Pro-Metrics

An analysis of cooperation networks related to research projects between universities in the Chungcheong region in Korea: Suggestions for strengthening university networks

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ABSTRACT

Objective. This study aims to obtain information regarding how 54 universities in the Chungcheong region of Korea are conducting joint research. More specifically, the study seeks to understand the network characteristics and main patterns according to which universities in the Chungcheong region are conducting joint research and to obtain the information necessary to utilize the network structure between universities as a strategy for future regional development.

Design/Methodology/Approach. For this purpose, we investigated the number of joint research projects conducted among these 54 universities in 2022, obtaining the most up-to-date information possible. Network analysis was performed based on the surveyed data.

Results/Discussion. The research results show that five clusters exist in the Chungcheong area. The universities that play a central role include KAIST, Chungnam National University, Chungbuk National University, Kongju University, and Korea National University of Transportation.

Conclusions. Because these universities constitute important bases in the region and have close links with neighbouring universities, they are expected to play an important role in future regional development.

Originality/Value. One of the academic implications of this study is that it applied social network analysis methods to research-related partnerships between universities in the Chungcheong region to identify universities that play an important key role.

Keywords: Inter-university cooperation network; joint research; Chungcheong region, network analysis method.

INTRODUCTION

MANY recent studies point out that collaborative networks among regional universities are particularly important in terms of regional innovation (Appio *et al.,* 2019; Bejinaru *et al.,* 2023; Bejinaru *et al.,* 2018; Cai *et al.,* 2020; Clarysse *et al.,* 2014). Through sharing, universities can use knowledge and technology to produce innovative ideas and products. Universities produce and possess cutting-edge technology and knowledge, and if they work together to share knowledge and technology, they can help local companies develop innovative products and services. This will revitalize the local economy and promote growth.

In addition, universities play an important role in regional development by nurturing talent. When universities in the region work together to develop and expand education and research programmes, the nurturing of local talent will be strengthened, and local companies will be able to secure more capable workers. However, above all, the reason why cooperation networks between regional universities are important is that they help form industrial clusters in the region (Graça *et al.,* 2017; Cepeda-Carrion *et al.,* 2012; Scaringella and Radziwon, 2018; Piscicelli, 2023; Kolomytseva and Pavlovska, 2020). These clusters are important in bringing together companies in similar industries to promote innovation and improve competitiveness. Furthermore, universities possess research resources and facilities, and by sharing these resources with local businesses, they can realize research and development projects, thereby promoting innovation.

For this reason, if the cooperation network connecting local universities is strengthened, local government and government agencies will also likely increase support for local innovation projects. This will enable further innovation through funding, policy, and infrastructure support. In summary, collaborative networks of regional universities play an important role in promoting regional innovation by integrating knowledge, technology, talent, resources, and government support. This, in turn, can promote the growth and development of the regional economy.

Despite this, in the case of Korea, it is difficult to say that the cooperative network of local universities is well-established. The reasons include lack of resources, institutional obstacles that make cooperation between universities difficult, and lack of cooperation due to the absence of leadership to promote and support collaboration between universities in the region. Obstacles that hinder inter-university cooperation networks must also be continuously addressed.

Under these circumstances, it is most important to obtain basic information on the extent to which the cooperative network between universities in the region is currently in place and what form it takes. If such research data is accumulated, it will become possible over time to establish where the central axis of the network is and also to identify the institutions that play a central role in each area and the detailed networks within the network within the region (Saura *et al.,* 2023; Thomas *et al.,* 2021; Bejinaru and Baesu, 2017). Understanding the characteristics of these networks will enable us to provide important policy information when establishing regional innovation policies through university cooperation at the national level or cooperative policies between universities at the regional level.

Recognizing these needs, this study seeks to analyse the characteristics of the cooperative network relating to research projects being carried out between four-year universities located in the Chungcheong region (Chungbuk, Chungnam, Daejeon, and Sejong).

THEORETICAL DISCUSSION AND RESEARCH PROBLEM SETTING

Studies relating to the importance and effectiveness of collaborative networks between universities in specific regions have been conducted in many countries (Bejinari, 2022; Bigliardi *et al.,* 2021; Bratianu, 2002; Faber *et al.,* 2019; Sestino *et al.,* 2020; Markkula and Kune, 2015; Ghisellini *et al.,* 2016; Birkner *et al.,* 2017; Bratianu *et al.,* 2020; Burciu *et al.,* 2023; Cho *et al.,* 2022; Prokop, 2022; Cobben *et al.,* 2022). They can be classified as follows:

1. Studies relating to the economic importance and impact of inter-university cooperation networks. These studies mainly analyse the economic impact of university-industry cooperation on the local economy and

emphasize the positive impact on the formation of industrial clusters and regional development. In addition, they contain topics that analyse how regional cooperation networks between specific universities and other universities in a specific region contribute to knowledge transfer and the promotion of innovation and explore the impact on the local economy.

2. Studies relating to talent development and education. These studies cover many topics, examining the relationship between university networks and regional development and analysing the impact of cooperation between universities on talent development and knowledge transfer. In connection with these studies, examine university-industry cooperation patterns and investigate the impact of this cooperation on local talent development and technology transfer.

