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Forecasting Korean National Innovation System and Science & Technology Policy after the COVID-19

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Abstract The COVID-19 is a pandemic that affects all facets of our life and will change many patterns in science technology and innovation. A qualitative study was conducted using Focus Group Interview involving ten industry-academia-research experts with the objective of identifying changes in Korea's national innovation system and science & technology policy after the COVID-19. Eight questions were designed, based on the major components of the national innovation system, such as companies, universities, and research institutes, to discuss the changes in the national innovation system and science & technology policy. Also, keyword analysis and cluster analysis were performed using the network analysis program VOSviewer. It is predicted that, in the wake of the COVID-19, Korea's national innovation system will shift to a new paradigm that is more decentralized, responsive, and autonomous. Furthermore, several policy agendas that can turn these changes into positive momentum of change in science & technology policy are presented.

Keywords COVID-19, Focus Group Interview, national innovation system, S&T policy, keyword analysis

I. Introduction

The World Health Organization (WHO) declared the COVID-19 (Coronavirus Disease 19) a global pandemic on March 11, 2020. The COVID-19 is a respiratory virus whose first outbreak occurred in Wuhan, China, in December 2019; it was initially called SARS-CoV-2, because it is similarity with SARS in 2015.

The COVID-19 is expected to shift the focus of public health from treatment to prevention and management by raising interest in the health and

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biotechnology industry. There is a high probability that the global supply chain will be reorganized to respond to the new normal of non-face-to-face remote services and the strengthening of home-centered activity. As the worldwide spread and damage generated by the COVID-19 increase, international organizations, the public sector, and private companies around the world are working to develop therapeutics and vaccines against the disease (Seol and Ko, 2020 forthcoming).

The U.S. is formulating policies to develop therapeutics and vaccines to respond to the COVID-19. President Trump introduced the vaccine development and distribution project 'Operation Warp Speed' at a briefing on May 15, with the expectation to develop vaccines by the end of this year, and aiming to produce 300 million doses by January next year. The EU Commission set up a Corona Response Team and launched a new campaign called Corona Global Response, raising 9.8 billion Euros to develop vaccines and therapeutics, and providing 48.5 million Euros to the Horizon 2020 projects. Japan announced, in April, the development of medicines and vaccines as a national policy.

The Republic of Korea has launched the Private-Public Joint Action for the COVID-19 Medicine and Vaccine Development and is establishing various programs for rapid commercialization. In particular, the Korean government has provided the technological sources of coronavirus to the private companies for the test kit. Further, a technology-centered approach, such as medicine and vaccines, is at the core of the Korean response. And all the policies have been selected by experts, not government officials. Accordingly, the Korean response to the COVID-19 has become a model case in the world (Seol and Ko, 2020 forthcoming).

In this paper, ten industry-academia-research experts participated to a Focus Group Interview to forecast Korea's science & technology after the COVID-19, then a network analysis was performed based on the output. The objective is to examine the possible national innovation system and science & technology policy in the post-COVID-19 era.

II. Theoretical Backgrounds

1. Studies on post-coronavirus

1.1 Korea

After the coronavirus outbreak, many articles have appeared discussing post-coronavirus. However, most of them are short stories or personal opinions, and academic articles are rare. In early August, a search of the Korean academic information service – riss4u DB – with the keywords ‘after coronavirus’ and

'post-coronavirus', identified 29 papers, except those related to the healthcare sector. Table 1 lists the fields dealt with by the papers.

Table 1 Academic research after coronavirus

	No. of articles	Topics
Technology	8	Construction (3), city planning, health regulations, new materials, automobiles, electronics
Policy	8	Job (2), economy, finance, transportation, real estate, social service, youth
Industry/Economy	7	Economic crisis, construction, tourism, real estate, oil, fisheries, airports
Others	6	Education (2), Christianity (2), communication, etc.

Note: riss4u DB as of August 2020.

Looking at these results, discussion about the impact of the coronavirus has taken place in many places. But the seriousness of the problem calls for urgent technological, industrial, and government responses.

