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Analysis of National Basic Research System: The Case of South Korea

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Abstract In this paper, we analyze the basic research system in South Korea. We propose a national basic research system consisting of value, openness, input, transformation, and output. Based on this framework, we set up interview questionnaires, and 15 key informants have been interviewed. According to our results, first, in terms of value, basic research is recognized as an activity for creating knowledge in the understanding of nature. Second, as for openness, scientists and policy experts agree that active interaction with the global community is an important value for the national research system. Third, in terms of sustainable research resources, scientists are strongly required to effectively allocate research funding, maximizing the creativity of researchers and the efficient sharing of research equipment. Fourth, in transformation, basic researchers maintain that the Korean research system has is extremly dependent on the government's external control, and its self-regulative system has been weak for over half century onw. Fifth, for global competitiveness, the interviewees agreed that the quality of basic research in Korea is approaching that of its global competitors. Finally, we put forward some policy implications on the basis of these findings.

Keywords Basic Research, scientific values, openness, sustainability, autonomy, South Korea

I. Introduction

Research systems include research costs, policies and institutions, the perceptions and culture of scientists, and the stakeholders and facilities that support research activities. The characteristics of research systems are becoming more crucial to their performance as the business of modern science becomes increasingly sophisticated, complicated, and massive. Contemporary

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science arguably depends on organization, whereas early modern science depended on scientists' individual talents.

Basic research in Asian countries faces two challenges. One is creating an autonomous society domestic scientists within and outside of the country as well as establishing an appropriate environment for high-quality basic research. The other is invigorating the connection between basic research and its socioeconomic exploitation. Sometimes, these two forces can be in conflict with each other, particularly with regard to policy practices. In other words, an emphasis on the commercial application of basic research is likely to hamper scientists' pursuit of the original purpose of basic research (i.e., the fundamental understanding of nature).

This paper focuses on the importance of systemic consistency and analyzes the basic research system in South Korea (hereafter Korea). We propose a framework analyzing a basic research environment in the case of Korea. On the basis of those interview data, we will identify the characteristics of Korean basic research system. Based on those empirical findings, we put forward some policy implications to enhance the basic research system in the country.

II. Data and Methodology

1. Overview

Science does not take place in isolated laboratories alone. Rather, it is a social phenomenon that is closely related to social and economic factors, such as colleagues and funding. Therefore, to understand science in depth, its context and the environment surrounding it need to be considered. In this way, a systematic view of science can provide us with an insightful lens into the totality.

Here, we propose to call this the national basic research system. Our new approach includes various conceptual elements as shown below. The national basic research system consists of an internal system, its borders, and the external environment. The external environment includes political and economic systems and organizational culture. The internal environment is comprised of various scientific organizations, which consist of public and private universities, public research institutes, and private laboratories in firms. Research subjects are supported by intermediary organizations, such as funding agencies, technology transfer offices, and governmental agencies. Moreover, aspect of scientific culture such as autonomy, criticism, and free sharing are also critical elements of the system.

The figure below illustrates the concepts and components of the national basic research system. The boundary distinguishes the internal system and the outside environment. The outside environment consists of political, economic, and overseas research institutes. Internal environments (i.e., institutions and cultures) and research actors (i.e., universities and research institutions) are closely related to each other. We assume that the national basic research system evolves through competition and cooperation with the global basic research institutes in the external environment.