3. Studies on industrial clusters and innovation. Most studies in this field emphasize the importance of industrial clusters and university-industry cooperation and address their impact on innovation and competitiveness. On this basis, these studies discover how university-industry collaboration supports and improves local innovation systems.

The research methods employed in the studies mentioned above are also diverse. They can be classified as follows (Dwivedi, 2023; Ellegaard and Wallin, 2015; Cegarra-Navarro *et al.,* 2021; Bratianu, 2007; Campos *et al.,* 2020; Aleves-Scaliza *et al.,* 2022; Bratianu, 2007; Thomas *et al.,* 2021):

1. Case study. These types of studies provide detailed analysis of collaboration networks in specific regions or universities to better understand the success factors, challenges, and impacts of collaboration.

2. Surveys and interviews. Studies using these methods establish the cooperative network's status, opinions and requirements through surveys and interviews with university officials, industry representatives, and local government officials.

3. Network analysis. Social network analysis techniques may be used to analyse relationships and connectivities between universities and visualize the network structure.

4. Policy analysis. Studies employing policy analysis investigate and analyse government policies, university policies, regional development policies, etc. to evaluate policy impacts relating to forming cooperative networks.

5. Quantitative analysis. Studies employing this research method analyse data using statistical techniques and evaluate the performance, economic impact, and impact on regional development of cooperation between universities.

The research methods presented above are used following the purpose of the research. They are meaningful in themselves and have both advantages and disadvantages. Among these methods, item 3 above, the social network method, is very important as a means of studying governance among so-called regional innovation entities, a factor which today is recognized as crucial in achieving regional innovation within the region. Social network analysis methods possess several advantages when analysing cooperation networks between local universities, the primary one being visualization of the relationships between the innovation entities.

Social network analysis can visualize complex relationships by several means, as follows:

1. Taking the form of a graph (Choi, 2020, 2023; Choi *et al.,* 2023). Thereby, connectivity and patterns between universities can be intuitively understood, making the network structure easy to understand.

2. Grasping centrality. Social network analysis can calculate centrality indicators to identify universities that play an important role within the network. Centrality indicators measure information transmission, leadership, influence, etc., and help identify key players in collaboration.

3. Identifying clusters. Social network analysis helps identify collaboration groups between universities. Universities with similar research fields, interests, or goals can come together to form clusters, which can strengthen cooperation.

4. Enabling information transfer and knowledge sharing. Social network analysis helps us to understand how information and

knowledge flows are shared (Choi, 2023). This can optimize research collaboration, educational programmes, and technology transfer between universities.

5. Tracking change. Social network analysis can track network changes over time, allowing us to detect and adjust for growth patterns, strengthening or changes in a collaborative network.

6. Establishing regional innovation policies and strategies. The results of social network analysis can be used to improve regional development and university cooperation policies. Through data-based decision-making, strategies can be established to support regional innovation and development.

There are numerous advantages of social network analysis as a method of analysing cooperative relationships between regional innovation entities. In the case of Korea, however, while several studies have analysed the networks existing between certain universities, few studies have analyzed collaboration networks between universities. Against this research background, the present study set the following two research questions:

1. What are the characteristics of the cooperation networks for research-related projects among universities in the Chungcheong region?

2. What are the policy implications of the analysis results concerning cooperation networks among these universities?

ANALYSIS DESIGN

Analysis target and analysis period

The universities subject to analysis in this study are four-year universities and junior colleges located in the Chungcheong region. The Chungcheong region consists of four metropolitan cities and provinces, Chungbuk, Chungnam, Daejeon, and Sejong, and includes, as stated, not only four-year universities but also junior colleges. As of 2023, there are 54 four-year universities and seventeen junior colleges in the Chungcheong area. Since most research activities are centred on four-year universities, this study excludes two-year colleges and

universities and analyses only the 54 four-year universities.

The analysis period of this study is confined to 2022, and the analysis uses the most recent data. The research project is registered at NTIS (https://www.ntis.go.kr/ThMain.do), and the most recent data are from 2022. In the future, it will be necessary to analyse change trends using multi-year data. However, because the amount of data to be collected for this study is so large, we will conduct a single-year analysis starting from 2022.

Data collection method

The data required for analysis includes all commissioned tasks/joint research for each project implementation agency on the National Science and Technology Knowledge Information Service (NTIS) website. Following a certain filtering process, matrix data was created, focusing on the number of studies conducted between each agency.

Data analysis method

Centrality analysis was performed by constructing the number of research projects operating between the 54 universities as matrix data. We seek to analyse the characteristics and the detailed structure of the university network in the Chungcheong region through processes such as establishing the betweenness centrality score of each university institution, undertaking network simplification through Path Finder Network (PFnet) analysis, and clustering.

ANALYSIS RESULTS

Basic analysis

The number of research projects conducted by the 54 universities in conjunction with other universities in 2022 is shown in Table 1. It can be seen that the Korea Advanced Institute of Science and Technology (KAIST) has the largest number of research projects, with 294, followed by Chungnam National University with 257. It appears that 26 universities, almost half of them, have not conducted even one joint research project.

