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A Spatial Structure of Agglomeration Pattern Near High−Speed Rail Station of Korea and Japan

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ABSTRACT

The operation of high−speed rail (HSR) has an effect on the agglomeration economies, and the impact is shown as a relocation of individual firm and worker to where business activity can be maximized. The proximity to the HSR station could be considered as a core district to maximize the industrial benefit through the HSR network. From this perspective, this study considers the agglomeration effect of HSR within the HSR station−area and analyzed the agglomerated spatial pattern through hotspot analysis by service industry in the cases of Korea and Japan using GIS. This study analyzed the service industry within 1km distance from 8 HSR stations of Korea and 4 Kyushu Shinkansen stations of Japan. The results suggest that the hotspot patterns are observed in the service industry within 1km distance from the HSR station of Korea and Japan, except for two HSR stations of Gupo station and Kagoshima−Chuo station. Leisure, amusement, association, and other specific service industries could be affected by HSR passengers and knowledge−spillovers through HSR station. Therefore, the observed hotspot districts near the HSR station−area could explain an agglomeration pattern of the service industry through a closeness to the HSR station. Further, we could expect that the impact of HSR affects the service industry, and the impact could attract business activities of the service−area to maximize their benefit from HSR travelers. With the result, it is required to build up a supportive policy to maximize the HSR' s impact on the service industry when considering the HSR station−area development.

KEYWORDS : High−speed rail, KTX, Shinkansen, Spatial location pattern, Agglomeration.

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요 약

고속철도(HSR)의 운영은 집적이익에 영향을 미치며, 개별 경제활동들은 경제적 이익을 극대화할 수 있는 곳으로 이전한다. 이러한 측면에서 볼 때, 고속철도역과의 인접성은 고속철도 네트워크를 통한 이익 극대화를 영위할 수 있는 핵심구역으로 간주할 수 있다. 본 연구에서는 GIS를 이용한 한국과 일본의 서비스 산업 핫스팟 분석을 통해 고속철도역 주변에 대한 집적효과를 분석하고자 하였다. 한국과 일본의 집계구 데이터를 활용하여 분석을 수행하였으며, 일정 규모 이상 도심에 위치하고 있는 고속철도역이 입지하고 있는 한국 8개, 일본 큐슈신칸센 4개역을 대상으로 하였다. 분석결과 구포역과 카고시마츄오역 등 2개 역을 제외한 나머지 10개 역들 반경 1km 이내에서 서비스산업의 집적이 관측되었다. 여가, 레저, 협회 및 특정 전문 서비스산업들의 경우 고속철도승객을 통한 관광객 유입 혹은 지식교류 등의 효과를 영위함으로써 사회경제적 이익을 얻을 수 있다. 이를 고려했을 때, 역 주변에 대한 핫스팟의 도출은 역 접근성과의 관련성을 보여줄 수 있을 것이다. 분석결과를 정책적으로 보았을 때, 향후 역 주변 개발에 있어서 서비스 산업과 관련 산업들의 사회경제적 이익을 극대화할 수 있도록 지원 또한 필요할 것이다.

주요어: 고속철도, KTX, 신칸센, 입지패턴, 집적

Introduction

HSR is a mass transportation for passenger travel, and its operation could have diverse socioeconomic impacts on a region. If the location of the HSR station fulfills several conditions, the opening and operation of this new mass transportation can be employed to enhance an intangible value−added. The most important condition is the accessibility to the HSR station. A well developed feeder−service for transportation and geographical proximity to the HSR station could maximize the impact of HSR. Considering the significance of closeness to the HSR station, the HSR station−area is firstly regarded as a place for business activities. In addition, the concentration of business activities in a specific area of a region could attract more additional impacts through an agglomeration effect in maximizing economic benefits. The concentration of business activities enhances the economic benefits in itself, and the economic benefit more attracts the relocation of business in the district. With the consideration of these backgrounds of proximity to the HSR station and the agglomeration effect, we could envisage an agglomeration near the HSR station to maximize its impact. In this background, this study aims at estimating the impact of HSR on the agglomeration of service industry near the HSR station and comparing the international cases of Korea and Japan to show the relation between HSR operation, proximity to HSR and the agglomeration effect by HSR. In order to achieve the research goal, we focus on 12 HSR stations of Korea and Japan, and then analyze the spatial pattern within 1km distance from the HSR station, using RStudio and QGIS 2.18 and 3.2.1.

