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Identifying Tourism Patterns in Post-Pandemic South Korea
: Insights from Social Network Analysis*

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Abstract

This study aims to analyze the typical characteristics of regions preferred as tourism destinations in the post-pandemic era and examine the effects of the pandemic on people's tourism behavior. Utilizing the origin-destination (O-D) data captured by South Korea's toll collection system (TCS) between 2019 and 2021, the research explores differences in tourism behavior before and after the COVID-19 pandemic. Social network analysis, specifically, degree and eigenvector centrality, serves as the employed research method. The findings reveal three significant characteristics of post-pandemic tourism patterns. First, an increase in the popularity of local provinces as tourist destinations is noted, and this is accompanied by a decrease in the tour centrality of the Seoul metropolitan area. However, the centrality of the Seoul metropolitan area is being revitalized as the post-pandemic era progresses. Second, there was a noticeable decrease in the centrality of numerous tollgates between 2019 and 2020, indicating an elevated level of public concern regarding infection prevention measures. However, between 2020 and 2021, many tollgate centralities increased, suggesting a shift in people's attitude towards the infection. Third, driven by people's demand for natural tour spots with limited human contact, the post-pandemic era has witnessed the emergence of new tour sites. These findings are significant, as they enable the prediction of future changes in tourism behavior amid recurring pandemics, potentially informing government policies on urban development. Thus, this study underscores the essential role of tourism research in shaping future urban policy.

Keywords Social Network Analysis, OD Data, Pandemic, Tourism, South Korea

Ⅰ. Introduction

The social changes triggered by the COVID-19 pandemic are not transient phenomena. Historical pandemics such as SARS, MERS, Ebola, Avian Influenza (bird flu), and H1N1 flu (swine flu) indicate that COVID-19 will not be humanity's last encounter with pandemics (Gill, 2020). Experts anticipate recurring pandemics throughout history and observe that the pandemic cycle is gradually shortening (Gill, 2020). Moreover, the COVID-19 pandemic has persisted for an extended period due to subvariant mutations. Variants such as Alpha, Delta, and Omicron have emerged, further extending the pandemic beyond expectations. This enduring pandemic era necessitates humanity's adaptation to pandemic lifestyles. To cope with this prolonged pandemic era, countries worldwide, including

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the South Korea, have reviewed and implemented "With COVID-19" policies, enabling coexistence with the virus rather than waiting for its end. Therefore, adapting and coexisting with pandemics is imperative. To achieve this, it is essential to anticipate and prepare for changes in our daily lives during pandemic eras based on a thorough analysis of past experiences.

The COVID-19 pandemic has caused significant changes in traffic patterns. Many studies have reported a decrease in public traffic and traffic volume due to COVID-19. Specifically, some studies have focused on the reduction in public transportation usage (Jang, 2021; Lee et al., 2021), analyzed changes in transportation habits (Cho et al., 2020), and examined the correlation between traffic volume and the number of confirmed COVID-19 cases. However, further research is necessary to understand traffic patterns between regions and movements related to tourism.

Moreover, traffic patterns are a crucial factor influencing a nation's industrial structure. For example, traffic restrictions have led to the revitalization of the delivery industry, while the dine-in restaurant industry has experienced a decline due to increased food delivery services. Analyzing traffic patterns provides insights into overall changes in our daily lives.

Therefore, this study aims to demonstrate the common characteristics of human movement patterns during the pandemic by comparing the centrality of South Korean cities(tollgates) before and after the pandemic. The study will utilize highway traffic data to measure regional centrality before and after COVID-19 and analyze changes in tourism patterns in the post-pandemic era. By comparing changes in regional centrality, the study seeks to identify common characteristics of regions where regional centrality increases due to COVID-19. This study will contribute to the establishment of national transportation policies by enabling the prediction of changing traffic patterns in the post-pandemic era. Additionally, analyzing tourism-related traffic is meaningful from a regional development and policy perspective as it allows local governments, tourism industry workers, and small business owners to identify competitive tourism spots in the post-pandemic era and revitalize the tourism industry.

II. Literature Review

This study utilizes the social network analysis (SNA) method to examine changes in the influence of regions before and after the COVID-19 pandemic. SNA is widely employed in various fields, including organizational sociology, political science, organization theory, and strategy, as it allows for the analysis of different elements within social networks, such as relationships between individuals or web search keywords (Zaheer et al., 2010). The fundamental principle of SNA is to represent each element of a social network as dots and lines based on graph theory. The relationships between these dots in the graph are then interpreted using indicators such as density, inclusion, and centrality. Network analysis provides a structural perspective that is particularly useful in tourism studies (Scott et al., 2008).

Social Network Analysis is a commonly utilized research method in the field of tourism due to its capacity to examine different components of a network and their connections, making it a critical tool for tourism research (Scott et al., 2009). For example, Hong et al. (2015) employed degree centrality, eigenvector centrality, and closeness centrality to explore the correlation between destination centrality and tourism flows. Similarly, Park et al. (2016) utilized social network analysis to investigate the multiple destination tourism patterns of visitors to Gyeonggi-do in South Korea, using degree centrality and eigenvector centrality to understand tourism patterns beyond simple frequency comparison. Additionally, Liu et al. (2017) conducted a network analysis to examine the tourism mechanism in Xinjiang, China, and identified a relationship between three types of proximities (region proximity, grade proximity, and tenure proximity) and the tour attraction network. Despite the wide range of network analysis research in this field, further investigation is needed regarding tourism destinations (Liu et al., 2017).