UNIVERSITY NAME	TOTAL	UNIVERSITY NAME	TOTAL
Kkotdongne Univ.	0	Sooncheonhyang Univ	39
Kunkook (Glocal) Univ.	12	Usong Univ.	2
Konsin Univ.	0	Uone Univ.	0
Konyang Univ.	6	Eulji Univ.	0
Konyang Cyber Univ.	0	Joongbu Univ.	6
Korea Univ. (Sejong)	52	Joongwon Univ.	0
Kongju Education Univ.	0	Cheongun Univ.	0
Kongju Univ.	94	Cheongju Education Univ.	0
Int'l Brain Education Univ.	0	Cheongju Univ.	25
Kukdong Univ.	4	Chungnam Univ.	257
Global Cyber Univ.	0	Chungbuk Univ.	67
Kumgang Univ.	0	Kdi	0
Nasalet Univ.	14	Kaist	294
Namseoul Univ.	0	Korea Teachers Univ.	2
Dankook Univ (Cheonan)	38	Korea Transportation Univ.	55
Daejeon Catholic Univ.	0	Korea Technology Univ.	12
Daejeon Univ.	22	Korea Tradition and Culture Univ.	2
Daejeon Seminary	0	Korea Baptism Univ.	0
Mokwon Univ.	22	Hannam Univ.	38
Paejae Univ.	0	Hanbat Univ.	44
Baekseok Univ.	0	Hanseo Univ.	14
Seoul Venture Univ.	0	Hoseo Univ.	50
Sangmyung Univ. (Cheonan)	20	Hongik Univ.	16
Seowon Univ.	0	Police Univ.	0
Sunmoon Univ..	2	Defense Univ.	0
Semyung Univ	12	Daejeon Seminary	0
Soonbokum Seminary	0	Science and Technology Univ.	0

Table 1. Number of research projects conducted by the 54 universities (as of 2022)
(Source: analysis of data from Korea's NTIS system).

Betweenness centrality analysis

The results of the betweenness centrality analysis using Netminer 4.4, a specialized program for network analysis, are shown in Figure 1. It can be seen that the Korea Advanced Institute of Science and Technology and Chungnam National University are located in the very centre and have the highest value in terms of centrality.

Table 2 shows the In-Degree Centrality and Out-Degree Centrality values derived from the Degree Centrality analysis process. SSince the number of research projects is commonly applied among each institution, the two values are the same.
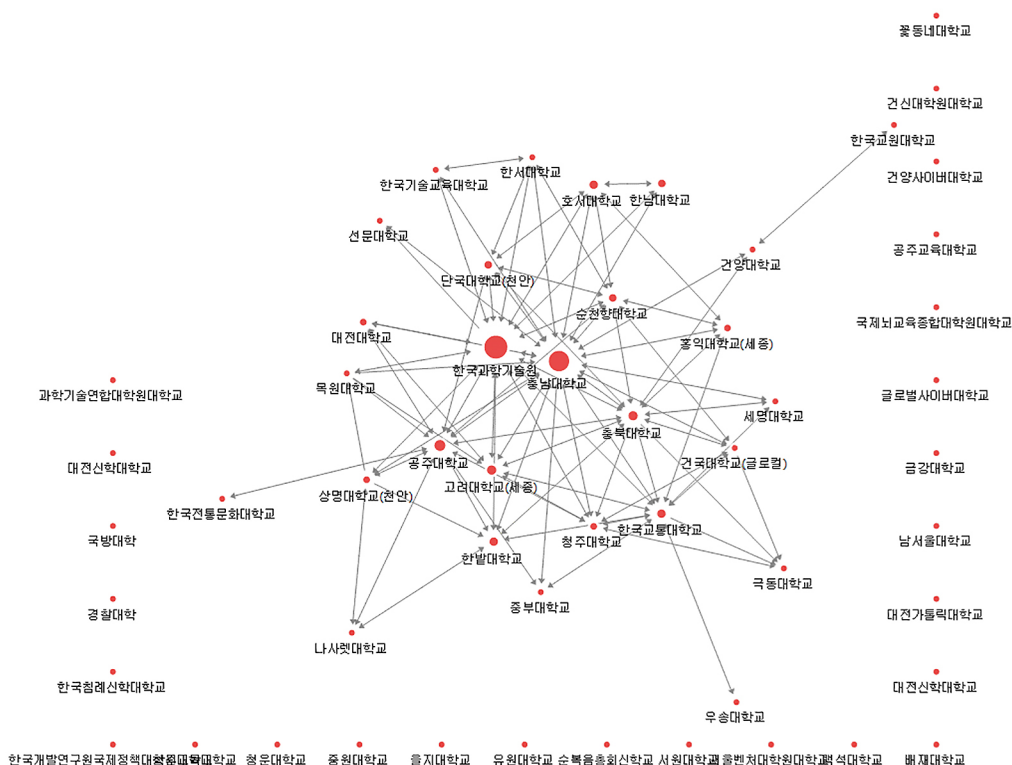
Figure 1. Betweenness centrality analysis results.