Agglomeration and the impact of HSR

1. A relation of HSR and agglomeration effect through a spatial pattern

Considering that HSR is a transportation for the passenger travel, its socioeconomic impact might be limited compared to goods. However, as a passenger transport, HSR impact could be intensified in the intangible benefits resulted from HSR travelers. The tangible value signifies the monetary benefit related to production and consumption, whereas intangible value is a socioeconomic value that occurs outside the market. One of the external effect of intangible value is an agglomeration effect caused by the location of each business activity at a specific area, and the agglomeration effects attracts more firms to the spot (Malmberg *et al.*, 2000).

The agglomeration effect originally stands on the basis of decreased production cost through sharing resources and increased revenue through local transaction (Malmberg *et al.*, 2000). In the business activity under the agglomeration effect, the socioeconomic agent achieves reduced production cost by sharing the input resources, decreased transport and traction cost through an enhanced interaction between supplier and consumer (Malmberg *et al.*, 2000). A labor input in production activity is also covered, for the abundant job opportunity by the concentration of firm attracts and enhances skilled-labor pool. It is not only confined in the production process, but attained in the consumption activity. The agglomeration in the consumer standpoint, the agglomerated area is an attractive market, which can maximize their cost-efficiency through the reduced supply price and competitive market structure in the area. Given that the above benefits are tangible benefit through the agglomeration, intangible benefit of agglomeration stems from non-market activities. The location of companies concentrated in the areas promotes non-economic activities such as knowledge-exchange, which leads to a technological breakthrough. In this point of view, Johansson and Quigley (2004) also contend that individual business can be benefited from the knowledge-spillover through an enhanced proximity. With this context, professional and technical knowledge exchange could be also combined with the agglomeration effect.

Chatman and Noland (2011) explain that the public transport results in enhancing a density of employment through agglomeration economies. An important determinant of transport and agglomeration in their view is the travel time increasing connectivity between economic agents. Unlike intra-city transport network considered in the agglomeration, HSR as an inter-city mass transport has a different role in the agglomeration economies in urban space. HSR is mainly a mass transportation facility which has a significant role in the urban spatial structure, since a huge number of people are gathered and dispersed through the transport network linked to HSR station. It can be assured that the HSR operation attracts tourist from other city and this inflow of visitors stimulates the business activity through their consumption for accommodation, food, sightseeing, leisure and so on. In addition, the HSR passenger for business trip enhances the external effect through business meeting and knowledge-exchange. These are a direct impact through HSR, and 2nd-order impact through the passenger visiting for business and tourism can be also achieved. In the long-term, the number of business activities and the size of individual company affected by HSR operation are connected into the birth of new business and the relocation to the place where the benefits can be maximized through HSR passenger. And one of the representative area of this phenomenon is the HSR station-area which can be utilized for inter-regional traveling.

Therefore, we can consider that the impact of HSR as a passenger transport is able to bring about socioeconomic benefits. The business activities can be located near HSR station-area in order to utilize the HSR effect by enhancing their economic benefits. Further, the agglomeration effect promotes the relocation and economic benefits, and it attracts more business activities to the area.