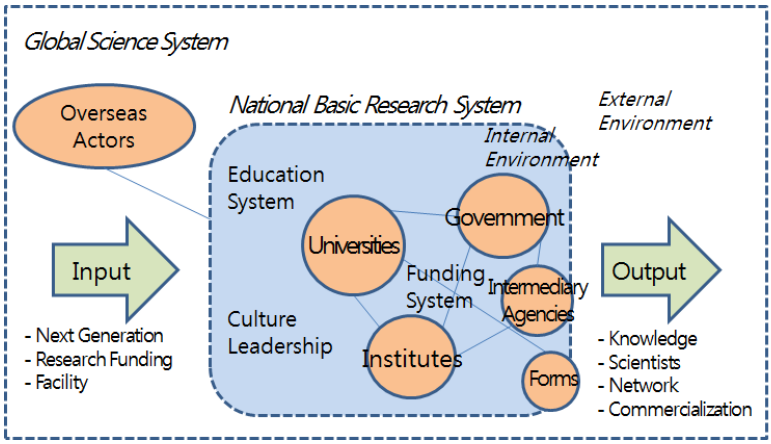

Figure 1 Concepts and components of national basic research system

We adopt the case study method based on interviews with individual researchers in South Korea. To conduct analysis at the national level, we interviewed researchers who could provide a insightful information on the operational system of national basic research. Individual researchers can be regarded as embedded units in a case. Because we chose the Korean research system as the case, this paper is based on a single case study. Lower-level units, such as individual scientists, can provide information about on higher-level units, such as the national system, in a single case with multiple embedded units (Yin, 2009). This case study enables us to understand the evolution of the national basic research system. In the Korean policy environment, we examine the strengths and weaknesses of the system and upcoming changes to it. On the basis of the results of the analysis, we put forward policy implications for Korean innovation practitioners as well as scholars.

2. Analytical Frame

Based on the concept of the national basic research system, detailed elements of the system can be suggested: value, external openness, sustainability, autonomy and innovation, and global competitiveness. Through these five perspectives, we identify the structural characteristics of the system. This analytical framework is presented in the figure below.

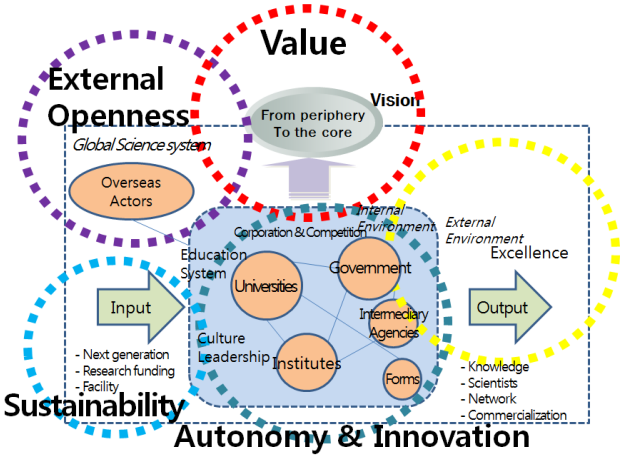

Figure 2 Analytical frame of interview

First, a value can be understood as a system goal and vision that the national basic research system is intended to achieve. This provides a critical direction for the entire system to move forward. For example, possibly the system aims to move toward to the core of the global science system, or to contribute to the domestic economy.

Second, in terms of external openness, the environment can be defined as being outside the boundary of an organization. An organization that interacts with an environment can be called an open system. This open system allows the use of external resources to adapt to the environment. Openness is a particularly important issue for Korea, which lacks science and technology resources such as top-tier scientists and large amount of research funding.

Third, input is a critical element for the sustainability of the system. Input factors such as talented young researchers, stable research funding, and state-of-the-art research equipment and facilities are critical for the sustainable survival of the system.

Fourth, actors in the system are required to each create their own autonomy and innovate within a self-regulated area, while the knowledge generated in

the system is actively circulated to create economic benefits based on an interdependent network. In this process, the channel connecting different actors (e.g., a university-industry collaborative research project) is more important than before.

Finally, the basic research system fosters its own next generation, which can also be regarded as its output, for global competitiveness. In addition, it advances the human understanding of nature and boosts the national economy through knowledge transfer and technological commercialization. For this not only scientists, research funding, and equipment and facilities, which are required for scientific activities directly, are necessary but also institutions, cultures, and policies that support research activities.

Table 1 Interview questionnaires

Issue area	Sub-area	Questionnaire
Vision (value)	Definition	What is the definition of basic research?
	Values	What are the core values of basic research?
	Motivation	What is the motivation for conducting basic research?
Environment (openness)	Openness	Is the basic research environment open to overseas researchers?
	International collaboration	What is the importance of overseas collaboration in large facilities?
Input (sustainability)	Funding	Does the support system for basic research operate properly?
	Equipment & facilities	Have researchers been provided with appropriate equipments and facilities?
	Researchers	Are talented young researchers attracted to our system?
Transformation (linkage / autonomy)	External autonomy	Is science and technology respected as an independent area?
	Internal autonomy	Are scientists enjoying autonomy in planning and implementing basic research?
	Research ethics	Are research ethics strongly established in the scientific community?
Output (competitiveness)	Highly qualified scientists	Are there talented researchers who can lead the academic world?
	Excellence in performance	Have world-class performances been created?
	Socio-economic contribution	Is the scientific knowledge produced by basic research for economic and social benefit?