UNIVERSITY NAME	IN-DEGREE CENTRALITY	OUT-DEGREE CENTRALITY
Kaist	2.773585	2.773585
Chungnam Univ	2.490566	2.433962
Kongju Univ.	0.90566	0.886792
Chungbuk Univ.	0.622642	0.641509
Korea Univ. (Sejong)	0.566038	0.490566
Korea Transportation Univ.	0.509434	0.528302
Hoseo Univ.	0.471698	0.471698
Hanbat Univ.	0.433962	0.415094
Sooncheonhyang Univ.	0.377358	0.377358
Dankook Univ. (Cheongan)	0.358491	0.358491
Hannam Univ.	0.358491	0.358491
Cheongju Univ.	0.226415	0.245283
Daejeon Univ.	0.207547	0.207547
Sangmyung Univ. (Cheonan)	0.150943	0.188679
Hoingik Univ. (Sejong)	0.150943	0.150943
Nasalet Univ.	0.132075	0.132075
Hanseo Univ.	0.132075	0.132075
Kukdong Univ.	0.113208	0.037736

UNIVERSITY NAME	IN-DEGREE CENTRALITY	OUT-DEGREE CENTRALITY
Semyung Univ.	0.113208	0.113208
Korea Technology Univ.	0.113208	0.113208
Konkook Univ. (Glocal)	0.09434	0.113208
Konyang Univ	0.056604	0.056604
Mokwon Univ.	0.056604	0.207547
Joongbu Univ.	0.056604	0.056604
Sunmoon Univ.	0.037736	0.018868
Usong Univ.	0.018868	0.018868
Korea Teachers Univ.	0.018868	0.018868
Korea Tradition and Culture Univ.	0.018868	0.018868
Kkotdongne Univ.	0	0
Konsin Univ.	0	0
Konyang Cyber Univ.	0	0
Kongju Education Univ.	0	0
Int'l Brain Education Univ.	0	0
Global Cyber Univ.	0	0
Kumkang Univ.	0	0
Namseoul Univ.	0	0
Daejeon Catholic Univ.	0	0
Daejeon Seminary	0	0
Paejae Univ.	0	0
Baekseoj Univ.	0	0
Seoul Venture Univ.	0	0
Seonwon Univ.	0	0
Soonbokum Univ.	0	0
Uone Univ.	0	0
Eulji Univ.	0	0
Joongwon Univ.	0	0
Cheongun Univ.	0	0
Cheongju Education Univ.	0	0
Kdi	0	0
Korea Baptism Seminary	0	0
Police Univ.	0	0
Defense Univ.	0	0
Daejeon Seminary	0	0
Science and Technology Univ.	0	0

Table 2. Value of degree centrality.

Figure 2 shows the results of concentric circle analysis. The closer to the very centre of the concentric circle a university is located, the more central the role it plays within the network. It can be seen that the Korea Advanced Institute of Science and Technology and Chungnam National University are located in the very centre.
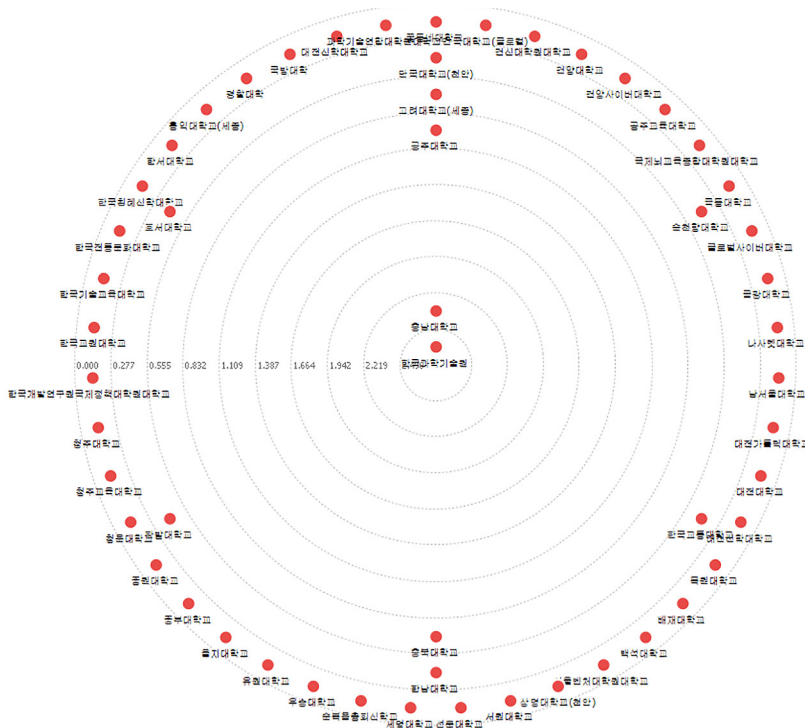
Figure 2. Concentric analysis results

