be found by lowering technology risks, or by performing additional R&D in order to provide companies with the conviction that the technology can be commercialized.

However, such additional R&D for technology commercialization is different in nature from so-called R&BD. Let’s take an example of new drug candidates technology. The possibility of commercialization can be determined by running pre-clinical tests on animals or clinical trials on humans, but the budget needed to conduct a complete animal test or a small-scale clinical test is often beyond what ordinary public research institutes can afford. Also, in the case of consider material technology, the research activities for actual commercialization of a technology and the assessment of the possibility of applying the technology to a manufacturing process is not familiar to the researchers of public research institutes, and is different from their specialty of pioneering new frontiers of research. For these reasons, establishing incubators for the sole purpose of commercializing technologies developed by public research institutes can be a potential solution to the problems above. For the technologies belonging to (3), the solution should be to establish a new company and launch a new product based on the new technology. However, with the exception of some based in the US, most researchers have a strong aversion to starting a company. This phenomenon can be explained as follows.

In the US, the funding system for start-ups is well established, like the venture capital system. Furthermore, researchers who work for start-ups that fail can find jobs again easily, and job security is not so high, giving researchers the incentive for taking risk and setting-up a company. Also, American entrepreneurs prefer to make use of their research outcomes, rather than devoting themselves to research itself as a life goal. In contrast, researchers in other countries tend to make research itself their lifelong goal. They prefer only to do research under a system where job security is guaranteed. In addition, in countries other than the US, encouraging researchers to start up a company is very difficult due to the lack of efficient funding system like venture capital, or a safety net to support failed entrepreneurs.

Accordingly, to commercialize the technologies in category (3), business incubators for public purposes can be a good solution. For these reasons, this study proposes public business incubators or other practical alternatives in order to increase the commercialization of technologies developed by public research institutes, analyzes related case studies, and suggests ideas for the successful operation of these incubators.
III. Success and Limits of the US Research Corporation

Research Corporation (RC) in the US was a company which specialized in managing the patents registered by universities from the 1910s through the 1980s. RC had a business model in which it contracted with universities, took over inventions from the universities, carried out the further R&D activities required for commercialization, and earned revenue by giving licenses to companies or selling products on its own. It took over technologies, conducted the additional research needed for commercialization of the technologies, and divided revenue, if any was generated, with the universities which gave the patents to RC. In other words, RC is a company with the same business model as that of the public incubators which this study proposes.

RC originated from the research of Professor F. G. Cottrell of the University of California, Berkeley in the 1910s. Cottrell invented an ‘electrostatic precipitator’, which would eliminate the smoke and dust in a chimney, to control industrial air pollution, based on a study done by Lord Oliver Lodge of England. Cottrell wanted to fund scientific research with the revenue obtained from giving a license to companies for using his patented electrostatic precipitator. So, he founded RC with the help of the Smithsonian Institute. At first, RC tried to earn revenue by transferring its electrostatic precipitator technology to companies. However, simply managing patents and transferring technology did not generate enough revenue, so RC broadened its business to include further developing electrostatic precipitator technology, business planning, and direct selling.

In the process, RC garnered a lot of attention from universities which wanted professional management of their patents, financial support for further R&D, support for commercialization of technologies, transfer of technologies, and creating revenue. Backed by this enormous attention, RC acquired various patents from universities around the US and made a great deal of profit through technology transfer. Among its patents was a method to synthesize vitamin B1, nystatin (an antifungal drug), cortical hormone, reserpine, and a methods for cultivating seeds.

Despite its great success, the business model of RC had inherent weaknesses. As shown in Table 1, the top 5 patents made up 72% to 98% of the total revenue, leading to major revenue fluctuations when there were changes in these top blockbuster patents. Also, while RC acquired patents from a whole sector of research, the revenue came mainly from the Bio Technology (BT) sector during its entire existence. This imbalance was extreme, and so the revenue and investment in each research sector did not strike a balance.

In other words, patent acquisition, patent management and investment for technology development were done in all sectors, but profits were created disproportionately in the BT sector. This was a great weakness of RC’s business model.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total revenue (adjusted to 1996 prices)</th>
<th>Total revenue from top 5 patents</th>
<th>Percentage of top 5 patents' revenue (%)</th>
<th>Percentage of BT among top 5 patents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945</td>
<td>4,713,671</td>
<td>4,604,511</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>1950</td>
<td>5,528,162</td>
<td>5,160,811</td>
<td>93</td>
<td>90</td>
</tr>
<tr>
<td>1955</td>
<td>7,485,868</td>
<td>5,991,276</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>1960</td>
<td>6,516,215</td>
<td>5,389,883</td>
<td>83</td>
<td>100</td>
</tr>
<tr>
<td>1965</td>
<td>4,504,708</td>
<td>3,486,411</td>
<td>89</td>
<td>93</td>
</tr>
<tr>
<td>1970</td>
<td>13,070,160</td>
<td>12,432,968</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>1975</td>
<td>5,823,032</td>
<td>4,755,064</td>
<td>82</td>
<td>83</td>
</tr>
<tr>
<td>1980</td>
<td>9,041,497</td>
<td>6,947,132</td>
<td>72</td>
<td>100</td>
</tr>
<tr>
<td>1985</td>
<td>13,869,300</td>
<td>12,776,616</td>
<td>92</td>
<td>100</td>
</tr>
</tbody>
</table>