3. Collection and Details of the Data

According to the analytical framework suggested in the previous section, specific interview questionnaires were created in five categories (i.e., vision, environment, input, transformation, and output) as shown in Table 1.

No.	Affiliation	Gender/Status	Time and Venue	Code
1	K (H University)	Male/Professor	2016.2.2. H University	K1
2	K (S University)	Male/Professor	2016.2.2. S University	K2
3	Y (K Institute)	Male/Senior researcher	2016.2.4. K University	Y3
4	K (S University)	Male/Professor	2016.2.15 S University	K4
5	M (S University)	Male/Professor	2016.2.16. Online	M5
6	K (K Institute)	Female/Senior researcher	2016.2.16. K Institute	K6
7	K (K University)	Male/Professor	2016.2.16. K University	K7
8	K (C University)	Male/Professor	2016.2.11. C University	K8
9	S (U University)	Male/Professor	2016.2.12. U University	S9
10	M (U University)	Male/Professor	2016.2.12. U University	M10
11	L (B University)	Male/Professor	2016.2.12. U University	L11
12	S (J University)	Female/Professor	2016.2.4. U University	S12
13	L (S University)	Male/Professor	2016.2.2. S University	L13
14	H (S Institute)	Female/Senior researcher	2016.3.19. S Institute	H14
15	P (E Institute)	Female/Senior researcher	2016.3.19. E Institute	P15

In accordance with these questionnaires, a total of 15 basic researchers and policy experts were interviewed. In February, 2016, 13 interviews were conducted, and 2 interviews were conducted on March 19, 2016. The interviewees were 11 professors and 4 public research institutes researchers. There were 11 men and 4 women. The interviewees consisted of 13 basic researchers in the fields of life sciences, physics, magmatic science, and others

and 2 researchers in the field of science and technology policies. The interviews were partially supported by a project commissioned by the Ministry of Science, ICT and Future Planning titled "A Study on the "Basic Research 2.0 Strategy" for the Convergence and Synergy," supervised by Sang-Seon Kim. In this study, however, the analysis was done using a different framework.

III. Results and Discussion

In this section, we analyzed the statements of interviewees according to the five points of the basic research system presented earlier: value, openness, sustainability, autonomy, and competitiveness. We considered common comments and various ideas suggested during the interview. We attempted to identify the operational mechanism in the national basic research system.

1. Values and Vision

Most scientists agree with the definition of basic research as "an experimental or theoretical work carried out in order to achieve knowledge of the fundamental or observable fundamental principle, without worrying about specific applications or usage," stated in OECD (2002, 34). Most of the interviewees mentioned that basic research, including basic science, is the initial stage of R&D for creating new knowledge. Furthermore, there were concerns that over-emphasis on economic benefits could weeken the original purpose of basic research.

> I generally agree with the OECD's definition of basic research. The essence of basic research should be the expansion of knowledge and the fulfillment of curiosity rather than the applicability of knowledge. I am concerned that too much focus on industrial value undermines the proper implementation of the basic research. I feel frustrated when someone talks about the economic benefits of basic research (Professor K2).

With regard to how they valued basic research, interviewees tended to state that they were motivated by curiosity and reward based on reputation. Researchers note that creative knowledge production contributes to the national economy in the long run. Furthermore, it is also important to build systemic capability in the process of the generation of benefits.

> I think, for bright graduates, the greatest motivation for becoming a basic researcher is academic curiosity rather than economic payoff. Thus, this is closely related to the desire to extend the frontier of human knowledge and to be recognized as the first discoverer (Professor K2). National competitiveness in basic research will enables to lead an international collaborative research. Furthermore, we can establish the capability to properly solve social problems (Researcher K6). The capability of basic research allows national actors to explore and understand cutting-edge knowledge in a global network. Thus, they can apply the knowledge found to the domestic industrial environment (Professor L13).