1.2 The world

Nine academic papers were identified through a SCOPUS DB search, excluding the field of healthcare that directly relates to coronavirus. This number was small, reflecting only a period of seven months since the outbreak. Topics covered include caring, university, climate change, telehealth, laboratory life, US and China, values of nature, web/app use, and harmony of politics-society and nature.

2. Focus Group Interview

2.1 Methodology

Focus Group Interviews (FGI) has been adopted in many fields since the methodological presentation by Stewart and Shamdasani (1990), Morgan (1998), Krueger (1998), Bloor et al. (2001). The use is extensive because it has the advantage of not only being able to gather collective views, but also being able to establish and share common experiences or beliefs.

Tobias et al. (2018) reviewed FGI studies in the area of biodiversity and conservation research during the 1996-2017 period. Studies using FGI have these characteristics: 3-21 participants, with a median of 10, seven focus group meetings per investigation, and 90 minutes of discussion for each meeting. However, more than half of the studies do not report the sample size and group size. Hyde et al. (2005) point out the essential problems that may arise from the

application of FGI. Their study, which explores adolescents' gender perceptions, shows that participants may not tell their most in-depth stories in public. A full description of the participants' personal stories is an essential condition for a successful FGI.

Greenwood et al. (2017) show that FGI also has two ways to obtain data: interview and group discussion. Cyr (2015) divides Focus Group Interviews into individual-centered, group-centered, or interactive types of participation, and each approach has advantages and disadvantages. If the FGI focuses on each individual's opinion, it is advantageous to confirm any fact or theory. If the focus is on the group, pre-checking is necessary to derive any fact. On the other hand, interaction has the advantage of searching for unknown facts and common perceptions.

Since both individual interviews and group interviews have their advantages, many studies use personal interviews and FGI in parallel. Gill et al. (2008) compare the interview method and FGI for medical research. Rosenthal (2016) explains when and under what circumstances the two methods should be chosen. Laestadius et al. (2019) show the application of several types of FGI methods.

In line with this, we use individual interviews and FGI in parallel. The summary of the method used is as follows.

1. Questions are designed based on components of the national innovation system.
2. Written opinions or answers for each question from each participant are collected, and interactive discussions are recorded.
3. A small group discussion among the 10 participants was set up. First, issues were divided between after-coronavirus and during-coronavirus. Second, written opinions were categorized by subject.
4. The recordings of interactive discussions recorded were transcribed and used for network analysis, clustering keywords according to the connection relationship of keywords.

2.2 Detailed process

The detailed process is as follows. The first FGI lasted three hours on June 11, 2020. The FGI survey and interactive discussion involved ten industry-academia-research experts in the field of technology innovation and technology policy. They experience in this field spans from 15 to 35 years.

Table 2 FGI target information

Participant	Sex	Age	Affiliation	Major interest
A	M	65	Business/university	EOT/policy
B	M	57	Research institute	STI strategy
C	M	66	University	STP/MOT
D	M	58	Policy institute	STP/regional innovation
E	M	48	University	Regional planning/modeling economy
F	M	44	National Assembly	STP/futurology
G	M	48	Research institute	ICT & ICT industry policy
H	M	62	University	BT policy/MOT
I	M	51	University	STP
J	M	48	University	STP/EOT

Note: EOT=economics of technology; MOT=management of technology; STI=science technology innovation; STP=science technology policy

The survey started with the introduction, then the conversion, followed by the main question, and ended following Kruger and Casey (2000).

Eight questions were put forward as the main questions. Each question related to the main elements of the national innovation system, such as enterprises, universities, government research institutes, supporting organizations, and government policies.

Table 3 FGI Questions

Stage	Contents
Start	Introduction of participants
Confirmation	Whether COVID-19 has triggered changes in the national innovation system
Topics of Conversation	The importance of technological innovation and policy after COVID-19
Major questions	1. What is the most significant change brought about by the COVID-19? 2. What will happen to the content and pattern of innovation? 3. What will changes be in the innovation and production system in industries? 4. What will changes be in research and education of universities? 5. What will changes be in government research institutes? 6. What will changes be in technology innovation policy? 7. What will changes be in science & technology support institutions? 8. How to prepare for the changes of the national innovation system?
Closing	Summary and comments

After ensuring the anonymity of transcripts and investigation, an atmosphere was created to be conducive to the process of discussion and sharing. The investigation process is as follows. First, after introducing the surveys, the purpose and questions were explained. Second, surveys were conducted based on eight open-ended questions, and interactive discussions were held. Each talk was organized into documents. Fourth, after the interview was over, significant comments were read to understand the opinions of experts from the perspective of outsiders.