In addition, when, in the 1960s, the universities began in the 1960s to adopt a model in which the universities themselves would manage and commercialize their patents, RC had a lot of difficulties. In order to win the battle to acquire good patents, RC strengthened its services for inventors and increased patent-related expenses, which reduced its profit. Despite these investments, it was still difficult to exclusively secure patents with good quality. Moreover, many patents which had brought RC a great deal of profit eventually expired. RC went through a vicious cycle of falling revenue, lowered competitiveness, failure to acquire patents, and again reduced revenue from the commercialization of technologies. Eventually, Research Corporation Technologies (RCT), an independent for-profit corporation, was established in 1987 to run some competitive business areas of RC, while RC was converted to a non-profit foundation to give financial support to universities. Since then, RCT has concentrated on the BT sector which generates high profit, and worked as an incubator which nurtures a selected few promising technologies.

RC provides us with important implications for the operation of technology commercialization incubators. First, incubators for technology commercialization are feasible. The fact that RC has existed over a long period of time suggests that if a few promising patents are selected and
commercialized into blockbuster businesses, independent incubators can actually work. RC also shows us the difficulties that incubators can experience. As discussed above, RC invested in all sectors of research, but its revenue came only from a certain technology sector. Of its numerous patents, only the top 5 generated meaningful earnings. So, if not run wisely, incubators can have the problems of other entities for technology commercialization—TLOs, industry-university cooperation organizations, technology holding companies, etc.—and eventually fail.

The success of RCT, the spin-off of RC focusing on certain research sectors and improving profitability by selecting outstanding patents, as well as the success of Germany’s Lead Discovery Center of Max-Planck (LDC), located in Germany, demonstrate how public incubators can overcome past failures to develop a sustainable business model. Let’s take a look at the example of LDC. LDC was established by the Max Planck Institute in Germany to overcome the problems of the research results in the bio technology (BT) sector. Many research results in the BT sector are expected to generate much profit (e.g. if successfully commercialized, many BT research results can produce new drugs to fight cancer; despite their high price of 50,000 – 100,000 USD annual cost per patient, annually, demand for new cancer drugs is always high), but because enormous investment is needed and there are high technology risks, no companies are willing to directly invest (C1 in Figure 3). If public incubators can push ahead with the commercialization of these technologies in the BT sector and move C1 to C2 with lower risks, many companies would take notice and want to buy the technologies. This would enable the incubators to make profit through technology transfer. Under these assumptions, the Max Planck Institute set up LDC. From the many technologies developed in the Max Planck Institute, LDC chose technologies that can be transformed to the drug candidates of high marketability, and made money by transferring the technologies to companies.

As it takes a lot of money and investment to develop new drug candidates, the Max Planck Institute gave a great deal of financial support to LDC. In this business model, if LDC makes a profit through technology transfer and technology commercialization, LDC pays part of the profit back to the Max Planck Institute. The Max Planck Institute provides financial support for a few selected projects, which LDC selects via a thorough review process involving industrial experts, who had worked for global pharmaceutical companies, to ensure objective selection process and minimization of the likelihood of reckless investment. Early on, LDC transferred technologies to Bayer, a global pharmaceutical company, and Qurient, a biotech-venture, and then broadened its activity model. It received research funds from multinational pharmaceutical companies such as Daiichi-Sankyo, AstraZeneca, Merck Serono, and carried out studies to develop new drugs for them. Initially, it just incubated biotechnologies developed by Max Planck Institute, but more recently it has also incubated biotechnologies developed by German universities and the Helmholtz Association. LDC and RCT, which has been run successfully since 1987 when it became independent from RC, provide important suggestions for public incubators. Most of all, both are focused on a certain research sector. RC had acquired and maintained patents in many sectors other than the BT sector, compromising its profitability. In contrast, RCT and LDC concentrated on the BT sector, where they can make sufficient revenue through technology transfer, preventing their
limited resources from being wasted. Second, they focused on the quality of technologies rather than on the quantity of technologies. RC tried to secure as many patents as possible under the assumption that an enormous quantity would guarantee a number of patents which bring about blockbuster revenue (as universities started to manage their patents on their own, RC, in its efforts to win the battle to secure many great patents, even took over unnecessary patents in the bargain along with great patents.) However, RCT and LDC invested in and incubated a few technologies selected through a strict review and selection process, increasing their operational efficiency. Finally, they secured a budget for stable management. RC obtained underlying assets from the invention of the electrostatic precipitator and other subsequent blockbuster patents. Half of these underlying assets were handed over to RCT, and RCT has been using them to incubate great technologies. LDC is receiving some portion of research funds from project originators, and from these funds it secures basic operating expenses. The benefit of this stable operating budget becomes clearer when LDC is compared with other technology commercialization incubators in the new drug discovery tech-commercialization sector. One of these incubators is Spherium Biomed, from Spain. Spherium Biomed has a business model that is similar to LDC’s in which it receives biological research results from European universities, further develops these results, and transfers the resulting technologies to global pharmaceutical companies. The difference between LDC and Spherium Biomed is that while LDC receives research funds from its affiliated organizations (Max Planck and Helmholtz) and minimizes its spending of its own research funds, Spherium Biomed uses its own budget for most of its activities. So, due to its difficulties in securing research funds, Spherium Biomed has set budget limits of about 600,000 euros per project. (Other similar incubators, which spent a great deal of funds hoping to hit a jackpot with blockbuster technologies, experienced fall in revenue and eventually had no other option but to stop operating.) Because of these budget limits, Spherium should select projects which are not only promising but are also completable within the budget limits. Consequently, Spherium is less successful than LDC.

