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Article

Significance of discussing inter-Korean exchange and cooperation in science and technology: Why now?

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Abstract: North Korea has been isolated from the international community because of high-intensity sanctions. Nonetheless, research on North Korea should continue so that we are prepared not for contingencies that may occur because of sudden political changes in that country, as occurred after the unification of Germany and dissolution of the Soviet Union, and also to cope with future risks and threats wisely. This study conducted a quantitative survey regarding "inter-Korean cooperation in science and technology," targeting experts at the Korean government-funded research institutes. As a qualitative survey, focus group interviews (FGI) were conducted to gain insights into the possibilities, considerations, and procedures for inter-Korean cooperation in science and technology. This study is the first to conduct quantitative research on inter-Korean exchange and cooperation in science and technology and shows significant statistical results.

Keywords: north Korea; science and technology; exchange/cooperation; policy research

1. Introduction

North Korean leader Kim Jong-Un emphasizes the development of science and technology for a strong and prosperous country every year in the new year's editorial. He says, "Science and technology are the nation's most important strategic resources and the powerful driving force for social development (Rodong Sinmun, 2020)." Therefore, North Korea has implemented a policy that prioritizes science and technology. The country attaches immense significance to science and technology, emphasizing the duty of the State regarding science and technology in Articles 27, 50, and 51 of the Constitution (Song and Song, 2016). It announced the latest five-year national economic development plan at the 8th Congress of the Workers' Party of Korea held in January 2021, stating that science and technology are the force "that drives socialist construction and develops the national economy" (Ministry of Unification, 2021).

North Korea's policy of prioritizing science and technology is based on its interest in acquiring such technologies as necessary to improve the production capacity of such items, which the nations currently face an insufficiency. In other words, science and technology are the means to lift the nation's economy because the country has been isolated due to high-intensity sanctions from the international community. In this context, North Korea is significantly investing in science and technology, seeking to "turn all citizens into talented individuals in science and technology" and "integrate

science and technology with production," constantly emphasizing the significance of science and technology (Yoo and Kim, 2020).

The significance of inter-Korean cooperation might emerge in a rapidly changing state of affairs. Thus, examining experts' perceptions of North Korea in South Korean government-funded research institutes (KGRIs) will help improve the quality of future research projects and events on inter-Korean cooperation. Therefore, it is possible to identify which field of cooperation must be assigned greater significance in the future by systematically reviewing the perceptions toward inter-Korean cooperation in science and technology, which is expected to facilitate more effective cooperation. From a different perspective, we can identify the current status of inter-Korean exchange and cooperation, set the direction for improvement, and propose ways to promote strategic cooperation by deriving key elements to consider in inter-Korean exchange and cooperation and projects that must be prioritized.

2. Literature review

2.1. Trends in north Korea's science and technology and international cooperation

Since May 2022, the Yoon Suk Yeol Administration has been criticizing North Korea's missile and nuclear development, resulting in a tense relationship with its northern neighbor. However, South Korean experts who understand North Korea's science and technology must cultivate an awareness and attitude toward inter-Korean cooperation in science and technology. This research is necessary because it can be a significant clincher for peace on the Korean Peninsula and for preparing for possible rapid changes in North Korea's situation.

There is a dearth of reliable data on the current state of North Korea's science and technology. Nevertheless, previous studies and data suggest an increasing number of Science Citation Index (SCI)-level articles on international cooperation published by single authors (Noh et al., 2016). International non-governmental organizations (NGOs) and European institutions engaged in aid projects for North Korea in the context of the UN Sustainable Development Goals (SDGs) and the UN Framework Convention on Climate Change (UNFCCC) even in 2016, when economic sanctions against North Korea were intensifying (Song, 2023).

These organizations included the Research Institute of Organic Agriculture (FiBL), the Hanns Seidel Foundation (HSF), the International Federation of Organic Agriculture Movements (IFOAM), and the Swedish Red Cross. Notably, at that time, South Korea also continued to exchange and cooperate with North Korea in railway and forestry during the Moon Jae-in administration, despite the high-intensity sanctions against North Korea. In other words, there has been continuous cooperation on humanitarian and universal issues such as famine, ecology, and climate despite international sanctions against North Korea.

Given the passage of more than 80 years since Korea's division and the circumstances surrounding the two Koreas, there is no shortage of difficulties in inter-Korean cooperation and the arguments against it (Jang, 2021; Lee, 2023; Oh, 2021). As the variables of a new Trump administration grow, a strategic international

response that considers the foreseeable is needed.

Science and technology exchanges and cooperation between North and South Korea are considered important in understanding North Korea's defense technology and preparing for regime collapse. The need for international cooperation in science and technology is gradually increasing in the context of globalization (Jeong, 2000; Kwon, 2022; Oh and Ahn, 2009). In this situation, inter-Korean exchange and cooperation in science and technology can also be considered a significant topic.

2.2. Awareness of inter-Korean science and technology exchange and cooperation

Song et al. (2023) studied the attitudes toward North Korea's science and technology in the South Korean press. Although partisanship is not revealed as obviously as in the United States press, the South Korean media consistently exhibits a negative attitude in the context of North Korea's science and technology, even under different administrations. This bias is also evident in information sources. In this respect, examining the differences in human resources specializing in North Korea's science and technology may be significant. Byun (2018) argued that to increase the possibility of successful inter-Korean exchange and cooperation, the science and technology circles, the economic, educational, medical, and cultural circles, and private organizations must review exchange and cooperation in science and technology at their respective levels.