Public health issues, war, terrorism, and social conflict have a profound impact on tourism (Qiu et al., 2020). Analyzing the consequences of these impacts can help in developing future strategies. The outbreak of COVID-19 in 2020 had a significant negative impact on global consumer markets and international tourism demand (UNWTO, 2020). Tourism is particularly vulnerable to pandemics like

COVID-19 because it is highly sensitive to people's movements (Gössling et al., 2021). Concerns about contagion reduce tourism demand and increase the preference for destinations with lower population density (Everingham and Chassagne, 2020). Jin et al. (2019) conducted research on the impact of pandemics on tourists in China (Jin et al., 2019). Furthermore, a study that conducted network analysis on tourism patterns in Gangwon-do, Korea, confirmed that post-pandemic travel routes were simplified and focused on beach destinations (Jeon and Yang, 2021). Since COVID-19 may not be the last pandemic (Gill, 2020), it is crucial to conduct further research to predict tourists' behavior during pandemics, as current research remains insufficient (Jeon and Yang, 2021).

Previous studies on traffic demand prediction in Korea have primarily focused on weekdays and commuting (Chu et al., 2007), with studies on tourism factors considering only personal or psychological factors such as age, gender, occupation, income, and residence (Kim et al., 2004; Lee and Choi, 2020; No et al., 1994). Environmental factors, such as politics, economy, society, and culture, which can significantly impact the supply side of the tourism industry, have been largely neglected in previous studies (Kim, 1990). However, the COVID-19 pandemic has emerged as a crucial environmental factor that affects society's tourism demand. Although some studies have analyzed actual traffic data to examine traffic patterns (Chu et al., 2007), they have failed to consider the pandemic's impact on tourism-purpose traffic. Furthermore, the studies conducted after the pandemic have not yet analyzed the national scope (Jeong et al., 2023) or examined the 'pattern' of traffic (Bhin et al., 2021; Cho et al., 2020; Jang, 2021; Lee, et al., 2021; Lee, S. et al., 2020), or not used transportation data as scientific rationale (Mogaji, 2020). Therefore, this study aims to investigate the differences in the network by analyzing tourism-purpose traffic before and after the pandemic.

Ⅲ. Research Methods

1. Data Analysis Model

Several centrality indicators exist for calculating centralities, such as degree centrality, eigenvector centrality, closeness centrality, and betweenness centrality (Bonacich, 1987; Freeman, 1978). Degree centrality focuses on the number of connections between nodes in a network, while eigenvector centrality considers the influence of connected nodes when calculating the centrality of a node. In other words, a node's centrality increases when its connected nodes have higher centralities. Closeness centrality, an extension of degree centrality, measures the distances between a specific node and all other nodes in the network (Bloch et al., 2017; Carrington et al., 2005; Nystuen and Dacey, 1961). These different centrality measures emphasize distinct factors and are applied in various domains of study. Moreover, different variations of a single centrality indicator may be proposed by different experts.

In this study, we employed degree centrality and eigenvector centrality as measures of the centrality of each tollgate. Degree centrality and eigenvector centrality are widely used in regional network analysis. For instance, Ahn et al. (2021) and Lee et al. (2022) employed degree centrality and eigenvector centrality to analyze 14 Innovation cities in South Korea and evaluate the outcomes of the government's urban policy.

Degree centrality is considered the most representative measure among the centrality measures that analyze spatial structures. While degree centrality focuses on direct connections between nodes in networks (Ahn et al., 2021), closeness centrality and betweenness centrality analyze network control and efficiency, making them unsuitable for analyzing regional network patterns (Bonacich, 1987; Freeman, 1978). Degree centrality determines the influence and power of a specific node based on the number of nodes to which it is connected (Lee and Kim, 2006). In this study, tollgates are treated as nodes. Therefore, tollgates that are connected to more tollgates are interpreted to have higher centrality. The calculation equation for determining the degree centrality Ci of a node i is as follows:

$$Ci = \sum_{j=1}^{n} Xij \quad (1)$$

Ci : node i's degree centrality

n : The number of nodes

$\sum_{j=1}^{n} Xij$ = node i's connection number with other nodes

On the other hand, eigenvector centrality is an extended concept of degree centrality that not only counts the

number of connections a specific node has but also considers the power of other nodes to which it is connected (Cook et al., 1983). This realistic measurement is widely used to analyze spatial structure along with the degree of connection centrality (Kim, 2012; Kim, 2014; Lee and Kim, 2006; Lee and Ha, 2014; Lee, 2014). In this study, the traffic volume between tollgates is given more weight, and the calculation equation for measuring the eigenvector centrality Ci of node i is as follows:

$$Ci(\alpha, \beta) = \sum_{j=1}^{n} (\alpha + \beta Cj) Xij \quad (2)$$

$Ci(\alpha, \beta)$: node i's eigenvector centrality

α : A constant used to compute standardized centrality index

β : Level of interactions

Xij = The number of links between nodes I and j (traffic volume)