The small group FGI was gathered in early July to organize the contents derived from the first round. Four participants evaluated each statement. Since some answers did not appear in relevant questions, each response was assigned an appropriate position. Since there was often no distinction between 'during-coronavirus' and 'after-coronavirus', this small team discarded the 'during-coronavirus' answers. The difference between 'during-coronavirus' and 'after-coronavirus' is expected to depend on how and how long the coronavirus progresses. This group referred to the progression of the coronavirus examined by Seol and Ko (2020 forthcoming), the first article of the special issue about after-coronavirus.

III. Anticipation of Changes

1. The most significant changes caused by the COVID-19

The most visible change is that Korea's healthcare technology, which is considered to be a step or two behind advanced countries, has raised one step further and can rise to the global ranks. During the coronavirus period, the demand for diagnostic kits and thermal imaging devices from Korea exploded around the world. The stock price of the thermal meter company raised the most in the Korean stock market, 11 times from February 20 to August 6, 2020. February 20 is the day before the coronavirus outbreak in Korea. Also, the stock of Seagen and Humasis, companies that supply dozens of coronavirus diagnostic kit co, rose tenfold.

The second significant change is that the untact technology utilized during the COVID-19 will act as a trigger for the 4th Industrial Revolution. The term 'untact' comes from 'un-contact'. The online or mobile communication technology, artificial intelligence, and robot technology used for this are collectively called the untact technology. However, we include the development of the untact industry that supports the untact culture. In commerce, untacting requires someone to deliver the necessities and sell them in close proximity. The

growth of the delivery business and the convenience store located in a short distance is also expected to accompany the development of the untact industry.

Third, it is expected that various social systems and institutions will be built and reorganized to respond to national crises. Korea has already experienced once every few years animal epidemics, such as foot-and-mouth disease, and human epidemics, such as swine flu or coronavirus. Besides, Japan's ban on exports of essential materials to Korea in 2019 and flood damaged in August 2020 when the coronavirus was progressing can be included in the national crisis. The need to respond to the national emergency has increased. The monitoring and response systems related to this are expected to be strengthened throughout the country.

Fourth, a significant change is expected to strengthen the tendency toward individualism. This change, which is expected to be essential to the untact culture, will have a considerable impact on society and politics.

"The COVID-19 reduces the existing physical connectivity and replaces it with digital connectivity. But can the economy, society, and civilization that we have built up so far easily adapt to it? Various dissonances are expected in the process of overcoming, so it will be necessary to review them frequently."

Fifth is the emergence of the region as an essential subject of policy. It is not an exaggeration to say that the central government can respond to the social issues in Korea. However, Daegu city experienced a mass outbreak at the beginning of the coronavirus, and the local health and medical system collapsed. The administrative system failed to respond appropriately, so the central government had to handle the crisis. On the other hand, it is judged that Gyeonggi-do and Seoul Metropolitan City's response was determined and appropriate. These facts show that the policy of the central government is essential, but the response of local governments is also important. It can be said that the region also emerges as an important subject of policy in Korea.

Sixth is global change. Many of the participants emphasized the collapse of the global value chain with a national blockade to prevent the influx of coronavirus patients from other countries. Also, it was noted that the national priority over vaccines and therapeutics was a similar phenomenon, and the international value chain was inevitably affected by the dispute between the United States and China that unfolded simultaneously. It is expected that the value chain based on free trade will be weakened by efforts to control the technologies, drugs, and industries essential to the country.

Seventh, it is expected that government support will continue for the time being, for the socially weak and those who have suffered industrial and economic damages from the coronavirus. As a result, it is expected that the national aid policy will continue for the time being, with the government playing a big role in terms of welfare.