V. Successful Model for Technology Commercialization Incubators

So far, we have examined the need for incubators to commercialize public technologies, and discussed the conditions for their successful operation. Incubators that can successfully commercialize technologies and create revenue are needed. The creation of a new market, a desirable result of technology commercialization, is possible when a new technology with a good marketability is successfully commercialized (commercialization of technology in the exploratory business area). However, not all technologies belonging to the exploratory business area are possible to commercialize. Although there are companies which adopt these technologies directly, they are few in number. Moreover, different technologies in the same business area have different technological risks. Therefore, incubating technologies in an exploratory business area, reducing their risks systematically, and increasing demand for them is necessary. Some of the technologies in the exploratory business area can be moved into the potential business area. If commercialized successfully, technologies belonging to the adventurous business area could have profound socioeconomic effects. However, if they cannot be moved into the potential business area or the exploratory business area through persistent development efforts, the prospect for commercializing them would be very low. For-profit organizations like companies are reluctant to make these development efforts because of the high uncertainty. Therefore, public organizations should do this incubating work. Public incubators for commercializing great technologies are perfectly placed for this work, drawing more results from the research efforts of universities and public research institutes.

In the US and a number of countries in Europe, these incubators exist, and we can learn from their examples what must be done to guarantee a successful business. First, incubators should concentrate on a certain research field and have funds that will enable the stable operation of the business. RC of the US could not survive to the present because it tried to acquire, manage, and make a profit from patents in every research sector even though its revenue came only from the BT sector. From RC, RCT was born. RCT deals only with technologies in the BT sector. RC tried to secure revenue by realizing economies of scale through acquiring as many patents as possible, but it was not possible for one organization to manage patents from every research sector and make enough profits to survive. Though it is very difficult for Korean incubating companies to concentrate only on the BT sector considering the situation of the domestic industry, it is very important for them to select a
promising research sector and cultivate a specialty in that sector.
Second, incubating companies should focus on the quality rather than the quantity of patents and technologies. Their target should be securing great technologies, even if the number of these technologies is small. According to RC and AUTM of the US, the majority of royalties (75% or more) comes from a few (5 – 10) patents. In other words, regardless of how many patents/technologies incubators can have, only a very small number of patents/technologies can actually contribute to the generation of revenue. So, if technology commercialization incubators are to be run successfully with a certain degree of revenue, they should choose great, promising technologies/patents from a number of technologies/patents developed by public research institutes.
Finally, for the successful operation of technology incubators, research funds must efficiently and securely be provided to technology incubators. RCT runs stably because it receives research funds from the revenue RC’s underlying asset makes, while LDC secures stability by receiving research funds from the Max Planck Institute to incubate the technologies of the Max Planck Institute. In contrast, many technology incubators in the new drug development sector went out of business due to difficulties in securing revenue, and existing incubators have put a limit on their budgets, making them unable to operate efficiently.
It may not be easy to establish incubators which satisfy all of these conditions.
One feasible alternative is to create a translational commercialization R&D program within the existing research institutes, which would employ experts who can further develop early stage technologies into those at the level companies consider adoption. Indeed, the Korea Research Institute of Chemical Technology (KRICT) is currently running ‘TREND,’ a translational research project. With the financial support of the Ministry of Science, ICT and Future Planning, TREND incubates the technologies of domestic research institutes in the BT sector, and develops technologies to make candidate materials for new drugs for commercialization.
TREND receives 1 billion KRW of annual budget from the Ministry. It selects promising technologies, which can be developed into new drug candidates, from domestic BT research institutes, and then jointly conducts further research with these institutes to produce new drug candidates. Since 2013, it has incubated biological research results from Sungkyunkwan University, the Medical School of Yonsei University, and CHA University, using KRICT’s excellent facilities and the capabilities of experts, who developed new drug technologies soon to be approved by the US Food and Drug Administration (FDA). For three years, KRICT developed one preclinical candidate and two lead compounds. Of the developed technologies, two technologies have already been transferred to companies. In this way, KRICT has yielded better technology commercialization results than other research programs. In short, KRICT has successfully changed some of the basic BT research results of universities into technologies that are ready for commercialization through the utilization of TREND program.
KRICT’s TREND is a good model for technology commercialization incubators in Korea. TREND clearly satisfies the conditions presented above for the successful operation of technology incubators. It has dedicated itself to conducting research in the BT sector, and has secured experts. Moreover, it has focused on choosing great projects rather than on acquiring as many projects as possible, with the Pipeline Committee having industry experts actively involved in the decision process regarding projects selection for the further development, as shown in Figure 4. Finally, TREND can be run stably and produce good results because it receives financial support from the government. Indeed, it has achieved two cases of technology commercialization during the first three years of its existence.