2. Precedent studies about the impact of HSR and the spatial structure

The impact of agglomeration is inevitably related to transport network, for it emphasizes the accessibility between the business activities. At this point of view, previous studies try to estimate the HSR impact in the prefecture level (Wetwitoo and Kato, 2017), city and census level (Kim and Kim, 2016; Kim and Kim, 2018). Kim and Kim(2016) propose the changed agglomeration pattern within 2km from the HSR station of Korea between diverse industries, but they do not propose the relation between the HSR station and the hotspot districts. Kim and Kim(2018) make up for the weak link between the HSR station and the proximity by considering the direct distance from the census. They propose the agglomeration pattern near HSR station in the industries of accommodation & food service, retail and wholesale industry, real estate & leasing industry. Although they did not verify the correlation between the changed pattern and HSR station directly, the comparison between diverse HSR stations shows the impact of HSR. Shao *et al.*(2017) investigate the HSR's impact on the service industry, and propose HSR's influence on producer service industry. Further, they also propose the possibility of HSR promoting the service industrial agglomeration in the medium and small-sized cities along the HSR network. Graham and Melo(2011) consider the agglomeration economies with HSR and proposes that agglomeration benefits increases corresponding to the decrease of travel speed in the case of the UK. Hensher *et al.*(2014) introduced the approach of Graham and Melo(2011) to estimate the economic and social agglomeration effect of HSR for the case of Eastern Australia. They identified that the agglomeration effect on work and non-work related to travel through HSR scenario. Most studies take into account the aggregated impact of HSR, which is favorable for national level impact, but the approach does not focus inner urban area.

However, most studies estimate the HSR impact center on the city level or above, while only few studies consider micro-level structure. As mentioned above, this study focuses on the HSR station-area, which can be expected to be strongly affected by the HSR operation. The agglomeration effect could intensify the impact of HSR, and attracts more business activities. Further, in order to emphasize the distinctiveness of this study, we conduct a comparison between Korea and Japan, while Kim and Kim(2018) considered only the case of Korea. If this international comparison is able to propose a similar spatial pattern between different countries and different cities having diverse socioeconomic backgrounds, we could estimate the possible HSR impact.

Data structure and methodology

1. Data structure

Basically we utilize the census data (hereafter district) of Korea and Japan supported by the statistic bureau of each countries. This data has the smallest spatial unit for the economic business, so it will be possible to estimate the impact of HSR in the micro-level, while previous studies mainly focused on the city and province (prefecture for Japan) level. This data is already introduced by Kim and Kim (2016) and Kim and Kim(2018).

This study focuses on HSR stations of Korea and Kyushu Shinkansen of Japan. In the case of Korea KTX (Korea Train eXpress: high speed railway in Korea) has been inaugurated gradually since 2004, and Kyushu Shinkansen was opened in 2004 and 2011 in stages. However, the distinctive cultural, economic, and environmental background between two countries could hamper the comparison between inter-countries and inter-cities. Therefore, selecting target HSR stations follows several conditions. First, HSR station taking the high-speed track is only targeted, since KTX operation is mixed with high-speed track and conventional track. Second, urban scale of the HSR passing through the city is also considered. Third, the selected HSR station is located in the urban area to estimate HSR' s impact near the station-area, not the rural area. If the HSR station is located in a rural area, undeveloped census such as woods, fields, mountainous area could be only included. In the case of cities having two or more HSR station, we consider the HSR frequency per day. And the distance to HSR station is based on the closest HSR station within a city. Considering the city size of 1,000,000 people, frequency of HSR, and the location of HSR, five cities having HSR station in Korea are included in the analysis. In the case of Kyushu Shinkansen, there are no city having 1,000,000 people, so cities more than about 300,000 people, which are the biggest cities in Kyushu are selected.

The targeted HSR stations and cities in both countries are shown in Table 1. Hakata Shinkansen station of Japan was firstly opened in 1985 for Sanyo Shinkansen, but it is operated in Kyushu Shinkansen as well after 2011. So, Hakata station is also included as a part of Kyushu Shinkansen.

Korea and Japan have a different standard industrial classification, so the industrial category is reorganized into new nine categories. Although there are diverse industries, we focus on the service industry, which could be expected as a major industry affected by HSR operation. The reorganized service industry is shown on the Table 2.