2. The content and pattern of technological innovation after the COVID-19

First, it is expected that investments by the government and companies in the healthcare industry and technology, especially biotechnology, will be activated. As shown in Seol and Ko (2020 forthcoming), the first paper of the special issue of this journal, Korean companies are world-class in diagnostic kits and antibody drugs, and they rank just behind the advanced countries on coronavirus vaccines. Thanks to their success, it is expected that various new medical technologies will be challenging, and the necessary funds will be actively supplied to the private sector as well. Among the top 20 stock price hikes in the first half of 2020, 17 are bio companies.

Second, the development of technologies related to the 4th Industrial Revolution is expected to accelerate. The untact technology is gradually developing into an ontact technology adding AR and VR technologies, while the coronavirus is in progress. In this process, high-speed communication, whether online or mobile, is essential, and it is expected that the development of 6G technology will accelerate beyond 5G technology. Including these technologies, Korea has already defined DNA (data, network, AI) technology as essential for the 4th Industrial Revolution and is conducting national R&D. For the structure of technology related to the 4th Industrial Revolution, see Moon and Seol (2017).

Third, it is expected that the smartization of production and distribution will be further strengthened. In Korea, smart factory policies are already in place, but as the untact culture spreads, more investment is expected in smartization and ontact technology that will support untact.

Fourth, there is a matter that has been ignored by many speakers. The mass transportation industry, such as aircraft and ships, and the steel and oil industries that supply resources to it, are becoming unmanageable. As a result, investment in technologies in these fields is expected to be delayed or canceled, thereby hindering technological development.

In terms of changing patterns of technological innovation, first, technological development is expected to switch from a technology supply perspective to a problem-solving or social demand-based mode. In other words, this research's participants are expecting a significant change from technology-push-oriented to social R&D that goes beyond demand-pull.

Second, the technological response and success against the coronavirus gave us experiences that crossed the barriers of each field, which had been a chronic problem in Korea. In other words, the immediate multidisciplinary convergence research had a significant effect. As a result, it is expected that practical

convergence research will be strengthened in research to respond to urgency requirements.

Third, in the development of a coronavirus diagnostic kit or therapeutics, technology development and regulation work at the same time, showing excellent results. For this reason, regulation will be considered and proceed simultaneously from the R&D planning stage. Regulations can be divided into regulations related to technology development and regulations in the industrialization stage. Both regulations will be considered simultaneously, even in R&D planning. Also, this trend is expected to proceed both as national and industrial issues.

Fourth, there is a possibility that the technology policy at the local government level will be strengthened. As the central government is unable to scrutinize all fields, it is predicted that research on regional technologies will be enhanced with the increasing role of local governments. This trend is likely because it is the most comfortable option for the central government to reinforce the role of local governments.

3. Innovation and production system changes after the COVID-19

The first phenomenon in innovation in industries is expected to spread the technology development of the healthcare industry, the first to experience competitiveness. 'K-epidemic control (Korean epidemic control)' has had the effect of strengthening international brands not only of Korea itself, but also of Korean companies. The brand effect will lead to many attempts to unveil technologies that have been tried, but have not been working in the global market. In the stock market, discussions have already begun, particularly among companies with cancer-related platform technologies.

Second, it is expected that the speed of technology diffusion for the 4th Industrial Revolution will accelerate. The Korean government is already encouraging the development of technology for the 4th Industrial Revolution and spreading the existing technology into various fields such as smart factories, smart healthcare, and smart city, which are spreading to companies. It is expected to be strengthened further.

"In many cases, some technologies for the 4th Industrial Revolution have never been tried. Therefore, the investment strategy into the technologies is "try first and correct by trial and error." However, it has been proven that, owing to the coronavirus, this investment direction was correct."

Third, non-face-to-face market opportunities will expand; accordingly, the form of labor and the structure of the labor market will change through automation and AI. This trend is expected to take place in two directions. One is expected to emphasize expertise in new technologies. Therefore, the new

technologies for the education system for should be strengthened and expanded. The other is that technologies for the 4th Industrial Revolution, such as AI, will inevitably reduce jobs. It is natural to expect that the technologies for the 4th Industrial Revolution will cut down rather than create new jobs.