Currently, these translational research programs are limited to the BT sector, but they can be run in various fields. For example, a program in the nanomaterial sector run by a university, a research institute, or an enterprise can acquire original technologies from universities/research institutes and commercialize them. Considering that research activities in the Information
Communications Technology (ICT) and Nanotechnology (NT) sectors are relatively robust in Korea, commercialization programs in these sectors are expected to provide good results.

Thus far, we have analyzed why technology transfer and commercialization of technologies developed by universities/public research institutes are slow despite many efforts, and proposed the use of technology commercialization incubators to resolve this problem. We then examined the conditions needed for the successful operation of these technology incubators, and discussed the good example of TREND, a translational research program of KRICT. As pointed out earlier, the commercialization of public technologies has difficulties due to structural problems rather than a lack of ability on the part of technology suppliers or the technologies themselves. To overcome these difficulties, technology commercialization incubators which can operate stably are very important. Considering the situation of Korea, it may be difficult to make these incubators from scratch. However, as we can see in TREND of KRICT, a well-planned translational research program can successfully serve as an incubator, and play a big role in creating results for technology commercialization.

VI. Conclusion

References

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* Jaeeun Lee, YoungJu Go, Doo Young Jung, “A New Model to Analyze Technology Commercialization Results of Public Research Institutes Supported by the Government and Its Use,” the 51th Summer Symposium of the Korea Society of Innovation Management and Economics, June 26, 2015
KISTEP 10 S&T Policy Issues of 2015

President Youngah Park highlighted that "The science & technology community worldwide is innovating itself by taking the gender difference into consideration in various aspects including the clinical development processes of new medicine, and eliminating biases. As many economic opportunities are open, new markets must be created by taking gender into consideration."

Jin-Hee Yoon (Professor of Inha University) said "I want to highlight the importance of diversity. Diversity is an essential element for all societies to consistently develop, and according to the theory of social evolution, enables us to make better choices. Considering these various points, diversity needs to be secured eventually. I am glad that we are paying attention to gender diversity, where our society is the weakest."

Wonsik Choi (Director of McKinsey Korea) stated, "First of all, we need to shift the way we think. When we advance into so-called science & technology or future-oriented businesses, openness and coexistence are important but we also need to consider the scale. Toyota announced that it will provide its patents free of charge, and Tesla decided to share their patent for electric vehicles. While coexisting open ecosystem is good, but I do not think these acts were made solely with goodness of heart, but ultimately, the intention to expand their scale."

Shin Cho (Director of Yonsei Institute of Convergence Technology), stated that we need to determine whether foregoing R&D strategies were valid, and reconsider the respective roles of institutes conducting R&D, including the government, business enterprises, research institutes and universities. Lastly, Dongil Kwon (Professor of Seoul National University) said that while the efficiency of science & technology system is important, but it is necessary to study how to raise return on investment.

KISTEP 10 S&T Policy Issues of 2015 were selected based on the three needs: responding to changes in the future, enhancing national competitiveness, science and technology in society, and 29 political tasks by each issue were also selected.

KISTEP announced ‘KISTEP 10 S&T Policy Issues of 2015’ to preemptively respond to rapidly changing future environmental changes and to reinforce national competitiveness, and held the forum for discussion on January 21.

The forum commenced with the congratulatory address by Jang Moo Lee, Chairman of National Science and Technology Council, followed by the announcement of 10 S&T policy issues by Youngah Park, President of KISTEP, and panel discussions.

‘KISTEP 10 S&T Policy Issues of 2015’ were selected and technology in society, and 29 political tasks by each issue were also selected.

also in relation to establishment of science & technology innovation system in the era of creative economy, she highlighted that "The investment in areas that the private sector leads should be reduced when distributing the government R&D budget, and investment to public technology needs to be increased to support areas such as social benefit and prevent market failure." Also, she pointed out the importance of unifying the field of science and technology with North Korea to realize a powerful, unified nation centered on science & technology. She said that preparation should be made by research and analysis on the current state of science & technology in North Korea and by establishing a subcommittee for science & technology in the Presidential Commission for Unification Preparation.

Sung-chul Shin (President of Daegu Gyeongbuk Institute of Science and Technology), who chaired the following panel discussion, opened the discussion by saying that there is hope and passion for a second miracle in Korea, and that now is time for a new vision, strategy and spirit of the times for the next 50 years to come.