TABLE 1. Selected HSR station of Korea and Japan

Korea		Japan	
City	HSR station	City	HSR station
Seoul	Seoul, Yongsan	Kumamoto	Kumamoto
Daejeon	Daejeon, Seodaejeon	Kagoshima	Kagoshima-Chuo
Daegu	Dongdaegu	Fukuoka	Hakata
Busan	Busan, Gupo	Kurume	Kurume
Gwangju	Gwangju-Songjeong		

TABLE 2. Selected HSR station of Korea and Japan

Country	Korea	Japan
Year	2015	2014
Industry	Business facilities management & business support services	Living-related & personal services & amusement services
	Arts & sports & recreation related service	Compound services
	Membership organizations & repair & other personal service	Services & N.E.C

2. Research methodology

In order to achieve the research aim of this study, we follow a methodology and analysis introduced by Kim and Kim (2018). The authors studied HSR 's impact near the station-area through hotspot analysis. And they also proposed a variable to describe a business activity with consideration for distance to the HSR station by following.

A measurement of the economic activity (V_{mi}) of the census is estimated by multiplying the number of firms by the number of workers in a district. V_{mi} can explain how many economic activities are located in the specific census. This V_{mi} index is specialized to take into account the competitive business activity within a census and the scale of employment, which are able to propose how much the census is being actively engaged in the business activity.

$$V_{mi} = W_{mi} * F_{mi} \tag{1}$$

V_{mi} is the economic scale of industry m in census i, and W_{mi} explains the number of workers of industry m in census i. F_{mi} shows the number of firms.

To consider the proximity to HSR station, Kim and Kim(2018) introduced the direct distance from each census to the census having the HSR station as like equation (2). Introducing the direct distance could be effective to estimate the correlation of each census and HSR station in order for comparing different cities and countries.

$$V_{mi}^{\alpha} = \frac{V_{mi}}{Acc_{ij^s}} \tag{2}$$

V_{mi}^{α} describes V_{mi} considering a distance decay to HSR station, and Acc_{ij^s} is an euclidian distance from census i to census j^s having HSR station.

For this study Getis-Ord G_i^* (hereafter hotspot analysis) is carried out at the census level. Hotspot analysis is firstly exploited by Getis and Ord(1992), and it is widely used to examine urban spatial structure for a correlation between different area units.

$$G_i^* = \frac{\sum_j w_{ij}x_j - \bar{x}\sum_j w_{ij}}{S\sqrt{\frac{n\sum_j w_{ij}^2 - (\sum_j w_{ij})^2}{n-1}}} \quad (3)$$

In the formulation w_{ij} is a binary weight of 1 or 0, explaining the spatial correlation between census i and j. x_j is the value of census j, in this study it signifies V_{mi}^{α}. $\bar{x}$, S and n signify a mean value of , standard deviation of , and total number of census of HSR passing city respectively. G_i^* value close to zero describes a random distribution, while positive and negative value explain an intensive cluster of high value and lower value each.

The result of analysis

A descriptive comparison of data of firms, workers, and distance to the HSR station between target cities of Korea and Japan is shown in Table. 3. In the cases of the two countries, Korea has similar mean and standard deviation between HSR stations, whereas Kyushu Shinkansen of Japan has a disparity in mean and standard deviation between four HSR stations. Figure 1 shows a process of analysis of this study.