2. Data Collection and Rearrangement

1) Data Collection

This study examines the traffic volume data provided by the Korea Expressway Corporation's highway public data portal (http://data.ex.co.kr). The dataset contains information on all vehicles passing through 417 highway interchanges in South Korea. Data collection took place from the first week of May to the last week of December for the years 2019, 2020, and 2021, and a comparative analysis was conducted between these years. The choice of a one-year unit for this research is justified as a year encompasses various factors that can influence travel patterns, including weather and holiday seasons. To accurately assess the impact of Covid-19, this study aims to mitigate the influence of such factors by using a one-year comparison period. Additionally, the South Korean government's social distancing policy levels did not change at regular intervals, which makes them unsuitable for use as units in our data analysis.

This study aims to analyze the impact of COVID-19 on tourism-purpose travel patterns. However, tourism purpose travel data provided by the National Statistical Office (NSO) based on the census is typically disclosed several years after the data collection, following a lengthy period of correction. Data for 2019, 2020, and 2021, which are the subjects of this study, have not yet been disclosed, making analysis impossible. Despite these limitations, this study is expected to serve as a meaningful preliminary study for subsequent analyses when the NSO data are released.

This study had to use a substantial data and go through an adjustment process to make data more suitable for the analysis (Table 1). First, this study selected the TCS data. Although the utilization rate of other transportation modes has decreased significantly since the COVID-19 pandemic, the use of highways has increased, reaching 110% compared to the previous year (Jang, 2021) making highway movement a dominant transportation mode during the post-pandemic period. Furthermore, TCS data has the advantage of being generated more quickly than NSO data and it provides information on individual and nationwide mobility. NSO data is survey-based, whereas TCS data is collected by measuring actual travel using sensors, making it a more accurate reflection of reality.

Among the TCS data this study selected weekend and holiday data. In South Korea, movements for tourism purposes have a higher proportion on weekends than on weekdays. Furthermore, after the implement of '5 day workweek policy' in South Korea, the traffic for work purposes has decreased on weekends resulting an increased proportion of tourism purpose travel.

Table 1. Data adjustment process

Step 1	Step 2	Step 3
TCS data	Weekend & holiday TCS data	Weekend & holiday type No.1 & No.6 TCS data
• Highway utilization increased during pandemic • Fast data generation speed • Individual and nationwide traffic data available	• Tourism proportion higher during weekends than weekdays • Increase of tourism purpose travel during weekend due to 5-day workweek policy	• Dominant proportion of private car use compared to public transportation during pandemic period • Exclude movements of trucks

After, this study selected passenger car data from the TCS data. Cars are the most used transportation mode for tourism purpose travel. Cars had the highest percentage of usage among all modes of transportation on Saturday and Sundays for 'shopping purpose (34.1%, 41.9%)', 'purpose to travel to relatives (51.1%, 51.5%)', 'leisure purpose (28.7%, 33.6%)', and 'vacation (45.4%, 42.1%) while buses, subways/trains, and railroads were less frequently used (13.4%~36.1%) (Chu et al., 2007). The TCS data includes separate traffic volumes of type No. 1 to 6 vehicles. This study specifically extracted traffic data for type No. 1 and type No. 6 cars, representing passenger cars and light vehicles, to exclude other vehicle types such as trucks

Using TCS data has its limitations because it does not include tourism-purpose travels made with other modes of transportations than cars or, it may include movements for non-tourism purposes. However, this study conducted adjustment processes (Table 1) and we believe that when tourism-purpose data during the post-pandemic period becomes available in 1-2 years, this study can serve as a foundation for subsequent research.

2) Data Preprocessing

The TCS data were pre-processed using R-studio. The TCS data initially provided in day units, required merging of separate data files using programming. Additionally, unnecessary data fields and variables, such as data for type No. 2 to No. 5 cars, were excluded. Then, the centrality scores were calculated using the 'igraph' and 'ggraph' libraries of RStudio. To display the centrality scores on a map, tollgate addresses were collected, and x and y coordinates were created as a dataset using Xray map software. Finally, the centrality scores were merged with the tollgate coordinates, and map visualization was conducted using 'ArcMap software' (Figure 1).

Ⅳ. Finding and Discussion

1. Results of Centrality Analysis

In 〈Table 2〉, a comparison of centrality scores between years is presented. Tollgates were grouped based on South Korea provinces, except for Seoul, Incheon, and Jeju, where no tollgates are located. The top three provinces with the most significant increase in degree centrality scores between 2019 and 2020 are Gwangju, Gyeonggi-do, and Daegu, while the province with the lowest increase was Sejong. Between 2020 and 2021, the top three provinces with the highest