New Age, New Roles, New S&T Policies

KISTEP 10 S&T POLICY ISSUES OF 2015

Responding to changes in the future
- Gendered innovation in science and technology field
- Preparation for unification through S&T
- New strategies in the space age

Enhancing national competitiveness
- System for nurturing scientific talents
- Acceleration of S&T innovation
- Renaissance of manufacturing industry
- S&T diplomacy

Science and Technology in Society
- Job creation based on S&T
- Communication between S&T and society
- New roles of S&T in risk governance

The science & technology community worldwide is innovating itself by taking the gender difference into consideration in various aspects including the clinical development processes of new medicine, and eliminating biases. As many economic opportunities are open, new markets must be created by taking gender into consideration."
KISTEP 10 Emerging
Technologies of 2015

On February 26, KISTEP announced the 10 emerging technologies that will resolve social disparity. Since 2009, KISTEP analyzes emerging technologies and annually selects 10 emerging technologies in consideration of their social and economic impact. Recently, this research focuses on identifying technologies that are closely related to key issues in the future society. This year, ‘the increase of social disparity and inequality’ was selected as the key issue which requires immediate attention in the Korean society for next 10 years. The social disparity and inequality of the Korean society seen on the news and social data such as blogs and SNS were analyzed. The social disparities were categorized into healthcare, information, energy and culture - education, and 20 related technologies were selected. Among the selected technologies, 10 technologies were finally selected in consideration of feasibility of being realized in the next 10 years, responsiveness to the key issue, economic impact, and contribution to innovation.

01 Smartphone diagnosis

- **Definition**: The technology can measure biometric information and send the result instantly through sensors, camera and simple accessories for collected blood sugar level, blood pressure and heart rate.
- **Application**: The technology can replace expensive medical devices which make it easier to supply them at low price. In addition, it will improve health service accessibility and allow giving feedback simply with smartphone application.

02 Big data analytics for healthcare

- **Definition**: The technology collects patients’ hospital service use, medication, treatment and other various data including medical records to analyze useful information.
- **Application**: Based on the result, the technology can provide prevention of diseases and personal healthcare which in turn reduces the medical cost.

03 Bio stamp

- **Definition**: The technology is a sensor which can be attached to skin in order to monitor the person’s health.
- **Application**: The technology allows the elderly to simply monitor their health as when the device is attached to the skin it can automatically monitor the blood pressure, temperature, brain activities and so on, then send the data.

04 Li-Fi

- **Definition**: Wireless communication technology which combines high efficiency light LED and will using light.
- **Application**: The technology provides high speed communication service at low price at the intensity of LED where we cannot visualize without crossing of frequencies. It can majorly improve internet accessibility.

05 Tactile display

- **Definition**: The technology allows the user to actually feel certain objects from the surface that they touch.
- **Application**: Improve the elderly and the disabled is use of touchscreen, therefore, improve the convenience via reproducing the sense of touching virtual hand.

06 Vacuum insulation

- **Definition**: Insulation material technology using vacuum in order to minimize the heat loss.
- **Application**: The technology can reduce the causes of energy poverty through minimizing heat loss both in heating and cooling energy.

07 Smart learning

- **Definition**: The technology can increase the studying effect easily and efficiently by providing user centered contents and services with intelligence.
- **Application**: Learning contents are subdivided into different categories according to the user’s ability and characteristic, and provided with feedbacks from every session. This can provide the optimum learning environment and high quality educational environment to the user.

08 Beacon technology

- **Definition**: Local area network technology which allows useful information to the users automatically in a limited area.
- **Application**: The technology provides adverts, convenient information, payment information and so on automatically within a short distance, therefore, those who are not familiar with browsing can receive useful information.

09 Energy harvesting nano material

- **Definition**: Nano material technology which converts waste energy into useable electric energy.
- **Application**: The technology can be applied to collect unused energy from various transportation methods such as road and railway as well as vibration from human activity. The technology can create electricity at any time and place, therefore, reduce the energy cost of low income group.

10 Virtual reality

- **Definition**: Virtual space creation technology which re-create real or virtual object in 3D.
- **Application**: The technology can provide various virtual forms in a real space, for example, theme parks, museums and concert halls.
KISTEP Forum at UKC 2015

KISTEP held the KISTEP Forum at UKC 2015 (US-Korea Conference on Science, Technology and Entrepreneurship) in Atlanta, U.S.A. on July 30.

UKC 2015 was held with a theme of ‘Pursuing Excellence with a Servant’s Heart’, 1,300 scientists and engineers from Korea and USA participated, and 13 technical symposiums and 20 forums were held.

The KISTEP Forum was held to share the insights on technology foresight, technology assessment, R&D evaluation trends and S&T policy direction, understand the current landscape and share the future to better meet our long-term economic and social needs.

The forum speakers included Congressman Donald Manzullo (CEO of Korea Economic Institute of America), Dr. Tim Persons (Chief Scientist of U.S. Government Accountability Office), Dr. Moonjung Choi and Dr. Sangki Jeong from KISTEP. During the panel discussion, the participants in the forum discussed the change in industrial structure due to the recent advancement of science and technology.

On August 1st, President Park introduced the history, major functions and the international cooperation activities of KISTEP at the morning keynote session. During the conference, KISTEP delegation had the opportunity to introduce KISTEP’s activities to many Korean American scientists and engineers.
On the 25th, the forum commenced with the welcoming address by Dr. Youngah Park and congratulatory remarks by Dr. Jang Moo Lee, Chairman of The National Science & Technology Council and Rohana Binti Ramli, Ambassador of Malaysia to Korea. The Plenary Session began with a special keynote by a Speaker of the National Assembly, Dr. Ui-Hwa Chung, and presentations were made by Dr. Youngah Park (President of KISTEP) and Richard Stone (International News Editor for Science). During the General Sessions, Dr. Mohsin Khan (Zaheer Science Foundation), Dr. Rongping Mu (Chinese Academy of Sciences, Institute of Policy Management, CASIPM) and other speakers made topic presentations.