Shin et al. (2010) argued that a higher importance and level of science and technology may lead to a greater need for cooperation. Moreover, if technology has higher importance, there will be a stronger motivation to create a competitive advantage, and it will be more likely to promote cooperation. Few studies have investigated the importance of and performance in each field of inter-Korean exchange and cooperation in science and technology in establishing or optimizing cooperation plans. Thus, it is necessary to establish the primary data to seek active cooperation.

In terms of attitude, studies related to North Korea have thus far evaluated individual perceptions as a factor affecting the attitudes toward unification or related policies (Yoon, 2010). Similarly, perceptions toward inter-Korean exchange and cooperation in science and technology or incidental factors may affect attitudes toward cooperation. Attitudes also play a crucial role in inducing actual behavior. In other words, the attitude of science and technology experts toward cooperation is a crucial factor in actual future cooperation. Accordingly, it is necessary to identify the current attitudes.

2.3. Factors and areas to consider for inter-Korean science and technology cooperation

According to a survey by the Korea Institute for National Unification (Lee et al., 2020), South Korean society had a highly negative perception of North Korean security and regarded North Korea as dangerous or threatening. However, the study also revealed that South Korean citizens wanted exchange and cooperation with North Korea as much as they wanted military security against North Korea's nuclear weapons. Cooperation in science and technology for the prosperity of humanity

instead of anti-peaceful technology exchange or transfer might also be crucial. Thus, examining the fields and factors to consider in the context of inter-Korean exchange and cooperation in science and technology is significant.

Song (2018) argued that South Korea and North Korea can use exchange and cooperation in science and technology as a significant reconciliation tool. Inter-Korean cooperation in science and technology could facilitate the exchange of basic research on issues such as volcanoes, earthquakes, climate/environment, and ecosystem, which can be later reviewed regarding convergence research and technology commercialization at the global level (Song et al., 2018). Heo and Shim (2020) proposed six factors to consider for inter-Korean cooperation in natural science: 1) urgency of implementation; 2) connection to the Korean Peninsula (ecological community of the Korean Peninsula); 3) contribution to sustainable development (prosperity); 4) North Korea's acceptability; 5) foundation for implementation (cooperation conditions, budget); 6) project sustainability. Moreover, as the conditions for implementation may vary by project, it is necessary to identify these conditions and adopt systematic approaches such as examining the characteristics of each project, forming an inter-Korean consensus, and establishing a cooperative system.

This can be applied to natural science and science and technology in general. Therefore, identifying the implementation strategies and factors of cooperation in science and technology will significantly improve the directionality and strategically implement inter-Korean cooperation in science and technology.

3. Methodology

3.1. Overview

The survey items were designed as follows. First, we investigated the basic perceptions toward inter-Korean exchange and cooperation in science and technology, such as importance and attitude. Second, we developed questions determining the areas where cooperation is required in science and technology and the performance level of cooperation, as well as items inquiring about which factors should be considered in cooperation and which fields should be emphasized for each factor. Third, we defined the factors in five sub-domains for readiness in exchange and cooperation and designed items that can assess and measure these factors. Finally, we conducted focus group interviews (FGIs) as a qualitative survey that could not be contained in the survey results. We deduced implications on the procedures and possibilities for inter-Korean science and technology cooperation.

Respondents to the survey were all Unification Korea Association of Science and Technology (UKAST) members, which included field researchers and research managers mainly working on science and technology research and policy focusing on North Korea at KGRIs. Launched in 2016, UKAST currently has approximately 60 members and mainly analyzes North Korean science and technology research and trends, organizes academic events to share information and knowledge at home and abroad, and consults on and proposes North Korean policy to the South Korean government.

3.2. Design of survey

We ascertained the perspectives of experts of KGRIs regarding the need for inter-Korean exchange and cooperation by separating general exchange and cooperation from exchange and cooperation in science and technology. For general exchange and cooperation, we asked the respondents whether they thought cooperation and exchange with North Korea were necessary regardless of fields such as politics, economy, social culture, and technology, which was measured based on four items: "There is a need for political cooperation and exchange between South and North Korean governments"; "There is a need for economic cooperation and exchange between South and North Korean governments"; "There is a need for sociocultural cooperation and exchange between South and North Korean governments"; "There is a need for technical cooperation and exchange between South and North Korean governments."

The need for exchange and cooperation in science and technology determines the perceptions toward cooperation in science and technology, such as the extent to which experts think this cooperation is necessary. This was measured based on three items: "There is a need for cooperation and exchange between South and North Korean research institutions for the development of science and technology"; "There is a need for cooperation and exchange between South and North Korean governments for the development of science and technology"; "There is a need for inter-Korean cooperation in science and technology for the development of science and technology." The items were modified and supplemented to fit this study's topic and significance based on the items provided by Park (2020), and they were rated on a 5-point Likert scale ranging from "Strongly disagree" to "Strongly agree."