Meanwhile, Figure 3 shows the result of the clustering analysis, which simplifies a complex network and then groups small networks with important relationships into a cluster.
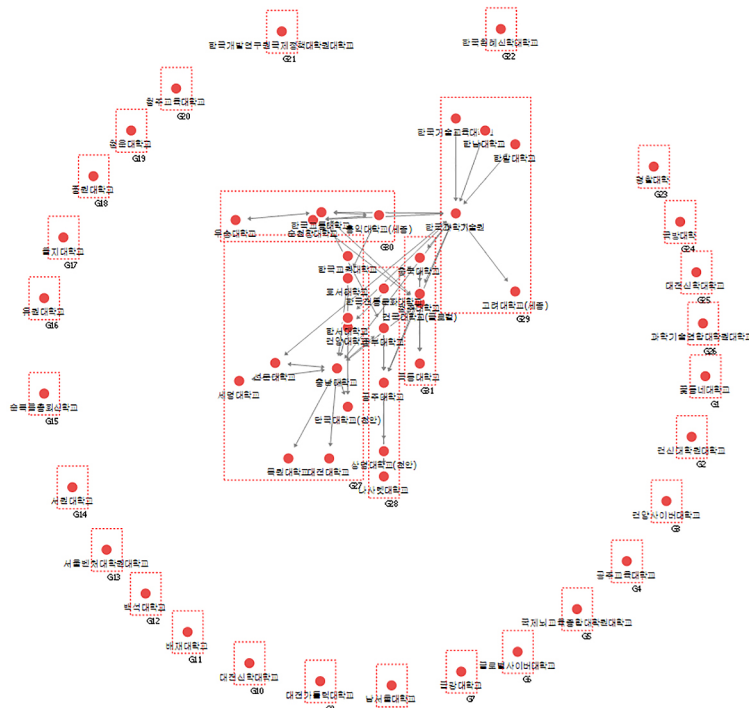

Figure 3. Cluster analysis results

In Figure 3, key small clusters appear, and these clusters are very important. The main purpose of cluster analysis is to find groups of nodes with high density within the network. These groups are strongly connected and have relatively little connection to nodes outside the group. The information that can be obtained through cluster analysis is as follows. First, it enables an understanding of the community structure. Communities, groups of strongly connected nodes within a network, can be identified. For example, finding friend groups in social networks and groups by research field in academic networks is possible. Such analysis identifies communities of closely connected universities.

In addition, it is possible to identify centrally located nodes within each cluster, which are likely to play an important role in the community. Universities included here and playing an important role are expected to continue to play a central role in research activities between these universities. Additionally, cluster analysis can better understand the structure and operation of the entire network. This is because various network functions can be identified by analysing the interactions between clusters.

As Figure 3 shows, a total of five clusters were derived through this analysis. The first of these is presented in Figure 4, which can be termed the Korea Advanced Institute of Science and Technology cluster. It includes the Korea Advanced Institute of Science and Technology, Hanbat University, Korea University of Technology and Education, Korea University Sejong Campus, and Hannam University.
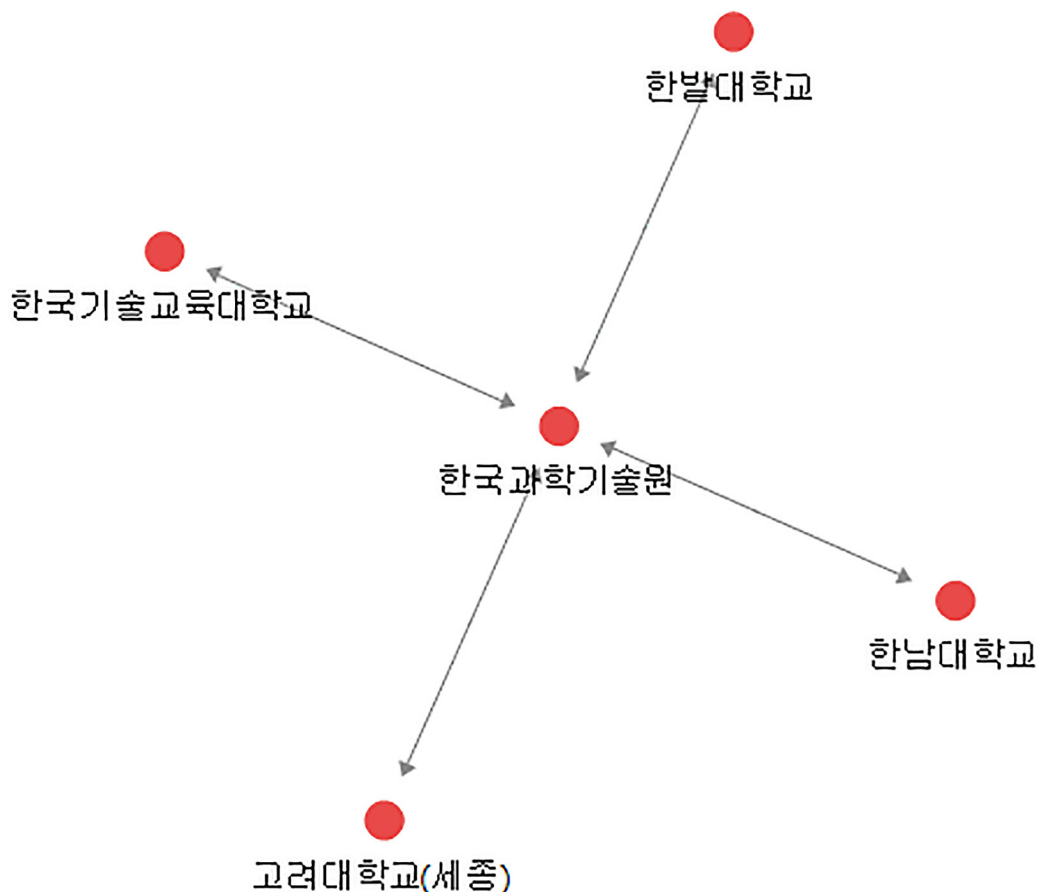