"It is expected that more people will lose their jobs than new jobs are created. Job countermeasures are not the realm of technology policy experts, but technical retraining for displaced workers as well as new technology education for existing workers are issues that technology policy experts should consider."

4. Changes in university research and education after the COVID-19

First, the most significant change seems to be the revitalization of non-face-to-face education and the search for technological alternatives to support it. The technology for the 4th Industrial Revolution applied to the education sector can be collectively called edutech, which will be significantly expanded in the future.

Second, a simultaneous change in educational content and educational methods is expected. When non-face-to-face education is reinforced, lectures by professors are recorded and stored. Then, simple transfer-type subjects will be attracted to the best professors and teachers in the country. A similar trend is also present in the pre-college education. Therefore, a platform for simple transfer-type educational contents will emerge, and university professors and teachers' task will be transformed into experiential and practical training. In that case, the hands-on professors/teachers will have a more significant coaching role than lectures.

Third, if experiential and practical education is emphasized, it is expected that region-specific education will be strengthened rather than centralized educational content. In such a case, regional universities will cater to research and education in response to local problems, and teachers will be given many examples suitable for region-specific training. This trend will provide an opportunity for memorizing culture, which is an educational pattern of the industrial society, to be transformed into creative or social problem response education.

"The local university will use local resources to transform the community into a single laboratory, and move toward a convergence system where students are experimenting and educating themselves, and professors' role will be transformed into coaching and advice provider to solve problems."

"If such a change occurs, the standards for faculty or lecture evaluation, which were assessed by research or lecturing, will change. A new concept of efficiency will be introduced in universities, and new evaluation system will be introduced accordingly."

Fourth, the trend of local universities in charge of job-displacement education or for those who have lost their jobs will be strengthened.

5. Changes in the government research institute after the COVID-19

First, the government research institute (GRI) will re-establish its function of preparing for a crisis in society. In other words, it is expected to have a research system that encompasses industry-academia-research as an essential means of the national crisis response system. Currently, since the research of GRI is conducted according to the three-year plan submitted by each new director, there is no capacity to carry out other tasks in GRI. However, in response to the coronavirus, government researchers have shown that they have played a substantial role in the industry-academia-research system on specific issues. Therefore, the GRI will be more strongly called upon to monitor social crises and develop technologies to respond to them. Of course, there will be empowerment and reorganization, accordingly.

Second, the government research institute will make fusion research possible by operating some changes to the current system, which is independent for each field. This change is because problem-response research is not usually solved in only one specific technical area. Of course, GRI is carrying out convergence research, however, each GRI in each technology field has a say in convergence research because each institute provides matching funds for the research. Therefore, a leader of convergence R&D cannot work appropriately.

Third, the foundation for the autonomy of GRI is expected to expand. Speed is necessary to monitor and respond to national crises, and independent decision-making is essential to conduct research on risks that are not immediately emerging, but expected. In convergence research, the autonomy of each research center will be strengthened, and the government's direct intervention will be lessened.

6. Changes in technology policy

It is expected that the government will first encourage R&D to solve national problems. The national task is to respond to a crisis or a disaster. It will also include responding to an industrial turmoil from the global value chain. Research on the field of materials and parts due to Japan’s 2019 export ban to Korea and the self-sufficiency of vaccines and therapeutics seen in vaccine nationalism is the national challenges facing the government.

Second, it is highly likely that a problem-solving technology development strategy for national tasks will be adopted. In these tasks, experts who know the final end-user will be in charge of the job.

Third, like the successful model in the development of technologies related to coronavirus kits and therapeutics, technology policies considering regulations simultaneously with technology development is expected to be strengthened. This model is not an unfamiliar policy model as it was a model that was used a lot when the Korean economy followed a catch-up strategy in the past.

Fourth, the government will play a role in conducting basic or applied research in fields that are on the verge of collapse due to the coronavirus or have no room for R&D. In that case, the research will be conducted by government research institutes.