The attitude toward inter-Korean exchange and cooperation in science and technology refers to the perception of experts of KGRIs regarding technical cooperation with North Korea, and this attitude is an influential variable in predicting behavior. Accordingly, the cultivation of attitudes may be a factor that can affect cooperation in the future. For measurement, the scale of attitude toward unification proposed by Kim and Oh (1999) and later adopted by Yoon (2010) was utilized in this study after modifying it in the context of exchange and cooperation in science and technology to fit this study better. Specifically, we rated five items on a 5-point Likert scale: "Inter-Korean exchange and cooperation in science and technology must be promoted"; "Funds for inter-Korean cooperation in science and technology must be raised"; "Inter-Korean cooperation in science and technology must be conducted more actively"; "It is necessary to cooperate with and economically support North Korea for the development of science and technology"; "Inter-Korean exchange and cooperation in science and technology must be conducted actively in terms of firms and the private sector."

To provide the basic perceptions data for performing tasks for cooperation in science and technology, we identified the field experts of KGRIs who considered inter-Korean exchange and cooperation necessary (essential) and how much progress is made in each field. The need (importance) and performance data are used to identify the current status and position of inter-Korean exchange and cooperation in science and technology.

For measurement, we extracted 15 fields of science and technology based on the National Science and Technology Standard Classification by the National Research Foundation of Korea regarding the study selecting ten significant fields of science and technology based on research related to international cooperation in science and technology (Shin et al., 2010). Subsequently, we developed items suitable for the survey and had the respondents rate them on a 5-point Likert scale. The 15 fields of science and technology included "machinery, materials, chemical engineering, electricity/electronics, information and communications, energy/resources, nuclear energy, environment, construction/transport, life science, agriculture/forestry/fisheries/food, healthcare, mathematics/physics, chemistry, and earth science (earth/atmosphere/ocean/astronomy)."

The specific survey items included "I think inter-Korean cooperation and exchange are necessary (important) in the field of ○○" and "I think inter-Korean cooperation and exchange are going well in the field of ○○," which were asked for each of the 15 fields as mentioned above of science and technology.

To identify which factors are considered by the experts of KGRIs in the process of planning and selecting inter-Korean exchange and cooperation projects and to examine which fields of science and technology must be prioritized depending on the factors considered, we developed items asking about the factors to consider regarding cooperation, as well as the critical fields of science and technology for each factor. As discussed, we suggested six items (Heo and Shim, 2020) to identify the factors for inter-Korean cooperation in science and technology. The respondents were to rank the items from first to fourth. Moreover, to identify the fields in which cooperation is required considering the six factors mentioned above, we asked the experts which fields of projects they considered necessary among the 15 fields of science and technology considering each factor.

3.3. Data collection and statistical analysis

The data were collected over 15 days (14 to 30 September 2022) via an online survey of experts of 25 KGRIs under the supervision of the Korea Research Institute of Bioscience and Biotechnology. The valid responses of 58 respondents collected from the survey were used in the analysis. For statistical analysis, SPSS 26.0 was used to conduct descriptive statistics, reliability analysis, gap (difference) analysis, Importance–Performance Analysis (IPA), cross-tabulation analysis, priority analysis, correlation analysis, confirmatory factor analysis, and hierarchical regression analysis. Additionally, we conducted higher-order factor analysis with confirmatory factor analysis using AMOS 23.0 in the analysis process; however, the analysis did not converge because of the sample size issue.

3.4. Focus group interview

Suppose North Korea reforms and fully opens up through preemptive nuclear abandonment and improvement in U.S.-North Korea relations. In that case, a large amount of foreign capital and workforce is expected to be injected into the country. To achieve the goal of activating private investment and business in North Korea, South Korean society needs to understand the needs of its customers. Collecting

information and views on investment and business from South Korean experts is significant since this activity identifies business demand. We thus conducted focus group interviews with experts in the various fields of science and technology and the financial structure for this cooperation.

In previous studies, the qualitative interview method is considered a linguistic act described within a particular social and political context (Schwandt, 1997) and a research strategy used to understand the attitudes and behaviors of acceptors. Focus group interviews (FGIs) involve the researcher collecting information face-to-face with multiple interviewees. As the interview process allows interactions between interviewees and interviewers, the researcher can come closer to a well-founded and transparent model of the subjects and topic under study while iterating the entire process of information gathering, interview analysis, and sometimes selection and validation several times (Herbert and Riene, 1995).

The focus group interviews were conducted online for 120 minutes on 1 July 2024, with the survey results and questions sent to interviewees via email in advance on 28 June 2024. The FGIs were conducted with two researchers from KGRIs and two experts in international development cooperation. They all have doctoral degrees and more than 15 years of experience in the field. However, most of the experts made it clear that their views were highly subjective, and they did not speak on behalf of the Korean government or the institution, therefore not representing the official position of the government or the institution.

The following questions were sent to the FGI participants in advance: First, what are your opinions on the survey results? Second, what are the possibilities for inter-Korean cooperation in science and technology under the current circumstances? Third, what are the considerations, possible areas, and procedures for inter-Korean cooperation in science and technology? These questions are expected to enrich the survey results and provide insights into the procedure and content of inter-Korean cooperation in science and technology.

4. Results of the survey

4.1. Basic/descriptive statistics

We surveyed the experts of KGRIs regarding their thoughts about the readiness of inter-Korean exchange and cooperation in science and technology, the need for cooperation, fields requiring cooperation, and considerations for cooperation. The survey was conducted with a self-administered questionnaire using an online survey platform for 15 days (14 to 30 September 2022), based on which we collected valid samples from 58 respondents.