Figure 4. Korea Advanced Institute of Science and Technology cluster

Figure 5 may be termed the Chungbuk National University cluster. This includes Chungbuk National University, Konkuk University Glocal Campus, Cheongju University, and Far East University. It can be said to be a relatively small cluster.
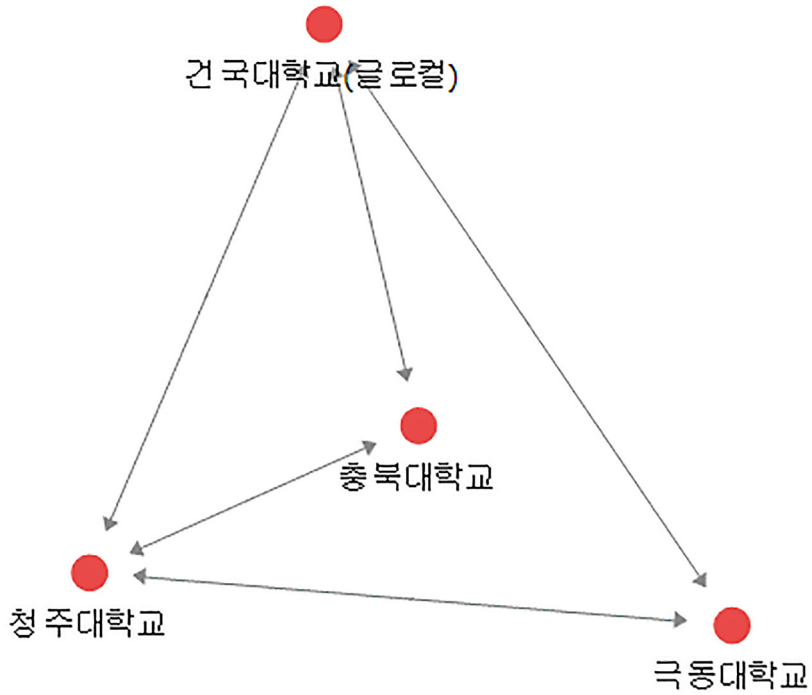
Figure 5. Chungbuk National University cluster.

Figure 6 can be termed the Kongju University cluster. This includes Kongju University, Sangmyung University Cheonan Campus, Korea University of Traditional Culture, Korea Nazarene University, and Joongbu University.
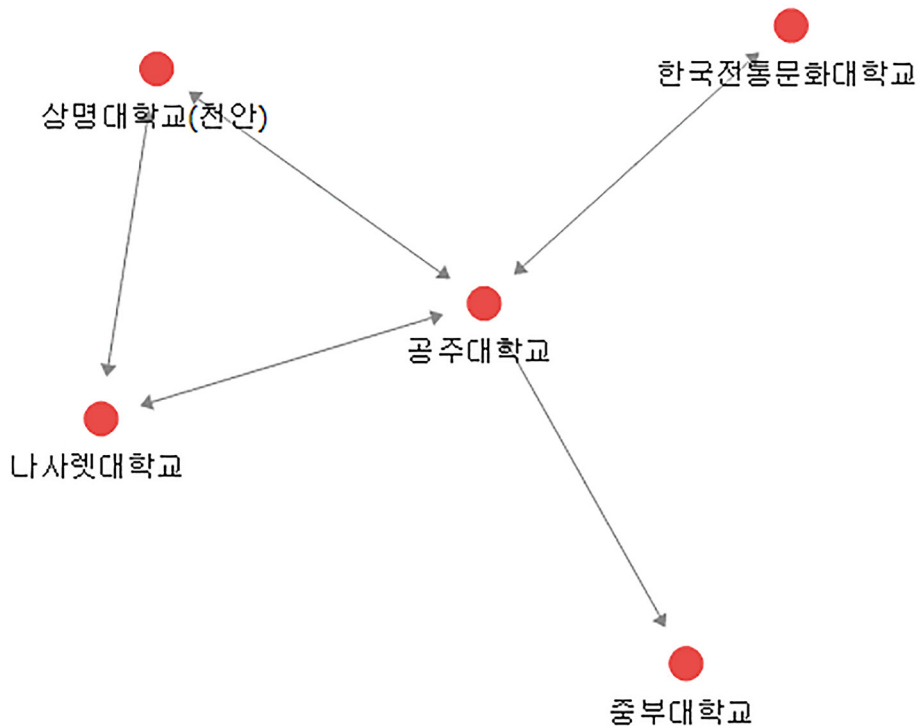