7. Changes in science and technology support organizations after the COVID-19

Science & technology support organizations are organizations that implement the government's science & technology policies. Therefore, they will move in the same direction as the government's science & technology policy. However, since support institutions have different tasks such as basic research and industrial research, various changes are expected depending on the nature of the institution.

The first change is that technology development for social problem solving will be strengthened more than it is now.

"The role will grow in the direction of creating an integrated role or creating a collaboration program and solving problems."

Second, the program planning function of the support organization will be further strengthened as the result of research, which must be immediately targeted to problem-solving. However, the planning function will be more likely to be conducted by private experts who are familiar with the problem, rather than by the support organization. This trend is very different from the present where the government even exercises a planning function.

"In the past, when conducting R&D that can be easily understood, it was carried out by relying on the role of public officials, but the volume of research without bring about correct answers will increase, and the situation where experts in the field will have to lead will increase."

8. Preparing changes for national innovation systems

The above questions looked at changes in each of the components of the national innovation system. However, some problems can be easily missed when these areas are analyzed separately. This section examines this matter.

The first is that technology policy needs to target industries that are collapsing or industries and fields where technology development is delayed due to

coronavirus. In addition to responding to positive changes, responses to areas experiencing negative trends should also be considered. It will be necessary to monitor and find alternatives for mass transportation industries such as aviation and buses, and oil and steel industries that supply raw materials to them.

Second, as technological innovation for solving social problems grows, the public procurement system must change accordingly. In social issues, there are more cases where there is no market than where there is a market, so the role of the market should be played in the public domain.

"In the past, if there was no market, the government did not invest. From now on, the state will be the consumer for the safety and interest of the people. Therefore, the public procurement system where the state can make purchases without a market will become important. In particular, technological innovation based on public demand will increase."

Third, if national tasks are emphasized, technologies that are socially important and can be ignored can emerge. Therefore, it is necessary to monitor this closely.

"Even though it is a vital technology socially, sometimes research does not respond to the issues. There will be a need for attention and monitoring for 'undone science' that cannot be performed systematically."

Fourth is the risk due to delays in changing the officials in charge of technology policy. If the technological approach to national tasks is emphasized and expanded, a big government is expected in the field of science and technology. Big government does not mean that the government does everything over the entire process of policy implementation, but this may happen. There may be a tendency for the government to take the initiative from planning to researcher selection and implementation. Therefore, it is necessary to limit this approach.

"After the pandemic, there was a change from small government to big government, and there was a lot of impact on the bureaucrats in science & technology governance, but I am concerned that it will have a negative effect."

IV. Analysis of keyword network in response

We extracted the main keywords in each response to FGI and looked at what patterns and trends were shown. Included in the appendix are 90 keywords commonly mentioned by many respondents.

Table 4 Key keywords in response

Keyword	Frequency	Keyword	Frequency
Technology	60	Industry	24
University	39	Change	24
Coronavirus	34	Money	22
Research	32	System	20
Government research institute	31		

When analyzing these keywords, the word technology was most often mentioned, 60 times, and university, coronavirus, research, government research institutes, etc., were mentioned over 30 times. The words mentioned over 20 times included industry, change, money, and system. However, since many words have similarities, it was challenging to find the overall emphasis only with individual words. Accordingly, keywords were reorganized by group, as shown in Table 4.

For the arrangement of keywords by group, VOSviewer Ver.1.6.15, a network visualization analysis tool, was used. This program is a technique based on an algorithm that finds correlations between keywords and binds highly related words. There are a total of seven groups derived from this process.