The demographic characteristics of the respondents are as follows. There were 43 men (74.1%) and 15 women (25.8%). Their ages were evenly distributed from the 20s through the 60s, with most in their 40s (31.0%, $n = 18$) and least in their 50s (10.3%, $n = 10$). The total sample that participated in this survey was 58, which is insignificant in traditional statistics. However, considering that the total sample studying North Korean science and technology at KGRIs is about 65 researchers, this can be considered a significant level.

Additionally, we asked the respondents how long they had been working in

science and technology, and the responses ranged from less than one year to 30 years or more. 22.4% (n = 13) claimed to have worked for 10 to less than 15 years, and 17.2% (n = 10) each for 5 to less than 10 years and 40 years or more.

A fundamental analysis was conducted on the critical variables included in the survey, and the results are presented in **Table 1**. The mean of the need for inter-Korean exchange and cooperation was 4.18 (SD = 0.94), which was extremely high, and Cronbach's α coefficient was also high at 0.93. The mean of the need for inter-Korean exchange and cooperation in science and technology was 3.95 (SD = 0.099), close to 4 and thus high; the reliability was also high at 0.96. The mean of the attitude toward inter-Korean exchange and cooperation in science and technology was 3.98, and Cronbach's α was 0.95.

Table 1. Mean, standard deviation, and reliability of the key variables.

Variable	Sub-variable		No. of items	Mean (*M*)	Standard deviation (*SD*)	Reliability (Cronbach's *α*)
Need for inter-Korean exchange and cooperation			4	4.18	0.94	0.93
Need for inter-Korean exchange and cooperation in science and technology			3	3.95	0.99	0.96
Readiness	Political conditions and environment		3	2.97	0.89	0.78
	Accumulation of experience and understanding[1]	Experience	2	5.84	10.27	-
		Knowledge	6	1.98	1.67	-
	Institution-level expertise		5	3.57	0.70	0.75
	Legal/institutional arrangement strategy		4	2.59	0.54	0.77
	Internal competency		4	2.30	0.98	0.94
Attitude toward inter-Korean exchange and cooperation in science and technology			5	3.98	0.94	0.95

[1] Among sub-variables of readiness, "accumulation of experience and understanding" was statistically processed with the sum instead of the mean of each item.

4.2. Difference between groups regarding the perceptions toward the need for inter-Korean cooperation

Table 2. Mean difference between perceptions toward the need for inter-Korean exchange and cooperation and those toward the need for inter-Korean exchange and cooperation in science and technology.

Variable	Descriptive Statistics			*t* (*p*)
	N	*M*	*SD*	
Need for inter-Korean exchange and cooperation	58	4.18	0.94	2.55 (0.014) [1]
Need for inter-Korean exchange and cooperation in science and technology	58	3.95	0.99	

[1] $p < 0.05$.

We conducted a paired t-test to examine the difference in perceptions toward the need for general inter-Korean exchange and cooperation and the need for inter-Korean exchange and cooperation in science and technology; the results are provided in **Table 2**. The perceptions of experts of KGRIs toward the need for general inter-Korean exchange and cooperation scored 4.18 out of 5, while the need for cooperation in science and technology scored 3.95. Testing the difference between these two types of perceptions revealed a statistically significant difference with $t = 2.55$ ($p < 0.05$). In

other words, experts seemed to think that general inter-Korean exchange and cooperation were more critical than exchange and cooperation in science and technology.

We conducted a one-way ANOVA to analyze whether there was a difference in perceptions toward the need for inter-Korean exchange and cooperation depending on the job of the experts working in KGRIs; the results are provided in **Table 3**. The results showed that, regarding the need for general inter-Korean exchange and cooperation, the F value was 2.38, and the significance level was 0.080, more significant than 0.05. This indicates that the mean difference between groups was not statistically significant. In other words, there was no difference in perceptions toward the need for inter-Korean exchange and cooperation depending on the job.

Table 3. Mean difference in perceptions toward the need for inter-Korean exchange and cooperation depending on the job.

Variable	Group / Position	*N*	*M*	*SD*	F(*p*)
Need for inter-Korean exchange and cooperation	R&D	35	4.08	1.03	2.38 (0.080)
	Policy research	13	4.52	0.45	
	Research administration	4	3.31	1.21	
	Business management	6	4.58	0.56	
Need for inter-Korean exchange and cooperation in science and technology	R&D	35	3.84	1.02	3.16 (0.032) [1]
	Policy research	13	4.41	0.49	
	Research administration	4	2.92	1.42	
	Business management	6	4.33	0.76	

[1] $p < 0.05$.

The demographic characteristics of the respondents are as follows. There were 43 men (74.1%) and 15 women (25.8%). Their ages were evenly distributed from the 20s through the 60s, with most in their 40s (31.0%, n = 18) and least in their 50s (10.3%, n = 10). Although the sample size of 58 is reasonably small, it can be considered significant because of its specificity, as it represents the entire sample of researchers studying North Korea's science and technology in KGRIs and the public sector. Experts from 17 out of 25 KGRIs participated in the survey; most of them were working at the Korea Research Institute of Bioscience and Biotechnology (n = 10, 17.2%), followed by the Korea Astronomy and Space Science Institute (n = 9, 15.5%) and Korea Institute of Energy Research (n = 6, 10.3%).