To sum up, we found an agreement that the uniqueness of basic research lies in the exploration of nature in terms of definition. Moreover, there is a wider consensus that a basic research policy should be implemented while considering this characteristic.

2. External Openness

In this area, we have insufficient external openness or globalization. In particular, it was commonly mentioned that the living conditions and culture of Korea are inappropriate for researchers to stay the course in the long term. Sharing research facilities and attracting overseas researchers are important issues. Interviewee raised additional issues such as simplifying administrative process and establishing research policy based on longer perspective.

> It is uncomfortable for foreign researchers to live longer-term in Korea, considering living our conditions and culture (Professor K2). There are many barriers to the globalization of science practice, such as insufficient housing, communication problems and modest research facilities. In particular, the lack of access to research equipment is critical (Professor K1). For overseas researchers, there is no reason to visit Korea as they do not need to use Korean equipment, which is not of high quality. Rather than attracting top-tier senior researchers from abroad, it is better to encourage younger foreign researchers to use domestic equipment. By doing so, they can collaborate with Korean supervisors using enhanced equipment based on domestic research funding (Professor S12). A current basic research policy based on a short-term perspective deters the openness of the

> domestic basic research system (Researcher K6). A drastic simplification of the administrative process based on trust in researchers in the field is essential for active international collaboration in basic research with advanced countries such as US and the EU countries. We have to take the risk that small number of scientists may commit fraud (Professor M5).

There should be a benefit for overseas researchers to come to basic research laboratories in Korea. This paid-out benefit would be made up by the enhancement to the quality of Korean basic research in the near future. In addition, the interviewees mentioned that increases in the amount of direct expenditure and invitations to distinguished scientists to train domestic students are required.

> The reason that foreign scientists do not come to Korea is that they do not think that there is much to gain from Korean laboratories. As our basic research capabilities increase, we believe that joint research with advanced countries will expand in due course. If there is a lot of give and take, each will create joint research for the other to collaborate in (Professor K2, K7 and S9). Exchanges of domestic and international experts are more important than exclusive invitations to researchers from advanced countries. The interchange of domestic experts is not so active. Compared with advanced countrie, Korea does not have requisite funding for academics. Personally, I have tried to cooperate with Spain and French CNRS, but I couldn't conduct this work because there was no research budget available for the project (Researcher K6). At the beginning, we were only able to invite overseas lecturers, but now a foundation for practical cooperation has been established that carries out Brain Korea 21 projects (Professor L11).

Most interviewees were optimistic about the globalization of the research system; however, they believed that the research quality and the funding system were working as barriers to external openness. To work this out, most agree that it is important to generate world-class research.

3. Sustainable Scientific Resources

When asked about sustainable scientific resources, the interviewees mentioned research funding, research personnel, and equipment. While the

demand for research is increasing exponentially, the funding supplied is increasing linearly. Accordingly, the funding system should be revamped so that individual research can be supported at the appropriate level. They also maintain that a remarkable expansion of bottom-up research based on individual proposals is necessary. In particular, the need for a separate fund for talented women, local researchers, and young scientists to be strengthened was identified. There was a strong recommendation for a switch to merit-based system evaluating the research proposals themselves (e.g., methods, strategies, and so on) rather than the applicants' background, such as their supervisors' reputation. Furthermore, some interviewees insisted that accountability and autonomy should be strengthened in the process of implementing and managing research expenses.

> With the increase in the number of researchers and the enhancement of research quality, total research costs have been steadily increasing. As a result, researchers are complaining of shortages in research funding in Korea (Professor K7). Research support systems should be completely changed to enable autonomous research based on a majority of basic researchers' needs and expertise (Professor K1). It is important to steadily expand the number of research projects for a majority of basic researchers. Although it is small, it is important to stably support these projects (Professor S12). The amount of funding for young researchers should be increased (Researcher P15). The proportion of bottom-up projects based on creativity need to be increased to a level above 50 % (Professors K2 and L3). Not only increases in research costs but also the effectiveness of the research implementation process is critical for the improvement of Korea's basic research system (Professor K4).