Table 2. Centrality score changes per province

Province	Degree centrality		Eigenvector centrality	
	Centrality change		Centrality change	
	2019-2020	2020-2021	2019-2020	2020-2021
Gangwon-do	175586.8	341627.6	0	0.00719
Sejong	70996.0	613736.5	0.00047	0.01182
Busan	251559.6	271045.9	0	0.00226
Gyeongsangnam-do	225300.6	396128.7	0	0.00508
Gyeongsangbuk-do	124660.9	358814.8	0	0.00536
Daegu	371708.3	720505.5	0	0.01317
Chungcheongnam-do	283436.1	304947.4	0.01805	0.00625
Gyeonggi-do	417340.1	508260.3	-0.00240	0.03184
Jeollanam-do	129166.9	212968.3	0.00174	0.00256
Jeollabuk-do	77396.8	296844.1	0.00226	0.00443
Chungcheongbuk-do	73068.7	517631.8	0.00539	0.02390
Daejeon	197570.0	974363.6	0.00829	0.02632
Gwangju	524986.3	451248.7	0.00428	0.00337
Ulsan	262440.8	449870.8	0	0.00210

Note: Centrality change indicates the average of tollgates' score differences between two years.

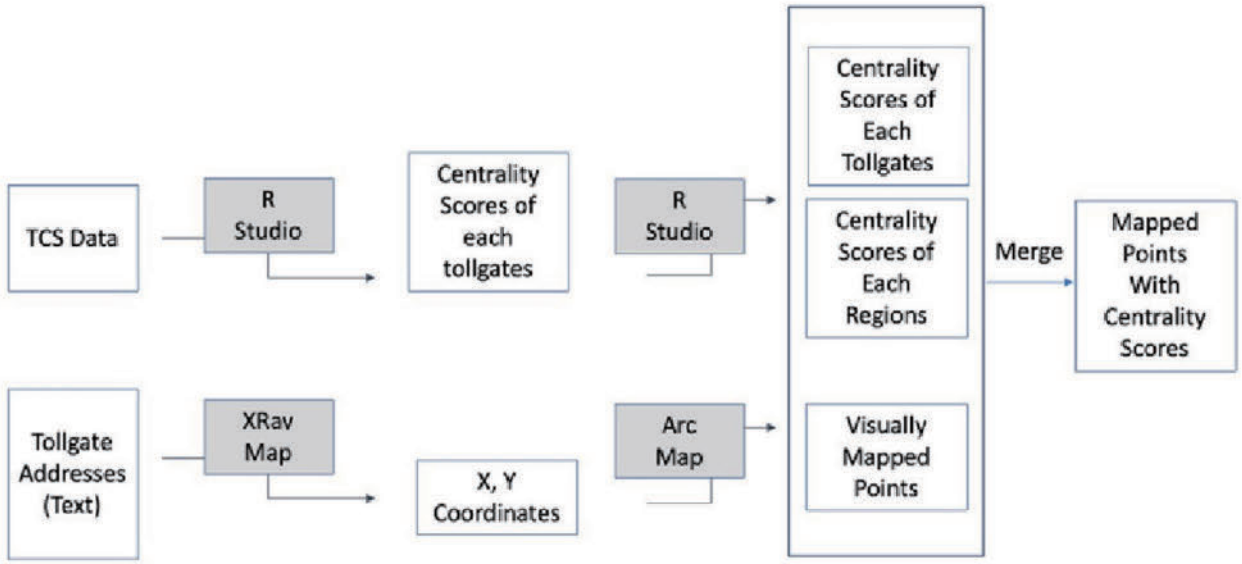

Figure 1. Flow of data analysis

increase are Daejeon, Daegu, and Sejong, while the lowest was Jeollanam-do. In terms of eigenvector centrality, the most significant increase between 2019 and 2020 was observed in Chungcheongnam-do, Daejeon, and Chungcheongbuk-do, while the lowest was Gyeonggi-do. Between 2020 and 2021, the top three provinces with the highest eigenvector scores were Gyeonggi-do, Daejeon, and Chungcheongbuk-do, and the lowest province was Ulsan.

〈Figures 2 to 5〉 display the visualization of the analysis results. The color and size of circles indicate centrality scores. Between 2019 and 2020, the degree centrality network underwent significant changes, particularly near local metropolitan areas such as Busan. Local networks expanded (Figure 2). On the other hand, the eigenvector centrality