Regarding the need for inter-Korean exchange and cooperation in science and technology, the significance level for (F = 3.16) was 0.032, below 0.05, indicating a difference in perceptions depending on the job. Specifically, the policy research group showed the highest perception toward the need for inter-Korean exchange and cooperation in science and technology (M = 4.41), followed by the business management group (M = 4.33). Moreover, the mean of perceptions for the R&D group was 3.84, and that of the research administration group was 2.92, showing the lowest perception level.

4.3. Priorities and IPA of inter-Korean exchange and cooperation in science and technology by field of technology

We statistically analyzed the importance (necessity) of inter-Korean cooperation in each field of science and technology and the perceptions toward the need for cooperation in science and technology overall to set the priorities in inter-Korean cooperation in science and technology for the 15 fields of science and technology in the National Science and Technology Standard Classification. First, we extracted the correlation coefficient between the need for inter-Korean cooperation in science and technology and the necessity of cooperation in each field, calculated the mean of importance (necessity) for each field, and set the priorities based on the sum of these two results.

The correlation coefficient shows the correlation between two variables; higher values indicate a stronger connection. Accordingly, we attempted to resolve the difficulty in identifying explicit priorities due to response bias when setting the priorities based on the mean alone. The results showed that the field of energy/resources was ranked first with the highest correlation coefficient + mean of 4.97, followed by healthcare, ranked second with a correlation coefficient of 0.63 and mean of 4.07, which added up to 4.70. Environment was ranked third with 4.66 (r = 0.61, M = 4.05). Conversely, nuclear energy was ranked 15th with a mean of 3.34 and a correlation coefficient of 0.06, up to 3.40, the lowest. Mathematics/physics was ranked 14th (correlation coefficient + mean = 4.11) and machinery 13th (correlation coefficient + mean = 4.19). The specific priorities for other fields are as shown in **Table 4**.

Table 4. Priorities in inter-Korean cooperation in science and technology.

Field	Correlation [1]	Mean	Correlation + mean	Priority
Machinery	0.62	3.57	4.19	13th
Materials	0.59	3.72	4.31	10th
Chemical engineering	0.67	3.67	4.34	9th
Electricity/electronics	0.65	3.66	4.31	11th
Information and communication	0.70	3.71	4.41	8th
Energy/resources	**0.66**	**4.31**	**4.97**	**1st**
Nuclear energy	0.06	3.34	3.40	15th
Environment	**0.61**	**4.05**	**4.66**	**3rd**
Construction/transport	0.58	4.05	4.63	4th
Life science	0.62	3.81	4.43	7th
Agriculture/forestry/fisheries/food	0.57	3.97	4.54	5th
Healthcare	**0.63**	**4.07**	**4.70**	**2nd**
Mathematics/physics	0.51	3.60	4.11	14th
Chemistry	0.61	3.62	4.23	12th
Earth science (earth/atmosphere/ocean/astronomy)	0.55	3.90	4.45	6th

[1] The importance was repeatedly confirmed through the correlation with the variable "need for inter-Korean cooperation in science and technology".

We conducted the IPA to determine the progress of inter-Korean cooperation in science and technology in each field and its importance; the results are shown in **Figure 1** and **Table 5**. The IPA is a method to establish future implementation strategies by placing each factor in Quadrant 4 based on its importance (necessity) and

performance and dividing it into quadrants based on the means of all factors.

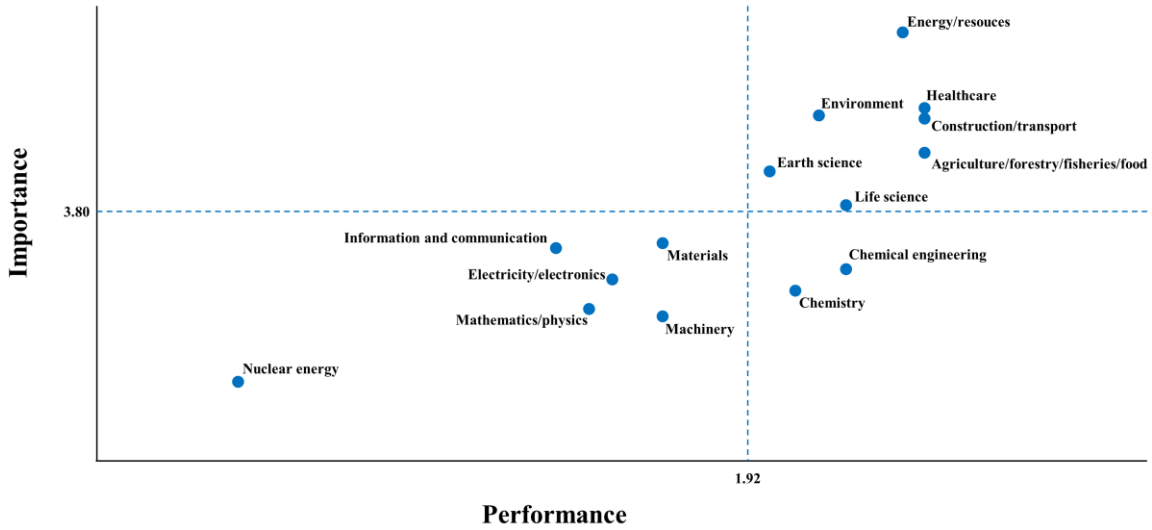

Figure 1. IPA of inter-Korean exchange and cooperation in science and technology.