With regard to research personnel, interviewees commonly agree that to attract new and talented researchers into the basic research area, the best educational environment, role models of scientists, and an atmosphere respecting researchers should be included. Furthermore, they argue that it is essential to stimulate the responsibility and pride of basic researchers and celebrate their socio-economic contribution to the society.

> A sense of mission and pride is lacking among basic researchers, and there is no role models who are extremely successful in the domestic basic research community (Professor K1). Young people choose professional occupations such as those of doctors and lawyers other than that of scientists because of its relatively

> low socioeconomic status (Professors K2 and S12, Researcher Y3). Public research institutes prefer a ready-to-work labor force, so it is difficult for graduates in the field of basic research to be hired (Researcher P15).

With regard to education, there were several recommendations: students should have face-to-face interactions with internationally distinguished gurus, and the educational system should promote creativity and collaborative activities emphasizing social skills. It has also been emphasized that basic research enables the young generation to live a happy life by satisfying their curiosity in the process of their participation in scientific enterprises. Some scientists suggested how the basic research personnel could be utilized on the basis of strong relationships between universities and public research institutions.

> There is a problem with an educational culture that emphasizes the "right one" answer rather than promoting various questions (Professor K1). The role of the laboratory is to nurture graduate students as creative researchers (Professors K2 and K7). Students in laboratories tend to have strong academic motivation due to their opportunities to visit overseas labs and interact with them (Professor K4). Creativity is cultivated through various external social activities and experiences, not just through work in the laboratory (Researcher K6 and Professor S9).

Finally, in terms of research equipment, interviewees argued that maintenance of existing equipment is important and that obtaining new, highly calibrated equipment is important as well. In particular, the importance of stable support from technical experts, operators, and programmers was highlighted. Thus, arguably, there is a need for separate government support programs for maintaining and repairing equipment and facilities. In addition, it was indicated out that high-technology equipment is more effectively, shared by overseas researchers than by those in Korea, where each piece of equipment is owned and operated by an individual laboratory. It is noticeable that the research idea is more critical for excellent research than the equipment itself.

> The purchase of advanced research equipment is important, but it is more critical to maintain and manage it effectively (Professor K1). Although the quality of research equipment in Korea has generally increased, the equipment has been inefficiently operated because of the lack of technical skills and additional funding for

> maintenance (Professors K2 and S12). Our research equipment has become state of the art, and now exploiting this equipment has become more important than before (Professor S9). High-techology equipment is shared efficiently overseas rather than being individually possessed (Professor K6). As part of the national research infrastructure, the equipment should be established and operated in public research institutes (Professor K7). Our government is inclined to stop supporting national facilities after they has been created (Professor S12).

To sum up, a qualitative change is required in the Korean basic research system in terms of research resources. Furthermore, interviewees demand immediate changes: the effective allocation of research funds, support of the creativity of research personnel, and increase in efficiency in the utilization of equipment.

4. Autonomy in Transformation Process

Fourth, with regard to external autonomy, interviews were conducted on independence from the government and society as well as the social responsibility of the Korean scientific community. While the public has a strong interest in science, scientists do not tend to participate actively in social issues in general. In order to mitigate this discrepancy, the need for the activation of a scientific society has been asserted.

> In South Korea, scientists have not initiated action on a social issue actively for half a century now. Rather, after the problem arises, the scientists are ordered to solve the problem perceived by the government (Researcher P15). With regard to the scientists' social participation, the scientific community needs a space and opportunities where we can freely express our opinions (Professor K1). Issues such as nuclear power, mad cow disease, and MERS are complexly intertwined with other social problems; therefore, it is very difficult to understand as a whole. Moreover, it is difficult for scientists to engage in the issues independently because of the government's strong control over research funding as well as over the scientific communities (Professor K8). Furthermore, the scientific community is hardly regarded as an independent professional group in South Korea (Professor K8). The South Korean scientific community is highly dependent on government and politics (Professors S9 and S12). It is

> problematic that politicians and governmental officials determine what scientific areas are to be supported and that the current basic research support system has been under a strong regulatory system (Professor S12).Building research agendas according to fashion, such as nanotechnology, bureaucrats tend to become overly reliant on the experts, who are very willing to help them. In this process, the bureaucrats may be unintentionally swayed by the experts (Professor M5).