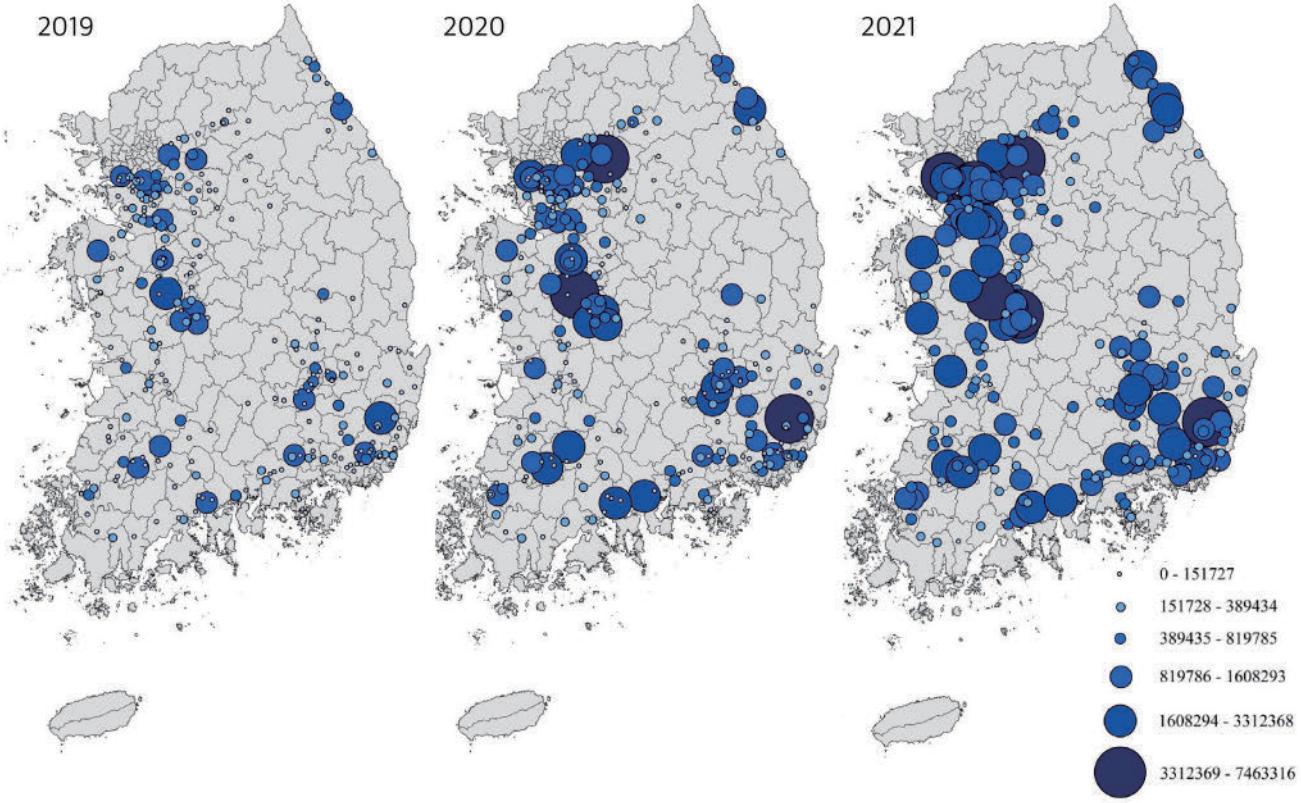

Figure 2. Degree centrality scores (2019, 2020, 2021)

networks showed no substantial differences throughout the target years (Figure 3).

However, despite this result, both the degree centrality and eigenvector centrality have shown a unique pattern of increase over the three-year period of 2019, 2020, and 2021. Interestingly, during the COVID-19 period, highway traffic volume actually increased (Jang, 2021). This can be attributed to the hypothesis that people tended to travel to more distant locations. Highway usage is typically associated with long-distance travel, indicating a preference among individuals to move towards areas with lower population density rather than areas with a high concentration of residents.

Degree centrality relies on the number of connections a tollgate has, while eigenvector centrality considers the traffic volume between tollgates. This study used eigenvector centrality because it can reveal the characteristics of both orientation and destination. Through the results of eigenvector centrality, the relationship between regions can be analyzed, not only the features of the destination itself. This is because when two nodes are connected, that connection affects the score of both the orientation and destination. The analysis reveals that new connections were established in the post-pandemic era, indicating the emergence of new movement trends. However, not many regions exhibited notable changes in eigenvector centrality compared to degree centrality, suggesting a minimal difference in traffic volumes, which could be attributed to decreased movements during the pandemic.

2. Discussion

1) Increased Popularity of Local Province

In 〈Figure 4〉, it is evident that the tollgates in the Seoul metropolitan area experienced a decrease in centrality. Despite the government's policy response to the pandemic and people's concerns and hesitations regarding movement and human contact, certain tollgates near local metropolitan areas such as Daegu and Busan saw an increase in centrality. Daegu and Busan are two of the six South Korean local metropolitan cities located in the lower southern part of the country. These cities play significant roles in the country's economy, culture, and transportation infrastructure. Generally, South Korean population is highly concentrated in Seoul and the surrounding areas, located in the central part of the country. Seoul, the capital city, is the most popu-

