Big data and Network Analysis in National Innovation Systems: The Roles of Academia, Industry, and Government Research Institutes and their Interactions

Eun Sun Kim[1], Yunjeong Choi[2], Jeongeun Byun[2[0000-0002-2563-4443]*]

[1] Division of Data Analysis, Korea Institute of Science and Technology Information (KISTI), South Korea
[2] Division of Data Analysis, Technology Commercialization Research Center, Korea Institute of Science and Technology Information (KISTI), South Korea
jebyun@kisti.re.kr

Abstract. This study examines the changes that have been made to KNIS since the 2000s, when Korea entered the group of developed countries. Using data on joint research, this study systematically analyzes the interactions among actors representing academia, industry, and government research institutes, and the innovative performance achieved through these interactions. This study argues that the while interactions through joint research generate innovative performance, such interactions have not been occurring as strongly as would be desired, and this has limited the potential for the growth of innovative performance. While reinforcing the capabilities of individual actors is important, this study emphasizes that to build a more effective and systematic NIS, the government should establish policies designed to strengthen the interaction among actors.

Keywords: National innovation systems, Big data, Network analysis, National R&D project, Interactions.

1 Introduction

South Korea achieved the quantitative growth of its economy with a national innovation system (NIS) characterized by strong government influence of research and development (R&D) investments, imitative R&D led by government-supported research institutes (GRIs), and the dominance of large firms in utilizing and disseminating the outcomes of R&D. In the 1990s, however, intensified competition through globalization and the emergence of latecomer developing countries such as China and India made it difficult for South Korea to continue to generate innovative performance through imitative R&D. In response to these changes, in the 2000s South Korea redefined its NIS as a system that facilitates the creation, exchange and diffusion of knowledge among academia, industry, and government research institutes and undertook to build a new NIS.

The South Korean national innovation systems (KNIS) had once been considered one of the most successful examples of a NIS in a developing country, but there have

been few studies on how the KNIS changed after Korea joined the ranks of the developed countries, and on whether this new KNIS has indeed resulted in innovative performance. This study is a systematic analysis of data on joint research, and examines the interactions among main actors that constitute the KNIS since the 2000s, and the innovative performance that resulted from these interactions.

2 Data and Analytical Method

This study aims to analyze the changes in the KNIS that have taken place since the 2000s by examining the national R&D projects. The dataset of national R&D projects was extracted from the National Science and Technology Information Service (NTIS) which includes information about 540,000 national R&D projects, such as government investment in R&D, joint research projects, and innovative performance.

First, the data of national R&D projects since the 2000s was collected in the NTIS. As the data of joint research projects was only gathered beginning in 2012, the data of 222,812 national R&D projects and 31,762 joint research projects were adopted from 2012 up to the latest available data period, which covered up to June 2017. Next, the data was classified by year and by the main actors that performed the projects. The programming language R, a software environment for statistical computing, was used in the data preprocessing and analysis. Based on the collected data, we examined the joint research network to understand how the main actors in the KNIS create, exchange and diffuse knowledge as they carry out projects. Before analyzing the joint research network, the hypothesis with regard to whether the joint research projects had an effect on innovative performance in the KNIS needed to be validified. It should be noted that we used information on the national R&D performance to analyze the innovative performance achieved by joint research. This is because the NTIS does not separately collect information on the performance of the joint research. Therefore, we hypothesized that the performance of joint research will be correlated to differences in the national R&D performance assessed in terms of the number of papers published, the number of patent applications and grants, technology transfers, royalty income from the technology transfers, the number of commercialized projects, and sales form the commercialized projects. We then performed Levene's homogeneity of variance test and validated the hypothesis with Welch's t-test using R software [1]. Next, we utilized NodeXL, an Excel template provided by Microsoft, to perform social network analysis (SNA) and modularity analysis on the actors that conducted joint research projects.