On the 26th, the launching ceremony for ASTN (Asian STI Think Tanks Network), a network for science & technology innovation think tanks of Asia, was held. Starting with a special keynote speech by Dr. Zakri Abdul Hamid (Science Advisor to the Prime Minister of Malaysia), 15 institutes from 11 Asian countries participated in the launch of ASTN and pledged to cooperate for the innovation of Asia. The members of ASTN will strengthen the partnership in science and technology and plan to solve common problems faced by the region. Furthermore, they expect that the network will grow to represent the region in addressing agendas such as climate change, energy depletion and environmental problems.

Dr. Youngah Park stated, “Through the launching of ASTN, we hope to solve ongoing problems and work together for the better future of Asia”.

Plenary Session and General Session III presentations followed, by Youngsuk Chi (Chairman of Elsevier), Michael Keenan (Senior Policy Analyst of OECD) and Lee Yee Cheong (Chairman of ISTIC Governing Board). Chairman Youngsuk Chi defined innovation as • the birth of new ideas and concepts • solutions to problems of present and future society • being simple and intuitive in retrospect. Chairman Youngsuk Chi emphasized, “We need passion, attitude without fear of failure, and perseverance for innovation.”

Dr. Michael Keenan introduced the OECD STI Outlook, a biennial flagship publication on recent and emerging trends in global science & technology innovation. Also, he emphasized the importance of foresight and policy establishment through meticulous analysis, stating, “Through STI Outlook, OECD forecasts megatrends for the next 10 to 15 years and predicts the change in the future joint research and the process of science & technology policy establishment.”

Dr. Youngah Park stated "AIF and ASTN are not one time events but have been started with a long term vision and to provide a platform for cooperative strategy for sustainable development.”

Details and photos from the 1st Asian Innovation Forum are available on Asian Innovation Forum website (http://www.asianinnovation.org).
Gender Summit 6
Asia-Pacific 2015

KISTEP in partnership with WISET (Women in Science, Engineering and Technology, President Heisook Lee) and NRF (National Research Foundation, President Min Keun Chung) held Gender Summit 6 Asia-Pacific 2015 with a theme of “Better Science & Technology for Creative Economy: Enhancing Societal Impact through Gendered Innovations in Research, Development and Business” at Seoul Plaza Hotel from August 26 to 28.

The Gender Summit, which started in Europe in 2011, is the place to suggest gender issues in research innovation and to create added values for R&D without gender bias in the fields of science, technology, engineering, mathematics and medicine (STEMM). It is the highest level meeting where the interested parties of scientists, high-level policymakers, R&D innovation experts, and gender experts gather, which reached North America in 2013 and Africa & Asia-Pacific regions in 2015.

The Gender Summit 6 aimed to create a sustainable science & technology ecosystem where both genders work more creatively in harmony by ensuring gender diversity in the science & technology field of Asia Pacific region.

During the Gala Dinner on the 27th, Dr. Youngah Park presented GII (Gendered Innovation Index), which is based on a recent study by KISTEP.

Gendered innovation offers the equal opportunities to both men and women to participate in science & technology, but also creates new knowledge and markets. Gender Innovation Index results from the measurement of three fields including - Social aspects (income disparities, the social awareness of female participation in science & technology, and the effectiveness of governmental support policy for female science & technology workforce) - Fostering female talent (female student ratio in science in higher education, female researcher ratio relative to total researchers, increasing rate of female researchers, etc) - Knowledge development (ratio of studies based on sex and gender analysis, number of patents based on sex and gender analysis).

KISTEP-CRDS Forum
S&T Innovation Policy and Nanotechnology R&D

KISTEP held ‘KISTEP-CRDS Forum’ at K Hotel on September 7th, to share the innovation policy for science & technology and R&D support policy for nanotechnology of Korea and Japan. The forum was co-hosted by KISTEP and Center Research and Development Strategy, Japan Science and Technology Agency (JST-CRDS).

The forum with a theme of ‘Science & Technology Innovation Policy and Nanotechnology R&D,’ proceeded in order of - Welcoming addresses by Dr. Youngah Park (President of KISTEP) and Takao Kuramochi (Senior Deputy Director General of CRDS) - Introduction to institutes by Dr. Doowon Cha (Managing Director of Division of Strategy Planning, KISTEP) and Takao Kuramochi - Presentation sessions - Panel discussion - Closing address.

The first part of presentation session, ‘Science & Technology Innovation Policy of Korea and Japan’, included presentations on ‘Science, Technology and Innovation Policy for the Creative Economy’ by Dr. Sung-Goo Han (Director of The Creative Economy Innovation Center, KISTEP), and ‘Current Science and Technology Innovation Policy of Japan and related activities of CRDS Science and Technology Policy Unit’ by Junichi Sone (CRDS).

The second part of presentation session with a theme of ‘Present and Prospect of Nanotechnology’, included presentations on ‘Overview of Korean Activity on Nanotechnology Development and its Commercialization’ by Jong-Ku Park (Director of Nano Fusion 2020 Project), and ‘Overview of CRDS Activities on Nanotechnology’ by Junichi Sone (CRDS).