Table 5 Keywords by FGI group

Group	Keywords
Innovation	Technology, COVID-19, market, innovation, social, technological innovation, pattern, technology demand, Connectivity, apartment, de-urbanization
Socio-economic system	System, Change, University, Society, Preparation, Economics, Education, USA, Korea, Digital, Ability, Research, Lecture, Concept
R&D	Research, government-funded research institutes, money, government, technology policy, research institute, incentive, SARS, future, labor cost, budget, epidemic, problem-solving, equipment
R&D Direction	Direction, investment, PBS, R&D, assignment, field, problem-solving, system, research society, support, autonomy, convergence, portfolio, source technology
Changing direction	Method, Industry, Non-face-to-face, New, Labor, Online, World, 4th, Untact, School, Issue, Smart, Expert, Decision Making, Research Foundation, Offline, Professionalism, Data, Marketing, Distrust
Drug & vaccine	Virus, enterprise, development, vaccine, treatment, MERS, technology development
Social response	Role, Global, Social Issues, Policy, Science & Technology, Response, Pandemic, Coordination

The research team gave the name to each group. The locations of some words are strange, but most words are in their place, reflecting the contextual meaning during the interactive discussion. The most relevant set of words is Innovation. Words such as COVID-19, technology, and innovation are associated in this.

The next group with high relations was named the Socio-economic system, and words that refer to the overall social economy include system, change, university, society, and economics.

The third largest group was named R&D. This group includes words such as research, government-funded research institutes, money, government, technology policy, research institute, incentive, SARS, and budgets that respond to social demands such as infectious diseases.

The fourth largest group is R&D direction. These include direction, investment, PBS (project-based system), R&D, assignment, field, problem-solving, system, research society, support, autonomy, convergence, portfolio, and source technology.

The remaining groups were Changing direction, Drug & vaccine and Social response. These three groups have almost the same degree of connectedness. The Changing direction group means the direction of social change, and there are words such as untact, 4th (industrial revolution), and smart, which means the direction of change. The Drug & vaccine group has the strongest mention of therapeutics and vaccines. The Social response group contains keywords such as pandemic, coordination, response, and role.

V. Conclusion

The COVID-19 has changed dramatically our real life, and we expect it to continue. We must now prepare system transformation that responds to environmental changes in advance, including another virus to come.

The government is facing an urgent need to improve the COVID-19 screening system, alleviate people's anxiety, and develop therapeutics and vaccines to promote economic activity. The Ministry of Science and ICT (2020) announced a plan to raise national competitiveness to the next level by strengthening strategic support for the entire biofield such as infectious diseases, medical devices, bio big-data, and new drug development through response to the COVID-19. This plan is an additional one to the existing policy of the digital transformation of society. The COVID-19 accelerates the transformation.

This article identified changes that might take place after the COVID-19 through Focus Group Interview of ten industry-academia-research experts on the national innovation system and science & technology policy. Many answers to eight questions were summarized, and implications for the future were presented. Also, the FGI result was schematically analyzed by keywords and

clusters through VOSviewer, a network visualization program. As a result, the COVID-19 is a crisis and an opportunity to promote new technological innovation, so policy experts should utilize it as positive momentum for change by supporting R&D systems and technology policies that promote technological innovation.

Some comments of this article are included in the policy of the Ministry of Science and ICT (2020), but there are many differences in the details. The same points cover digital transformation. Digital transformation is an essential point in preparing for the post-coronavirus. There will be a need to strengthen digital infrastructure and policy to integrate and utilize innovative technologies that lead to artificial intelligence, big data, and cloud. The range of non-face-to-face services, such as online platform-based education and remote work, so-called 'untact' or 'ontect' culture, is expanding.

The predictions highlighted here are not only about R&D efforts, but also the systemic changes to meet the new challenges. Furthermore, the approach to science, technology and innovation needs to be changed: from government-led research to autonomous field research, from field-specific research to convergence research, and from technology-push research to problem-solving research.

References

Bloor M, Frankland J, Thomas M. and Robson K. (2001) Focus groups in social research. London: Sage Publications.

Cyr, J. (2015) The Pitfalls and Promise of Focus Groups as a Data Collection Method, Sociological Methods and Research, 45(2), pp. 231-259. https://doi.org/10.1177/0049124115570065

Freeman, C. (1987), Technology Policy and Economic Performance: Lessons from Japan, Pinter.

Gill, P., Stewart, K., Treasure, E. and Chadwick, B. (2008) Methods of data collection in qualitative research: Interviews and focus groups, British Dental Journal, 204(6), 291-295.