Table 5. Summary of IPA results for inter-Korean exchange and cooperation in science and technology.

Section	Item
Maintenance/reinforcement	Energy/resources, healthcare, environment, construction/transport, agriculture/forestry/fisheries/food, earth science, life science
Concentrated effort	-
Inferiority ranking	Nuclear energy, mathematics/physics, machinery, electricity/electronics, information and communications, materials
Excessive avoidance	Chemistry, chemical engineering

The analysis results showed that the distribution was primarily concentrated in Quadrant 1. Quadrant 1 is the maintenance/reinforcement section, and the fields in this section are perceived as essential and currently under active cooperation. The typical fields of science and technology in this section are energy/resources, healthcare, environment, and construction/transport. This section can have a relative advantage over others and thus requires intensive development and active cooperation.

No fields in the concentrated effort section (Quadrant 2) and nuclear energy, mathematics/physics, machinery, and electricity/electronics were located in the inferiority ranking section (Quadrant 3); however, this section was not perceived as necessary and lacked implementation. Chemistry and chemical engineering were in the excessive avoidance section (Quadrant 4). Although this section is rated low in importance, it is under active cooperation. Additionally, we provided fields that must be targeted first based on the gap between performance and importance. Energy/environment was ranked first, followed by environment (second) and healthcare (third).

4.4. Factors to consider in inter-Korean exchange and cooperation in science and technology and the key business sectors for each factor of consideration

We used six items based on previous studies to identify the factors to be considered first in inter-Korean exchange and cooperation in science and technology. Based on the ranking of responses, each item was rated on a scale of 1 (Not selected) to 5 (Selected first) to calculate the score for each. The means of the factors were derived based on the results, and the factors perceived as most important were determined through repeated measures ANOVA (RM ANOVA), as shown in **Table 6**.

The results of the analysis are as follows. As a result of Mauchly's test of sphericity, the significance level for ($W = 0.70$) was 0.138, which met the criterion of $p > 0.05$, assuming that there was sphericity and enabling comparison of the factors. As a result of examining whether the mean difference was statistically significance by deriving the F value, the significance level for ($F = 5.79$) was 0.000, indicating that the mean difference between factors was significant. North Korea's acceptability showed the highest mean at 3.40 (SD = 1.44), followed by sustainable development (prosperity) at 3.16 (SD = 1.53). The factors of consideration that showed low means were urgency of implementation ($M = 2.17$, SD = 1.39) and foundation for implementation ($M = 2.29$, SD = 1.15).

Table 6. Comparing the means of factors to consider for inter-Korean exchange and cooperation in science and technology.

Variable	Descriptive statistics			Mauchly's W(p)	F(p)
	N	M	SD		
Urgency of implementation	58	2.17	1.39	0.70 (0.138)	5.79 (0.000)[1]
Connection to the Korean Peninsula	58	2.52	1.35		
Sustainable development (prosperity)	58	3.16	1.53		
North Korea's acceptability	58	3.40	1.44		
Foundation for implementation (cooperation conditions, budget)	58	2.29	1.51		
Project sustainability	58	2.43	1.38		

[1] $p < 0.001$.

To identify which of the 15 fields of science and technology were perceived as necessary when considering six variables of inter-Korean cooperation in science and technology, we conducted a cross-tabulation analysis, including factors of consideration and the fields of science and technology. We applied the multiple response analysis instead of individually analyzing the factors of consideration ranked up to third. The results showed that the field of science and technology perceived as most important in all six variables was energy/resources. The cross-tabulation analysis showed that the frequency of energy/resources was highest in all factors considered compared to other fields, especially in North Korea's acceptability at $n = 30$ (17.20%).

The fields ranked as second-most important in cooperation are as follows. First, healthcare (14.40%, $n = 25$) was the second-highest after energy/resources when considering the urgency of implementation. In comparison, construction/transport

(13.80%, $n = 24$) was considered significant when considering the connection to the Korean Peninsula. Environment (16.10%, $n = 28$) was perceived as the second-most important for sustainable development. At the same time, agriculture, forestry, fisheries, and food were chosen as the second most important factors when considering North Korea's acceptability, foundation for implementation, and project sustainability ($n = 27, 25, 24$). In terms of overall frequency, energy/resources were perceived as most important ($n = 173$, 16.60%), followed by agriculture/forestry/fisheries/food ($n = 129$, 12.40%) and construction/transport ($n = 122$, 11.70%). Conversely, chemistry showed the lowest frequency ($n = 5$, 0.50%), and mathematics/physics also showed low frequency ($n = 15$, 1.40%).

5. Focus group interview results

North Korea intends to focus on its scientific and technological capabilities and use science and technology as the cornerstone of its economic development every year in its New Year's address. Since 2016, the National Research Council of Science & Technology (NST) has formed the UKAST and prepared systematically for the demand to facilitate exchange and cooperation initiatives with North Korea in various sectors, including railway, electric power, energy, ICT, astronomy, standards, biological resources, mineral resources, traditional medicine, agriculture and food, and healthcare with the Korean Government-Funded Research Institutes (KGRIs) at the center. An expert from UKAST stated, "Due to the stringent sanctions on North Korea, UKAST is currently advocating for the establishment of a joint inter-Korean scientific research base on Mountain Baektu, with a focus on basic science, to be included in the national agenda of the National Assembly and KGRIs."