During the panel discussion, Dr. Jin Ho Ahn (professor at Hanyang University) and Dr. Young Jun Kim (Technical Director, ESM Inc.) discussed both countries’ science & technology innovation policy and the progressive cooperation measures in the field of nanotechnology.

Dr. Youngah Park stated “Korea and Japan, as leading countries in the development of Asia’s science and technology, are critical to the overall development of Asia.” and “This forum has been a opportunity for both countries to discuss the science & technology innovation policy and the starting point of R&D innovation in nanotechnology.”
The 7th Joint Korean-German Conference ‘Science and Innovation’ was held at the Grand Hyatt Seoul on October 13.

The Joint Korean-German Conference was organized by KISTEP, Embassy of the Federal Republic of Germany in Seoul, Alumni Network Germany-Korea (ADeKo), Korean Academy of Science and Technology (KAST), German National Academy of Sciences Leopoldina and Science and Technology Policy Institute (STEP).

The conference commenced with the opening remarks by Mr. Hwang-sik Kim (Chairman of ADeKo) and congratulatory remark by the German Federal President Joachim Gauck, and Minister Yanghee Choi (Ministry of Science, ICT and Future Planning) followed by the keynote speech by the Nobel Laureate, Prof. Dr. Christiane Nüsslein-Volhard.

The plenary session under the theme of ‘Science and Innovation’ was chaired by President of the German National Academy of Sciences Leopoldina, Prof. Dr. Jürgen Hacker. It was followed by the presentation and panel discussion by Dr. Chang-Gyu Hwang (President of KT), Prof. Dr. Helmut Schwarz (President of Alexander von Humboldt Foundation), Dr. Min Keun Chung (President of the National Research Foundation of Korea), and Dr. Hermann Gerlinger (Member of the Board of Carl Zeiss Germany).

KISTEP hosted the Session 2 ‘Risk management – Paving the way for Innovation’ with Friedrich-Alexander University of Erlangen-Nürnberg (FAU).

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After the session introduction by Dr. Youngah Park, the Part I ‘Enhancing Risk Management Capabilities’ was held to address the potential issues of risk management and discuss how different sectors of society can contribute to enhancing risk management capabilities. The part 2 ‘Responsible Public dialogue in Science and Technology’ explored the topics related to technology assessment and risk communication and identified the measures to promote responsible public dialogue in science and technology.

KISTEP hosted the ‘STI Policy and R&D’ session at the World Science & Technology Forum held at Daejeon Convention Center on October 19.

As a part of OECD Ministerial Meeting, the World Science & Technology Forum was organized to bring together world’s most distinguished science, technology and innovation (STI) leaders and gain from their inspiring visions and insights into the future of STI.

The session started with the opening remarks and keynote speech by President Youngah Park followed by the presentations of Torbjørn Røe Isaksen (Minister of Education and Research, Norway), Turki bin Saud bin Mohammad Al Saud (President of King Abdulaziz City for Science and Technology, Saudi Arabia), Chilhee Chung (Deputy President of Samsung Advanced Institute of Technology), Curtis Carlson (Former President of SRI International) and panel discussion.

President Youngah Park stated, “In recent times, we face challenges such as GDP growth slowdown due to low productivity, population aging, weak domestic demand and the large technology trade deficit. We should thus improve the governance and implementation of polices for STI. The policy should be continuous, consistent and consolidated. Also, strengthening investment in STI and increasing the efficiency is important.”
The 10th Trilateral S&T Policy Seminar

The 10th Trilateral S&T policy seminar was held in Kobe, Japan on November 9-10.

The S&T Policy seminar has been held since 2006 to discuss the current issues in S&T policy and promote cooperation among the five S&T policy institutes in Korea, China, and Japan. The participating institutes included Korea Institute of S&T Evaluation and Planning (KISTEP), Science and Technology Policy Institute (STEPPI), Chinese Academy of Sciences/Institute of Policy and Management (CAS/IPM), Chinese Academy of Science and Technology for Development (CASTED), and National Institute of Science and Technology Policy (NISTEP).

Hosted by NISTEP, over 50 participants shared major achievements of this year and covered various topics such as Index of Science and Technology, Innovation of Private Sector, Human Resources Policy of Science and Technology, and Technology Foresight.

KISTEP will host the next year’s seminar and continues to strive to build a platform for active discussion on S&T Policy and to promote multilateral collaboration.

The 7th KISTEP-ISTIC STI Training Program

The ’7th KISTEP-ISTIC S&T innovation training for high-level policy makers from developing countries’ was held at Grand Ambassador Seoul on November 23-27. The program was organized by KISTEP and the International Science, Technology and Innovation Centre for South-South Cooperation under the Auspices of UNESCO (ISTIC).

The program is designed for high-level policymakers from developing countries from Asia, Africa, and Latin America. During the program, the practical cases of the S&T innovation that have led successful economic development in Korea were discussed.

For this year, 22 participants of S&T policymakers from 17 countries attended the program. The program aims to share knowledge and experience on Korea’s national R&D system including S&T policy, a mid- to long-term planning, R&D budget allocation and coordination, R&D program evaluation.