3 Results

3.1 Innovative Performance in the KNIS

According to the results of the hypothesis tests, the performance of joint research has an effect on innovative performance in the KNIS. In detail, national R&D projects that conducted joint research achieved 0.75 more papers published and 1.16 more cases of

patent applications or registrations, on average. The number of technology transfers was analyzed to be statistically significant, and royalty income from the transfers in national R&D projects that conducted joint research was on average 7.5 million won more. Particularly commercialization, joint research results in more outcomes. The national R&D projects that engaged in joint research were accomplished 0.35 more cases of commercialization, while the sales from the commercialized projects were recorded to be approximately 500 million won higher on average. Since the premise that joint research affects innovative performance in the KNIS has been validated, the joint research network is examined to understand how the main actors in the KNIS interact with each other and create, exchange and diffuse knowledge as they carry out joint research projects.

3.2 Characteristics of the Joint Research Network

To understand the joint research network, SNA was used on a total of 31,762 cases of joint research projects conducted from 2012 to June 2017. Figure 1 is a visual presentation of our analysis the structure of the joint research network. In this diagram, cases with a degree of 2 or less have been omitted, while nodes that have high degree centrality with 10 or more links are shown more prominently. The joint research network consists of 16,760 individual actors and 23,017 relations between actors that proposed the joint research and those that received the proposal.

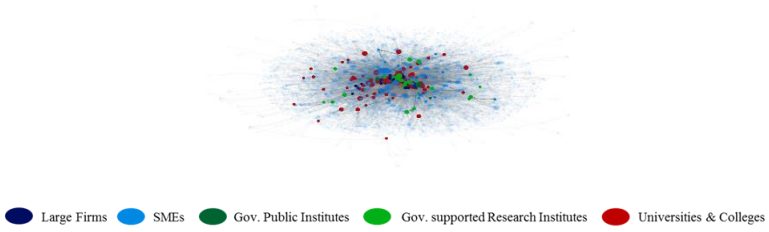

Fig. 1. The joint research network

Table 1. The mean centrality of the top two groups

Community		Nodes	Avg. In-degree (A)	Avg. Out-degree (B)	Avg. Betweenness	Avg. Closeness	(A)/node	(B)/node
Group1	Large firms	73	4.70	5.12	0.0001	0.10	0.06	0.07
	SMEs	906	1.33	1.09	0.0000	0.06	0.00	0.00
	Univ.&colleges	82	15.18	11.10	0.0003	0.11	0.19	0.14
	Public institutes	11	2.91	0.09	0.0000	0.11	0.26	0.01

	GRIs	10	21.73	52.27	0.0015	0.11	2.17	5.22
Group2	Large firms	6	1.50	1.17	0.0000	0.10	0.25	0.20
	SMEs	576	0.80	1.14	0.0000	0.05	0.00	0.00
	Univ.&colleges	42	16.86	10.67	0.0004	0.11	0.40	0.25
	Public institutes	11	2.36	0.55	0.0000	0.10	0.21	0.05
	GRIs	6	19.83	23.50	0.0005	0.08	3.31	3.92

We performed modularity analysis to understand the community structure of the joint research network. The results showed that a total of 957 communities had formed in the joint research network. Table 1 lists the top two groups that comprised the largest share of the joint research network. In all groups, it was analyzed that government-supported research institutes ranked highest in both in-degree and out-degree centrality but other indices such as betweenness centrality had slightly varying structural characteristics. Therefore, we proceeded to more closely examine government-supported research institutes, which ranked high in centrality, based on the nodes that determine each group's connectivity.

4 Conclusion

Upon systematically analyzing the KNIS, we found that actors' interactions do result in improving performance, but these interactions have not been as active as would be necessary to remove the impediments that are hindering stronger performance. Based on the analysis of this study, we offer the following policy recommendations. First, policymakers must encourage more national R&D projects to undertake joint research. Second, in addition to policies encouraging joint research projects, there must be policies designed to facilitate interactions. To promote interactions, the government not only should increase funding for SMEs, but also should induce such firms to engage in exchanges with a wider variety of actors. Finally, to promote balanced growth, rather than reducing the role of GRIs, the government should instead focus on encouraging them to participate in more joint research to expand their exchanges with other actors.

Acknowledge

This research was supported by Korea Institute of Science and Technology Information (K-23-L03-C03-S01).

References

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