Figure 6. Kongju University cluster

Figure 7 can be termed the Chungnam National University cluster. This is a very large cluster, which includes Chungnam National University, Sunmoon University, Mokwon University, Semyung University, Hoseo University, Daejeon University, Korea National University of Education, Konyang University, Dankook University Cheonan Campus and Hanseo University. Korea National University of Education and Semyung University, which are included in this cluster, are geographically included in the Chungbuk region yet are not included in the Chungbuk National University cluster. The fact that they are included in the Chungnam National University cluster, which has different areas, is desirable regarding regional development, but is essentially not good. It shows that Chungbuk National University, a base university in the Chungbuk region, is not performing its role properly as a base university.
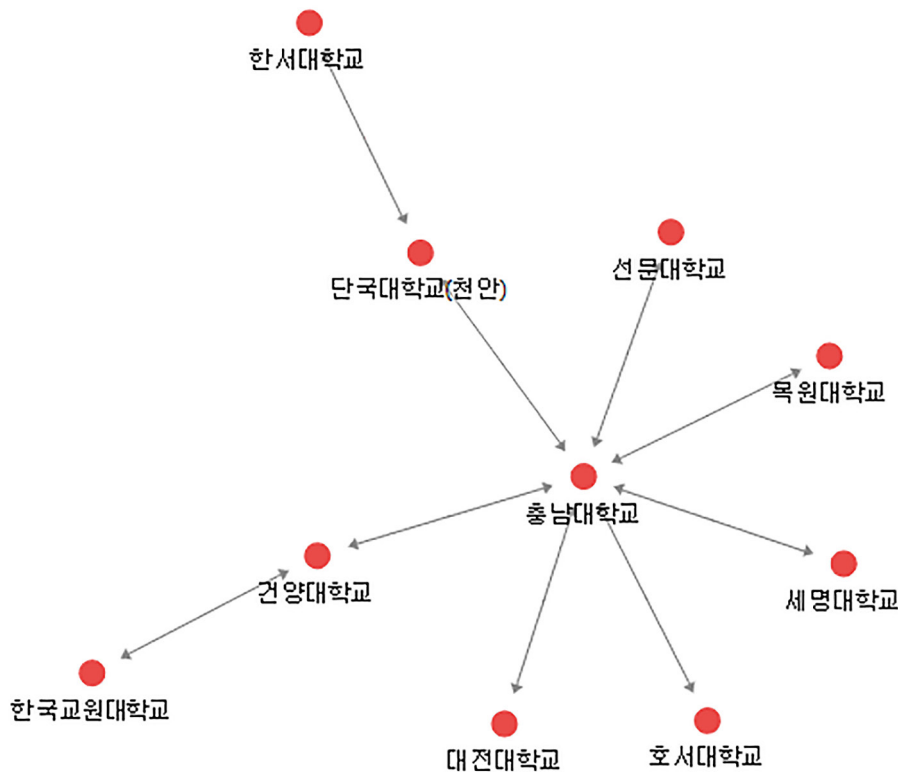

Figure 7. Chungnam National University cluster.

Figure 8 can be termed the Korea National University of Transportation cluster. This includes Korea National University of Transportation, Woosong University, Soonchunhyang University, and Hongik University Sejong Campus. The fact that Korea National University of Transportation is included in the Chungbuk region but not in the Chungbuk National University cluster and forms its own separate cluster shows that Chungbuk National University is not properly playing its role as a base university in the Chungbuk region.