Experts suggested that the rapidly evolving situation in North Korea requires careful observation, allowing both Koreas to leverage scientific and technological exchanges and cooperation as critical instruments for reconciliation. They proposed that the government consider a step-by-step approach through an initial effort of basic research, then interdisciplinary research, through technology that improves daily life, and finally, the gradual commercialization of innovations. They speculated that future cooperation could involve integrating South Korean capital and technology with North Korean labor and resources, gradually incorporating technology-based small and medium-sized enterprises (SMEs).

For specific technological cooperation, chemical technology, and ICT were highlighted as primary areas contingent upon removing sanctions. It was emphasized that North Korea's expertise lies more in coal chemical technology than in petrochemical technology, and communication infrastructure projects are expected to be highlighted to draw private investment when North Korea's reform and opening efforts materialize.

Under stringent international sanctions, bilateral and multilateral financial investments in North Korea are complex. However, preparations should be considered for future opportunities. Experts pointed out that long-term, low-cost, and no-cost financing options are available to the poorest and least developed countries through multilateral development banks (MDBs) such as the World Bank (WB) and the Asian Development Bank (ADB) by citing examples of previous transitioning countries such

as Vietnam, Mongolia, and China. However, they stressed that for North Korea to obtain assistance from MDBs, it would need to become a member of the IMF and gain approval from individual organizations, a process expected to require at least two to three years. Integration into the international financial system is essential for undertaking public infrastructure projects. The UN agency also highlighted that project aimed at humanitarian purposes and in line with the Sustainable Development Goals (SDGs), such as food security, rural development, and social and economic development, are expected to be carried out. Therefore, it is crucial to design projects that align with these development goals when considering future private investment in North Korea.

It was also described that during the current period of stringent economic sanctions on North Korea, private investments and public projects are challenging to realize due to uncertainties created by external factors such as geopolitical shifts and the limited institutional capacity within North Korea. Thus, regarding cooperation from the Korean government, it is considered realistic to incrementally broaden the cooperation scope through academic exchanges in fields such as pure science and climate adaptation, which take non-political avenues, irrespective of international sanctions. Finally, it was underscored that careful attention should be given to the types of appropriate funding sources and acceptance procedures at each phase of development cooperation projects. Furthermore, several avenues are available to promote development projects, including infrastructure, bilateral aid, combined bilateral and multilateral aid, and private investment. Therefore, it is essential to thoroughly examine the aid promotion system in preparation for the full-scale implementation of assistance to North Korea.

6. Discussion

For the Western society, North Korea is a country shrouded in mystery. Since detonating a hydrogen bomb in 2016, this country has been under high-intensity sanctions imposed by the international community. In a dynamic global political situation, the South Korean government's stance toward North Korea has changed from that of the Moon Jae-in administration, which emphasized reconciliation and peace as significant government projects, to that of the Yoon Suk Yeol administration, which focuses on national security and the Republic of Korea–US alliance.

In recent times, relations between North and South Korea have grown increasingly tense due to repeated warnings from U.S. intelligence and military officials about the potential for North Korea to conduct a nuclear test or to test-launch an intercontinental ballistic missile (ICBM). North Korea is likely to continue or even increase provocative steps, officials and analysts say, after it made strides in ballistic missile development, bolstered cooperation with Russia, and scrapped its decades-long goal of peacefully reuniting with South Korea (Smith, 2024). Now is the time to examine the situation on the Korean Peninsula within the framework of the Indo-Pacific security strategy. North Korea, which had already been isolated because of high-intensity international sanctions, has been struggling economically even more after the COVID-19 pandemic. After the failed attempts to reach an agreement at the Singapore Summit, hardline conservatives in the West have often remarked that the

Kim Jong-Un regime is hanging by a thread. Furthermore, regime change in South Korea has further ratcheted up the tension between North Korea and South Korea.

Discussing inter-Korean exchange and cooperation in science and technology is challenging. Nonetheless, we must continue our research on North Korea because we have experienced the unification of Germany and the dissolution of the Soviet Union. Additionally, knowing about oneself and one's enemy is essential to cope with risks and threats wisely. This study derived the survey results from 58 experts and officials working at KGRIs in South Korea. The survey can be considered comprehensive, as 65 researchers are currently in charge of North Korea at KGRIs.

The implications of this study are as follows. First, experts on North Korean relations in KGRIs were cautious, claiming that discussing science and technology within the general inter-Korean exchange and cooperation is necessary. Second, cooperation with North Korea in science and technology scored the highest in energy/resources, followed by healthcare, environment, and construction/transport. This is due to the expert insight that considers North Korea's demands and situations, such as its national circumstances as one of the least developed countries, health concerns such as COVID-19, and climate change. Third, as a result of analyzing the importance and performance of exchange and cooperation with North Korea, fields such as nuclear energy, mathematics/physics, and machinery, which are considered North Korea's strengths, turned out to be in the inferiority ranking section. Fields such as chemistry and chemical engineering were in the excessive avoidance section. This may be due to South Korean experts' views on North Korean nuclear weapons, North Korea's security technology, and the development of coal chemistry. Fourth, the elements to consider in inter-Korean exchange and cooperation in science and technology included North Korea's acceptability and sustainable development, scoring higher than urgency or foundation. In other words, this may reflect the awareness that cooperation with North Korea is necessary in line with North Korea's active demand and the SDGs as an international agreement.