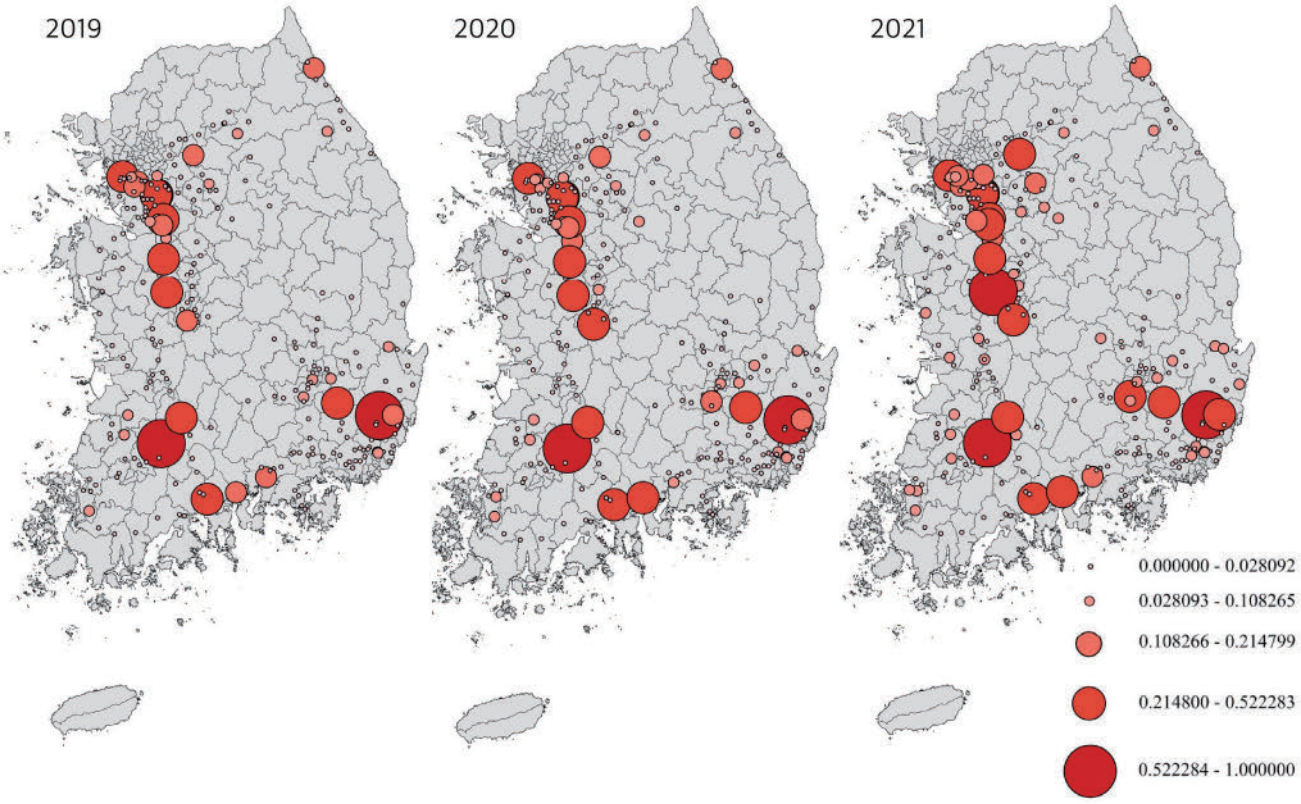

Figure 3. Eigenvector centrality scores (2019, 2020, 2021)