In terms of internal autonomy, even though research ethics were advanced, the government was criticized for interfering with scientific autonomy, such as in the case of various regulations on research expenditures. In order to enhance scientists' autonomy, there is a need to increase the number of bottom-up research projects and strengthen a society with the scientific temper by benchmarking advanced countries' cases, such as those of the American Association for the Advancement of Science (AAAS). Obsession with quantitative achievement can hinder the establishment of research ethics in the community, and scientists involved in ethical violations need to be strictly castigated.

> The autonomy of researchers in the research, planning, and implementation of research subjects, is expanding, but fundamental changes are needed. As research spending becomes increasingly transparent, the scope of inspection is widening and the flexibility and autonomy of use are becoming more vulnerable (Professor K1). The current tight funding system tends to regard funded researchers as potential criminals who are ready to do fraud in research expenditure (Professor L13). As research autonomy is the basic requirement for creativity, there should be more bottom-up research tasks than planned tasks from the government (Professor K2). Because of the burden of producing short-term research outputs, there is a limitation in planning and exploring creative research agendas based on a long-term perspective (Professor K8). The obsession with counting papers should be mitigated; rather, a qualitative assessment system aiming at measuring valid research output should be strengthened (Professor L11). For the scientific community to be respected independently, something like AAAS in the United States must be taken as a benchmark. In our country, scientists are heavily dependent on bureaucrats (Professor S9).

Historically, the Korean scientific community has been a royal agent for politicians and bureaucrats, who have taken on the role of giving major direction in the national science and technology system. During the catch-up period, this encouraged the efficient mobilization of national resources for technological innovation. However, this system no longer works properly because scientific communities have greater expertise in scientific decision making than does the government. In this vein, scientists and policy practitioners try to find solutions such as strengthening self-regulation internally and autonomous socioeconomic contribution externally.

5. Global Competitiveness of Scientific Outputs

The interviewees were asked to evaluate the quality of basic research achievement in Korea. Most interviewees replied that despite a short history of basic research, Korea has had a remarkable performance, which was only possible because of the strong support of the government. Quantitative indicators, such as the number of papers, have risen rapidly to the level of Korea's global competitors. Among them, a few world-class achievements have been attained even though we have not had a Nobel Prize winner yet.

> Despite the short history of basic research in Korea, it has developed remarkably because of the government's strong and steady support (Professors K1 and M10). The government's strategic investment in research has been a major factor in the rapid quantitative growth in research that has risen to a global level in certain areas (Professors K2 and L13, Researcher Y3). Although global-level research has been carried out very recently, it is extremely difficult to achieve originality. This is because the decision in basic research is based on the analysis of research trends in advanced countries. It is impossible for the government to invest in a completely new research area (Professor K6).
>
> In the process of project selection in Korea, it is not global originality but domestic originality that is enough for legitimization (Researcher H14). Korean basic research projects tend to follow mainstream research trends handed down by advanced countries. Consequently, the contents of basic research in Korea largely consist of imitation and repetition (Professor S12). Apart from the case of an extraordinary genius, there is a 30-year gap between our country and advanced countries (Professor K7). Our basic researchers are neither leaders nor at the top of the world (Professor S9).

Next, we asked how Korea could produce world-class researchers. Most interviewees agreed that we can produce globally competitive research by pursuing our own research themes rather than those defined in advanced countries. When these researchers supported in this way interact with world-class researchers, they will naturally reach the highest level. Moreover, continuous support for outstanding domestic researchers that is based on world-class facilities established for their purposes is critical. However, the weakness of the small size of the domestic peer group was also noted.

> Using a dual track system, we can produce world-class researchers. In other words, on the one hand, we would spread out a small amount of funding to the majority of researchers, and on the other hand, a large amount of funding is given to a few excellent researchers (Professor K1). Support for postdoc researchers and newly recruited professors is important (Professor K2). Yu-na Kim, a famous Korean skater, could achieve international standards by taking advantage of overseas resources in training. In a similar vein, making the best use of the international network is crucial for breeding top-level researchers (Researcher Y3). Because we have a small number of researchers, we have to support a research group in the long term to achieve global competitiveness (Professors S9 and S12).