President Youngah Park stated, “Science diplomacy is a new effort for the innovation of common prosperity of mankind.” She added, “I expect this training would be not only regarded as one of KISTEP’s programs, but also known as one of the best examples for science diplomacy. Also, I hope we can discuss the issues in different perspectives together with leaders from developing countries through this program.”
01. Science and Technology Innovation Capacity of Korea
02. Gendered Innovations Index (GII)
03. R&D Personnel in Major Countries
04. S&T Competitiveness of Korea
In the COMposite Science and Technology Innovation Index (COSTII) 2014, Korea ranked 7th among the 30 OECD countries.

- Korea scored 12.539, higher than the OECD average of 10.288.
- Korea’s ranking moved up from 8th to 7th, with the higher ranking in network and resources.

The United States ranked 1st maintaining its top position for 9 consecutive years. Switzerland and Japan ranked 2nd and 3rd for 5 years in a row.

Korea showed strength in activities ranking 2nd, while scores in environment were relatively low, ranking 23rd among 30 OECD countries.

- The ranking went up one place in activities and went down 3 places in environment.
- Among 5 categories, rankings in 3 categories (resources, activities, network) went up while rankings in 2 categories (environment, performance) went down.

### COSTII rankings of Korea in 5 categories

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<td>Resources</td>
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<td>Activities</td>
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<td>Network</td>
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<td>Environment</td>
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<tr>
<td>Performance</td>
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KISTEP developed indicators to measure gender aspects in national innovation systems and to find implications in STI.

Gendered innovation is the process that integrates sex and gender analysis into all phases of basic and applied research to assure excellence and quality in outcomes.

There are only a few statistics and indicators available on gendered innovation, and the GII was the first index to consider both gender perspective and innovation in S&T.

Among 5 Asian countries, Malaysia ranked 1st with high scores in social foundation and women empowerment. This result reflects that Malaysia has made considerable progress in promoting women’s rights and gendered innovations.
The major findings of “2014 Survey of R&D Activities” by KISTEP1 and “MSTI 2015-1” by OECD2 were collected to analyze and compare the R&D workforce in Korea and other countries.

1) “Survey of R&D Activities” is published by KISTEP by conducting surveys of all R&D activities in Korea to provide the baseline data for establishment of national R&D policies.

2) MSTI : Main Science & Technology Indicators compiled by OECD provides main indicators in S&T on OECD member and non-member countries. MSTI includes information on gross domestic expenditure on R&D (GERD), R&D personnel, business enterprise expenditure on R&D (BERD), government intramural expenditure on R&D (GOVERD), government budget appropriations or outlays for R&D by socio-economic objectives (GBAORD), patents, technology balance of payments (TBP), and economic indicators in the annex, including exchange rates and GDP.

The total number of researchers in Korea in 2014 was 437,447, showing an increase of 27,114 (6.6%) researchers from the previous year.

- R&D personnel including research assistants was 605,604, showing an increase of 36,271 (6.4%) researchers from the previous year.

The number of female researchers in Korea in 2014 was 80,904, accounting for 18.5% of the total number of researchers.

- The percentage of female researchers increased by 0.3% relative to the previous year, and is continuously on the rise.
The percentage of female researchers in Korea (18.5%) still remains low compared to other nations except Japan.

Of the nations compared, Russia had the highest percentage of female researchers (40.9% in 2013), followed by UK (37.8% in 2012), Italy (35.5% in 2012), and Germany (26.8% in 2011).

Global Competitiveness of Korea (WEF)

Strengths and Weaknesses of Korea in Technological Readiness and R&D Innovation

R&D innovation

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tr>
<td>Innovation capacities of companies (34°)</td>
<td>Quality of research at research institute (27°)</td>
</tr>
<tr>
<td>R&amp;D investment by companies (20°)</td>
<td>Cooperation between industry and academia (26°)</td>
</tr>
<tr>
<td>Government investment in high-technology products (22°)</td>
<td>Human resources in science and technology (42°)</td>
</tr>
<tr>
<td>PCT patent applications per 1 million inhabitants (8°)</td>
<td>Intellectual Property protection (68°)</td>
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</table>

Technological readiness

<table>
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<tr>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>Number of Internet users (15°)</td>
<td>Utilization of advanced technology (30°)</td>
</tr>
<tr>
<td>Number of fixed broadband internet subscribers per 100 inhabitants (7°)</td>
<td>Firm’s willingness to adopt new technologies (38°)</td>
</tr>
<tr>
<td>Number of mobile broadband subscribers per 100 inhabitants (7°)</td>
<td>FDI and Technology transfer (73°)</td>
</tr>
<tr>
<td>Number of telephone lines per 100 inhabitants (7°)</td>
<td>International Internet bandwidth (70°)</td>
</tr>
<tr>
<td>Utilization of advanced technology (30°)</td>
<td>Number of mobile phone subscriber per 100 inhabitants (72°)</td>
</tr>
</tbody>
</table>

According to the WEF Global Competitiveness Report, Korea ranked 26th among 144 countries. Switzerland ranked the 1st, followed by Singapore, USA, Finland and Germany.

Among 12 evaluation categories, Korea ranked high in ▲ Macroeconomic environment (7th), ▲ Market size (11th), ▲ Infrastructure (14th), ▲ R&D Innovation (17th).