Greenwood, M., Kendrick, T., Davies, H., Gill, F.J. (2017) Hearing voices: Comparing two methods for analysis of focus group data, Applied Nursing Research, 35, 90-93.

Hyde, A., Howlett, E., Brady, D., Drennan, J. (2005) The focus group method: Insights from focus group interviews on sexual health with adolescents, Social Science and Medicine, 61(12), pp. 2588-2599. https://doi.org/10.1016/j.socscimed.2005.04.040

Krueger R.A. (1998) Moderating focus groups. London: Sage Publications.

Kruger, R.A. and Casey, M.A (2000) Focus Groups: A Practical Guide for Applied Research, 3rd ed., Thousand Oaks: Sage Publications.

Kwak, K.Y. (2014), Analysis in Social Network, ChungLam Publishing.

Laestadius, L.I., Penndorf, K.E., Seidl, M. and Cho, Y.I. (2019) Assessing the appeal of Instagram electronic cigarette refill liquid promotions and warnings among young adults: Mixed methods focus group study, Journal of Medical Internet Research, 21(11), e15441.

Lee, J.H. (2020), An Analysis of Issues of Development and Supply of Antibody Drug and Vaccine of the COVID-19, KHIDI Brief Vol. 308.

Lundvall, B. (1992), "National Innovation Systems: Towards a Theory of Innovation and Interactive Learning," Pinter.

Ministry of Science and ICT (2020), COVID-19 MIST policy, https://www.msit.go.kr/web/msipContents/contents.do?mId=NTI4

Moon, Y.H. and Seol, S.S. (2017), Evaluation of the theory on the 4th Industrial Revolution, Asian Journal of Innovation and Policy, 6-3, 245-261.

Morgan D.L. (1998), The Focus Group Guide Book. London: Sage Publications.

Nelson, R.R. (1993), National Innovation Systems: A Comparative Study, Oxford University.

Park. S.U. (2020), Super Computer Power Initiative for Infectious Disease Response, KISTEP Issue Paper 2020-04.

Rosenthal, M. (2016), Qualitative research methods: Why, when, and how to conduct interviews and focus groups in pharmacy research, Currents in Pharmacy Teaching and Learning, 8(4), pp. 509-516.

Seol, S.S. and Ko, C.R (2020 forthcoming), Lessons from Korean response to the COVID-19: missing factors of sectoral innovation system, Asian Journal of Innovation and Policy.

Stewart D W, Shamdasani P.M. (1990), Focus groups. Theory and practice. London: Sage Publications.
Yoon, S.M. (2018), Efficient Promotion Plan of Daejeon Science Festival, Daejeon Sejong Research Institute, Policy Research 2018-43.

Appendix Keywords and Frequencies of FGI

Keyword	Freq.	Keyword	Freq.	Keyword	Freq.	Keyword	Freq.
technology	60	market	11	budget	7	ability	5
University	39	vaccine	11	NRF	7	education	5
COVID-19	34	virus	11	future	7	revolution	4
research	32	MERS	11	problem solving	7	Epidemic	4
Government-funded research Institutes	31	Enterprise	11	labor	7	Autonomy	4
industry	24	global	11	economy	7	Decision	4
change	24	Untact	10	PBS	7	fusion	4
money	22	new	10	laboratory	6	Problem solving	4
system	20	Field	10	World	6	Technology demand	4
government	19	USA	10	Technology development	6	connectivity	4
system	19	R&D	10	science Technology	6	concept	4
direction	17	pattern	9	assignment	6	portfolio	3
role	16	remedy	9	school	5	Coordination	3
lecture	16	issue	9	Pandemic	5	Small business	3
invest	15	SARS	9	De-urbanization	5	professionalism	3
Face to face	15	Technology policy	9	System	5	Source technology	3
Social	14	Korea	8	support	5	offline	3
Technology innovation	14	Preparations	8	incentive	5	Research fund	3
4th	14	Apartment	8	Labor costs	5	Marketing	3
online	12	smart	8	Research group	5	digital	3
social	12	Response	8	Social issues	5	MOEF	3
Development	12	Policy	7	distrust	5		
innovation	11	expert	7	data	5		