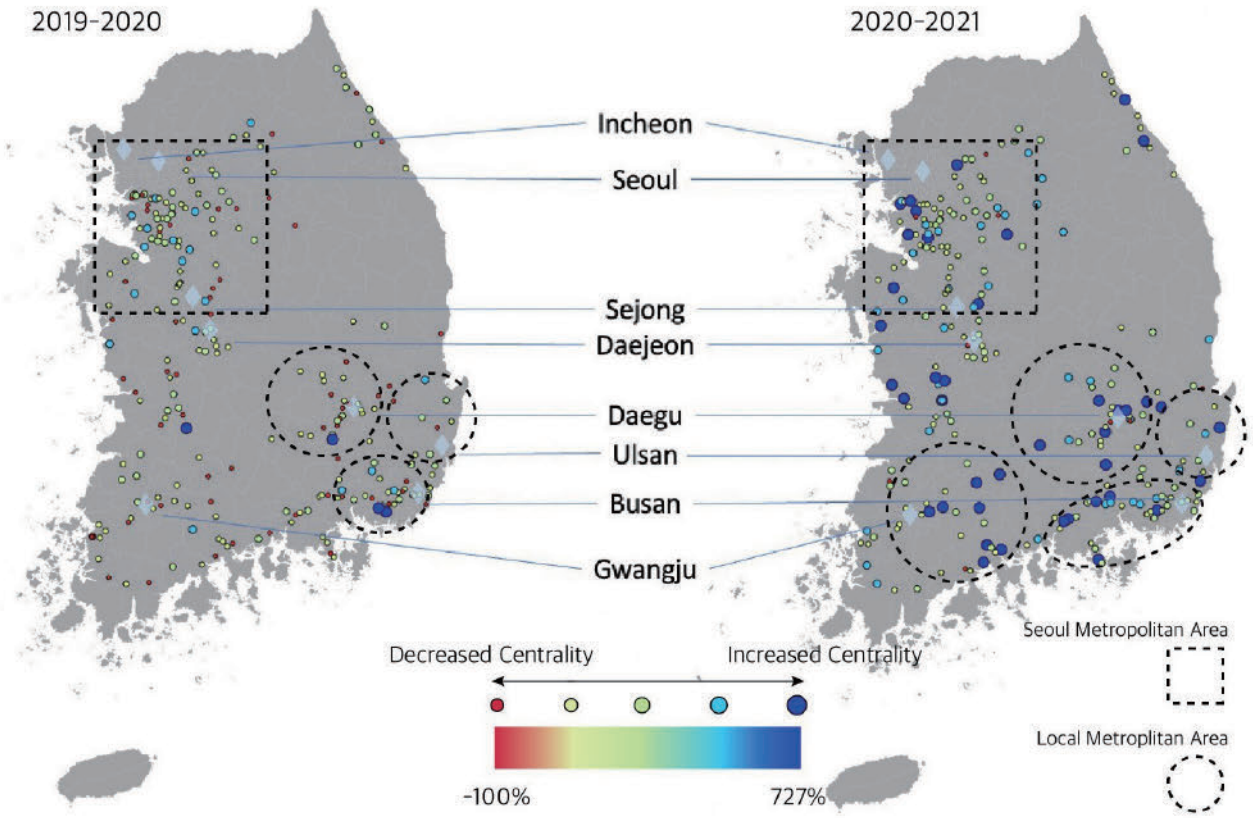

Figure 4. Change rate of degree centrality, 2019-2020 (left), 2020-2021 (right)

lous city and serves as the political, economic, and cultural center of South Korea. The surrounding areas, collectively known as the Seoul Metropolitan Area, including Incheon and Gyeonggi Province, also have a high population density. Therefore, the shift of concentration from the Seoul metropolitan area to regional metropolitan cities, such as Daegu and Busan, is a significant observation in the context of South Korea. It reflects the outcome of a major infectious disease, leading to a dispersion of the population from densely populated areas to regions. This trend further intensified in 2021. Alongside Daegu and Busan, the centralities of Gwangju, Ulsan, and Daejeon areas also experienced significant growth. Daegu, Ulsan and Daejeon are also other local metropolitan cities. This indicates a preference among people for local metropolitan areas and suburban out-of-town tourist destinations. In the post-pandemic era, individuals are inclined towards visiting low-density tourist spots to minimize human contact.

2) Seoul Metropolitan Area's Revitalization and Reduction of Caution Against Human Contact

Interestingly, unlike in 2020, the presence of red dots in the Seoul metropolitan area relatively diminished in 2021, while blue dots emerged (Figure 4). This phenomenon indicates an increased degree centrality in the Seoul metropolitan area, signifying the establishment of new connections to tollgates. The rise in degree centrality suggests that previously disrupted connections in 2020 have been restored in 2021.

Notably, the increase in centrality is not limited to the Seoul metropolitan area but is observed extensively throughout the nation. This observation highlights a significant rise in the number of tollgates with increased centrality. Such a trend implies a potential reduction in people's fear of COVID-19 over time. As the duration of the pandemic surpassed initial expectations, individuals have likely adapted to the challenges posed by the pandemic and adjusted their lifestyles accordingly.

3) New Tour Spots with Natural Resources

In 〈Figure 5〉, the beachside area of Gangwon-do province is highlighted in green. Unlike other regions where numerous blue points indicate an increase in centrality, Gangwon-do province lacks a local metropolitan area. However,