As seen above, there are four metropolitan governments in the Chungcheong region: Chungcheongbuk-do, Chungcheongnam-do, Daejeon Metropolitan City and Sejong Special Self-Governing City. There are 54 four-year universities here and, through establishing with which these 54 universities are conducting joint research, key universities can be naturally exposed. For this purpose, various analyses were attempted. It can be seen that five major clusters were derived through cluster analysis. In network analysis, important nodes located at the centre of a community are often referred to as nodes with high 'centrality'. These nodes can perform several important roles within the network. The meaning of the five universities that form the core of each community may be briefly summarized as follows:
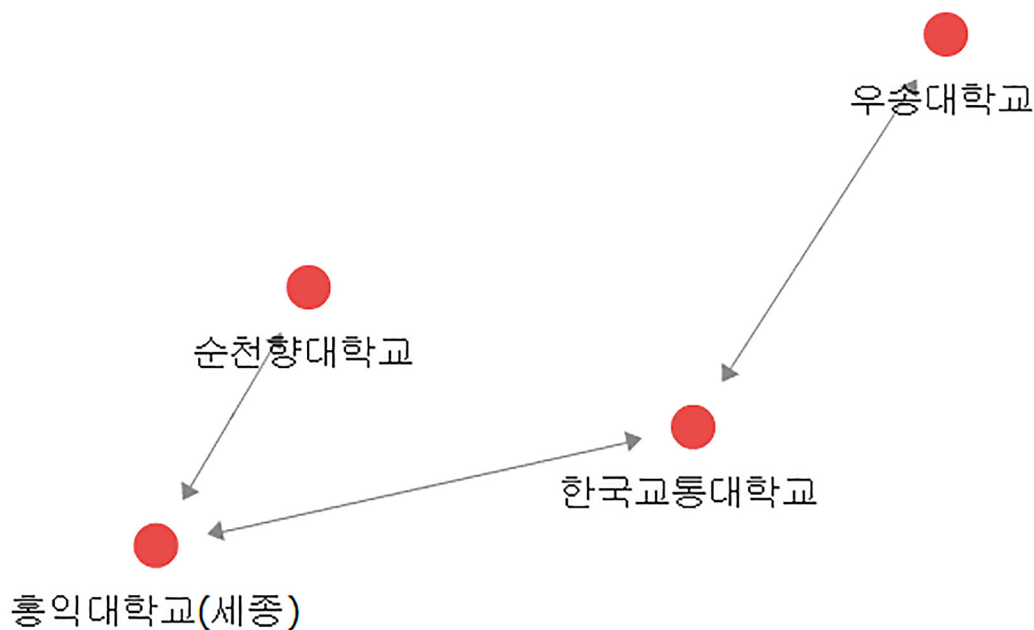
Figure 8. Korea National University of Transportation cluster.

1. It acts as an information intermediary. Central nodes are often located along the path through which information, resources, or influence flow within a network. These nodes can effectively disseminate information or act as intermediaries that can intentionally regulate the flow of information.

2. It plays a role in maintaining community cohesion. These nodes play an important role in maintaining the structural stability and cohesion of the community by maintaining connections with other nodes in the community. If these central nodes are removed, the network can fragment or weaken.

3. It plays a role in concentrating influence. Nodes with high centrality can often exert significant influence within the network. This is because they are directly connected to a large number of nodes or are located in strategic locations.

4. It serves as a base for the network. A central node can serve as a base connecting various parts of the network. In particular, broker nodes that form links between multiple communities can be important in maintaining the integrity of the overall network.

The role and importance of important nodes may vary depending on the type and purpose of the network. For example, in a social network, individuals with high centrality can strongly influence decision-making, and in a virus transmission network, nodes with high centrality can play an important role in the spread of disease. In this way, nodes in a central position in the network play an important role that can have a decisive impact on the network's health, efficiency and stability.

From this perspective, among the 54 universities located in the Chungcheong region of South Korea, Korea Advanced Institute of Science and Technology, Chungnam National University, Chungbuk National University, Kongju National University, and Korea National University of Transportation can be said to serve as nodes of an important research community within the Chungcheong region. However, it can be seen that although Chungbuk National University is a base university in Chungcheongbuk-do, it is not fully performing its role as a base. In this regard, Chungbuk National University is requested to strengthen the role of the research community within the region further in the future.

CONCLUSION

Network analysis relating to joint research among the 54 universities in the Chungcheong region of Korea is significant from several

perspectives. From an academic perspective, three meanings can be discovered. First, the pattern and structure of cooperation between regional universities can be identified. This means that patterns of research cooperation between universities can be identified through network analysis. For example, it is possible to analyse which universities are leading greater cooperation, and what the concentration of cooperation is. Second, it becomes possible to identify academic clusters. Cluster analysis can identify groups of universities that share specific research areas or academic interests, thus making it possible to identify the region's academic strengths and research focus areas. Finally, basic data that can facilitate academic diversity and integration can be secured. An understanding of academic diversity and integration can be improved by determining whether research collaboration across various academic fields is active or is focused on specific fields.

From a policy perspective, four meanings can be discerned. First, resource allocation can be done effectively. Information obtained through network analysis can help policymakers allocate research resources effectively. This can provide basic data to assist decisions about focusing resources on specific universities or fields or distributing them equally. Second, network analysis makes it possible to implement cooperation promotion policies. Identifying universities or fields where collaboration is not active enables policies to be developed to promote research collaboration between them. For example, special programmes could be put in place to strengthen weak links within the network.

Third, network analysis enables the development of research clusters. Discovering clusters of active collaboration in a particular field of research means that policies can be developed to develop that field into a regional academic centre. Finally, network analysis can be used to establish strategies for regional economic development. If the cooperation network between universities is linked to local industries, supporting the network can promote innovation and growth in the local economy.

In this way, network analysis and cluster analysis can help us understand the cooperation structure between universities and provide the basis for academic and policy decision-making. These analyses provide important information for academic development and community growth and can contribute to maximizing the efficiency and effectiveness of research collaboration. The five clusters relating to the 54 universities located in the Chungcheong region of Korea derived from this study can be utilized to achieve significant policy outcomes.

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Conflict of interest

The authors declare that there is no conflict of interest.

Statement of data consent

The data generated during the development of this study has been included in the manuscript. ●

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