Finally, we collected opinions on the performance management of basic research and socioeconomic contribution to the society. To manage the output of basic research, it is critical to accumulate and share various scientific impacts (e.g., knowledge stock and trained graduate intellectual properties). It was also suggested that the research assessment should be implemented according to whether internationally well-known scientists gave high marks or not. Interviewees argued that the short-term, marketoriented evaluation system is hindering high-quality research as well as the accumulation of research outcomes. There has been no system whereby basic research output is linked to the success of social and economic contributions, and there should be a platform to promote this process.

> As subjects for research have continuously changed according to the research trends initiated by the government, the accumulation of knowledge has been seriously impeded (Professor K2 and Researcher Y3). It is necessary to encourage a perception that current failure also will contribute to the upcoming research projects (Researcher Y3). Performance evaluation should be

> carried out on the basis of whether global leading research is delivered or not from the perspective of international peer groups (Professors K7 and M10). The requirement of visible performance for basic research tends to force researchers to focus on the number of papers (Professor L13). There has not been sufficient support for newly recruited professors challenging the commercialization of basic research in the high-risk and high-return area (Professor K4). To solve social problems, research groups should be prepared long before the problems crop up (Professor K6). If we want to cope with social problems, a concept of basic research considering the social context is required (Professor K8).

Scientists conclusively agreed that national performance has reached a certain level in the global scientific society. However, they identified the small size of research groups and the excessive focus on the short-term economic perspective as hampering a new quantum leap. To prepare for upcoming global competition, steady support for creative research and active interaction with the global community is needed.

IV. Conclusion

In this study, we analyzed the current status of the national basic research system on the basis of interviews with scientists and policy experts. To do this, we proposed a systemic perspective consisting of value, openness, input, transformation and output. From the results of the analysis, we put forth some policy implications that are based on a summary of the discussion of the previous section.

First, in terms of value, basic research is recognized as an activity of creating knowledge in the understanding of nature. To this end, basic research activity should be treated as a unique area for policy practitioners.

Second, in terms of openness, scientists and policy experts agree that that active interaction with the global community is an important value for a national research system. Nevertheless, due to the weak basic research capabilities and social institutional inadequacy, global openness has stagnated. To overcome this situation, strong support for creative and diverse research themes is necessary. Thus, the global openness of the system will be enhanced. Interviewees maintained that the quality of research and cutting-edge equipment are key factors in the interaction of overseas researchers. Accordingly, as the attractiveness of Korean basic research system is

strengthened, its initiation into participation in the global scientific community will be achieved.

Third, in terms of sustainable research resources, scientists strongly require that research funding be allocated effectively, that the creativity of researchers be maximized, and that research equipment be efficiently shared. To this end, the need for increasing the proportion of bottom-up research projects and of strong support for minority researchers who suffer from insufficient resources has been emphasized. Along these lines, in terms of research personnel, a variety of policy approaches should be exerted to create an institutional setting that provides recognition on the basis of merit. With respect to sharing research equipment by increasing global openness, an effective exploitation strategy is needed to be pursued.

Fourth, basic researchers maintain that the Korean research system has been overly dependent on the government's control externally, while its self-regulative system has been weak for half a century now. To mitigate this shortcoming, the government should encourage the autonomy of the scientific community; moreover, scientists have to strengthen the activity of social participation. In particular, the government intervention based on short-term marketoriented evaluation programs needs to be improved immediately. Further, the proportion of research funding without strings attached must be increased, so that researchers and basic research organization are able to plan on the basis of their own expertise.

Fifth, in terms of global competitiveness, the interviewees agreed that the quality of basic research in Korea is approaching that of its global competitors. However, it was noted that its small research group and market perspectives were a barrier for competing with other global competitors. To improve this, steady support for new themes and active interaction with global communities is essential. In addition, an evaluation system that is based on performance is strongly recommended. Accordingly, to overcome the weakness of small research groups, strengthening the attractiveness of Korean research facilities was suggested. Moreover, internationally distinguished scholars must be invited to participate in the process of research implementation and evaluation to boost Korea's quality of work to world-class levels.

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