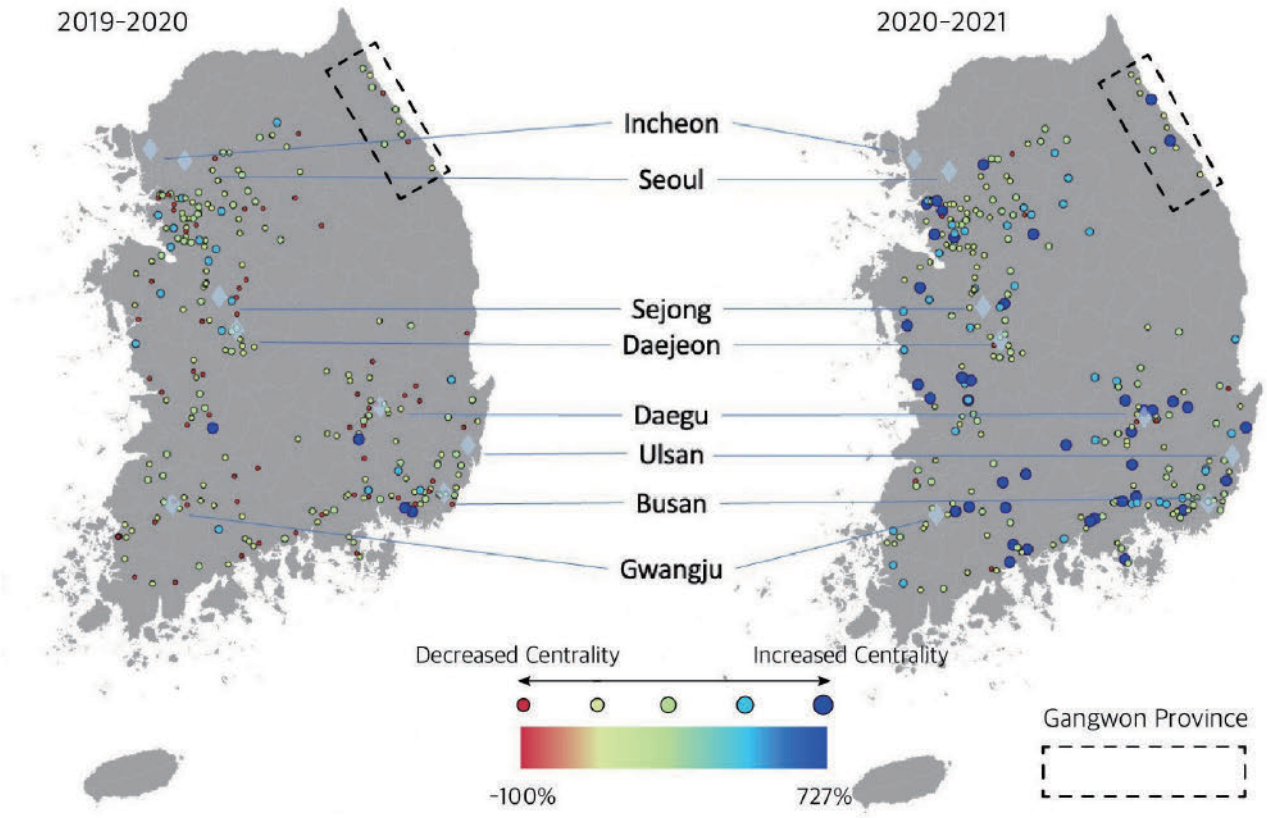

Figure 5. Change rate of eigenvector centrality, 2019-2020 (left), 2020-2021 (right)

in the case of Gangwon-do province, a network has been established along the beachside. The rise in degree centrality, which corresponds to the number of connected tollgates, suggests an expanded range of tollgate connections in Gangwon-do province. This observation indicates an increase in visitors to Gangwon-do's beachside during the COVID-19 era. Previous studies focusing specifically on Gangwon-do province have also reported an increase in visits to the province's beachside (Jeon and Yang, 2021).

Text mining analysis, examining Korean behavior using social network service data after COVID-19, revealed a heightened interest among Korean individuals in eco-trips and gourmet trips (Sung et al., 2021). Additionally, data from the Korea Tourism Organization's visitKorea data lab (https://datalab.visitkorea.or.kr/datalab/portal/main/getMainForm.do) indicated an increased preference among Koreans for nature tour spots and sports tourism tours between 2019 and 2020, as reflected in navigation search keywords. Conversely, historical tour spots, cultural tour spots, and shopping destinations experienced a decline in visits by Koreans during this period. However, between 2020 and 2021, there was a resurgence in interest for cultural tour spots and shopping locations, alongside nature and tourism sports spots. These findings align with the results of this study, demonstrating the growing popularity of local provinces and nature tour spots.

V. Conclusion

This study delved into the evolving landscape of tourism behavior in the post-pandemic era, leveraging Origin-Destination (O-D) data from South Korea spanning the years 2019, 2020, and 2021. Employing Social Network Analysis, specifically focusing degree and eigenvector centrality, we unearthed three pivotal characteristics shaping the post-pandemic tourism paradigm.

First and foremost, our investigation illuminated a noteworthy shift in tourist preferences, marked by an uptick in the allure of local provinces as favored destinations. This trend coincided with a waning centrality of the Seoul metropolitan area. However, intriguingly, as the post-pandemic era unfolded, the centrality of the Seoul metropolitan area began to regain its vigor. This dynamic shift underscores the fluidity of tourist choices in the wake of global

health crises. Secondly, we observed a fluctuation in tollgate centralities during the pivotal years of 2019, 2020, and 2021. Between 2019 and 2020, many tollgate centralities dipped, suggesting a relaxation in individuals' vigilance toward the virus. However, between 2020 and 2021, an opposing trend emerged, with numerous tollgate centralities experiencing an uptick. This shift hints at the nuanced changes in public attitudes toward infection risk over the course of the pandemic. Lastly, our research highlighted the emergence of new and unconventional tourist destinations in the post-pandemic era. This development can be attributed to the increasing demand for natural sites with minimal human interaction. The trend underscores the resilience and adaptability of the tourism industry in response to evolving health concerns.

The implications of these findings are profound. They offer valuable insights for predicting and preparing for future shifts in tourism behavior in the face of recurring pandemics. Policymakers can use this research to inform urban development strategies that are attuned to the changing dynamics of tourism. This underscores the essential role of tourism research in shaping and guiding the formulation of future urban policies.

In conclusion, our study not only sheds light on the transformative nature of post-pandemic tourism but also underscores the indispensable role of academic research in shaping resilient and adaptive urban policies. As we navigate a world marked by ongoing uncertainties, understanding the evolving patterns of tourism behavior remains crucial for fostering sustainable and resilient cities in the future.

This research has several limitations. The study relies on toll collection system (TCS) data, which may not capture all aspects of tourism behavior, such as non-motorized travel or movements without passing tollgates. It may also include movements for non-tourism purposes. It is also specific to South Korea, and the findings may not be generalizable to other regions or countries with different socio-cultural and geographical contexts. Moreover, the analysis is based on data from 2019, 2020, and 2021, covering a relatively short period of time. A longer time frame could provide a more comprehensive understanding of post-pandemic tourism trends. Therefore, future studies will be conducted over an extended period, utilizing multiple datasets to comprehend tourist mobility patterns more thoroughly.

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