Under the current state of international sanctions, it has become a fact that development projects in North Korea are not feasible. However, countermeasures are necessary in terms of preparing for a rapid regime change in Kim Jong-un's North Korea and keeping a close eye on the 2024 U.S. presidential election. Although hypothetical, the new phase may enable NGO emergency relief cooperation for oppressed North Koreans, and academic exchanges in fields such as pure science and climate adaptation can be considered. Despite numerous assumptions, it is imperative that the priority of inter-Korean cooperation in science and technology is to build trust with North Korea through exchanges in pure science and climate fields. Only then is it considered that a proper cooperation strategy such as networking and information sharing to promote private (investment) business as an alternative option may be devised in preparation for national and social infrastructure or profit-based private participation. Through the expert FGIs, the following procedures and items related to inter-Korean science and technology cooperation (when the situation changes) were derived, as shown in **Figure 2**.

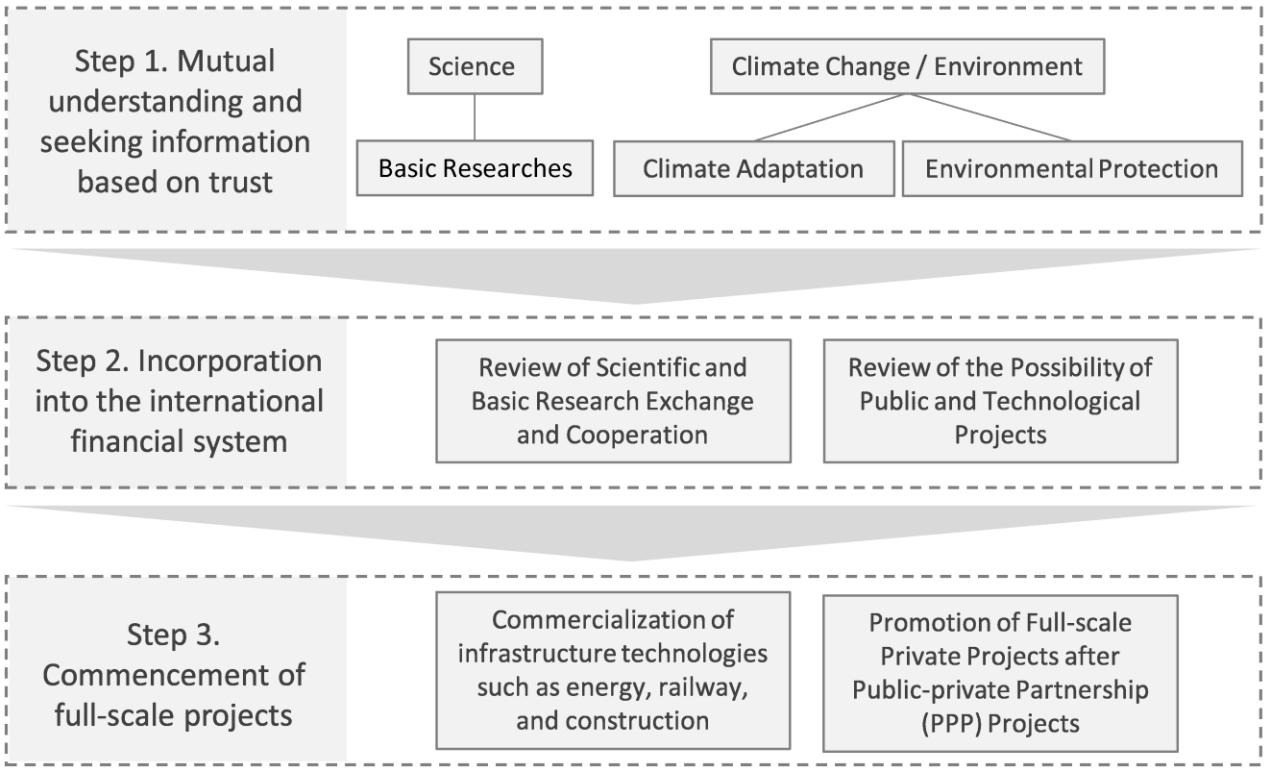

Figure 2. Procedures and items related to inter-Korean science and technology cooperation (when the situation changes).

7. Conclusions

This study has statistical limitations as it was conducted on South Korean experts in North Korea and involved only 58 respondents. Nonetheless, this study is the first to conduct quantitative research on inter-Korean exchange and cooperation in science and technology and shows significant statistical results. In addition, this study also conducted focus group interviews with experts to complement the qualitative research and discuss the areas of cooperation, processes, and financial arrangements for inter-Korean science and technology cooperation. Based on the results of this study, further research can investigate and analyze inter-Korean exchange and cooperation projects in science and technology conducted by KGRIs, through which it will be possible to identify the difference between expert perceptions and actual projects.

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