For the hotspot analysis, we estimate V_{mi}^{α}. If districts are shown as a hotspot, the districts describe that the business activities are concentrated in the districts under the degree of closeness to the HSR station. And we can assure that there is an agglomeration effect in the districts. However, in the calculation of V_{mi} of Korea, there is inconsistency between firm and worker in same census; for example, census i has the number of workers, while it has no company data, and vice versa. In this case, V_{mi} cannot be properly estimated, so the zero value is substituted by one. In the hotspot analysis, the census having 0

TABLE 3. Selected HSR station of Korea and Japan

	Station	Firm		Worker		Distance to the HSR station		Number of census
		Mean	SD	Mean	SD	Mean	SD	
KOREA	Seoul / Yongsan	4.092205	13.02595	36.58972	231.5957	8322.244	3711.393	19,153
	Daejeon / Seodaejeon	4.484039	10.40181	24.4013	119.835	4647.638	3249.598	3,070
	Dongdaegu	4.390016	10.67412	19.76867	74.31329	7562.239	4695.795	4,928
	Busan / Gupo	4.537195	11.68358	23.37033	110.8512	7552.325	4564.089	6,802
	Gwangju-Songjeong	4.855072	12.70429	20.91963	86.70139	8909.215	3171.892	3,036
JAPAN	Hakata	9.305272	19.16702	123.4277	510.97	6857.558	3998.583	1,176
	Kurume	10.27572	15.47839	80.88889	179.9328	6939.871	4814.615	243
	Kumamoto	5.951965	7.719529	53.19105	140.6121	5699.892	3130.429	916
	Kagoshima-Chuo	13.1412	18.02799	97.84496	220.943	5712.719	4440.963	387

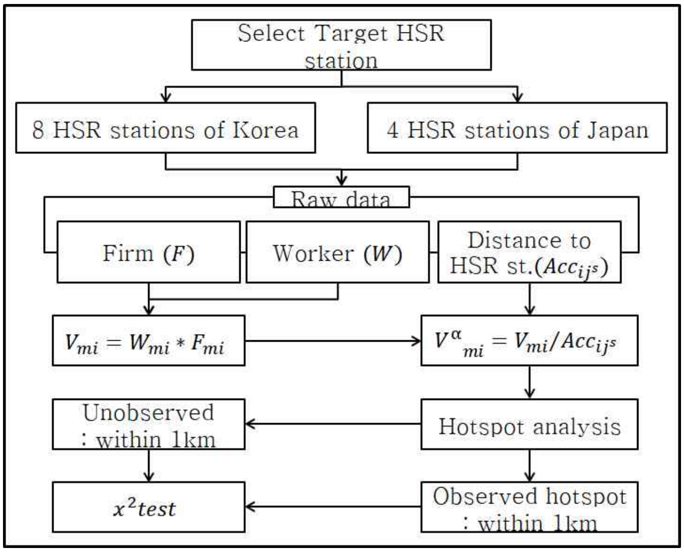

FIGURE 1. Analysis process

value in V_{mi} is excluded to control the overestimation, since even census having no business activity (V_{mi}=0) could be shown as a hotspot district.

The results of hotspot analysis for the service−industry in each HSR station are shown in Figure 2. An observation of the hotspot district within the HSR station−area follows three criteria. Firstly, the HSR station−area is the area within 1km from the HSR station. Secondly, a classification of hotspot (or coldspot) follows p−value under 0.05 criteria. Thirdly, a decision of whether the HSR station shows the agglomeration pattern of the service industry within the coverage is distinguished by that one or above hotspot district should be included within 1km from the HSR station. Here, the inclusion of one hotspot district is according to that over two− thirds of the hotspot district area should be included within the distance of 1km from the HSR station. In three criteria, the hotspot observation is decided by each HSR station of Korea and Japan, then they are organized in Table 4 according to the observation and unobservation in order to examine the similar characteristic between HSR stations having different socioeconomic backgrounds.

With the results of hotspot analysis, x^2 test is applied to compare the relation of hotspot districts and the HSR−station area. Table 5 describes the result of x^2test of Korea, Japan, and the sum of cases of two countries respectively. All of the three x^2

TABLE 4. Result of hotspot analysis by HSR station

Result	Korea	Japan
Hotspot observed	Seoul, Yongsan, Daejeon, Seodaejeon, Dongdaegu, Busan, Gwangju−Songjeong	Kumamoto, Hakata, Kurume
Unobserved	Gupo	Kagoshima−Chuo

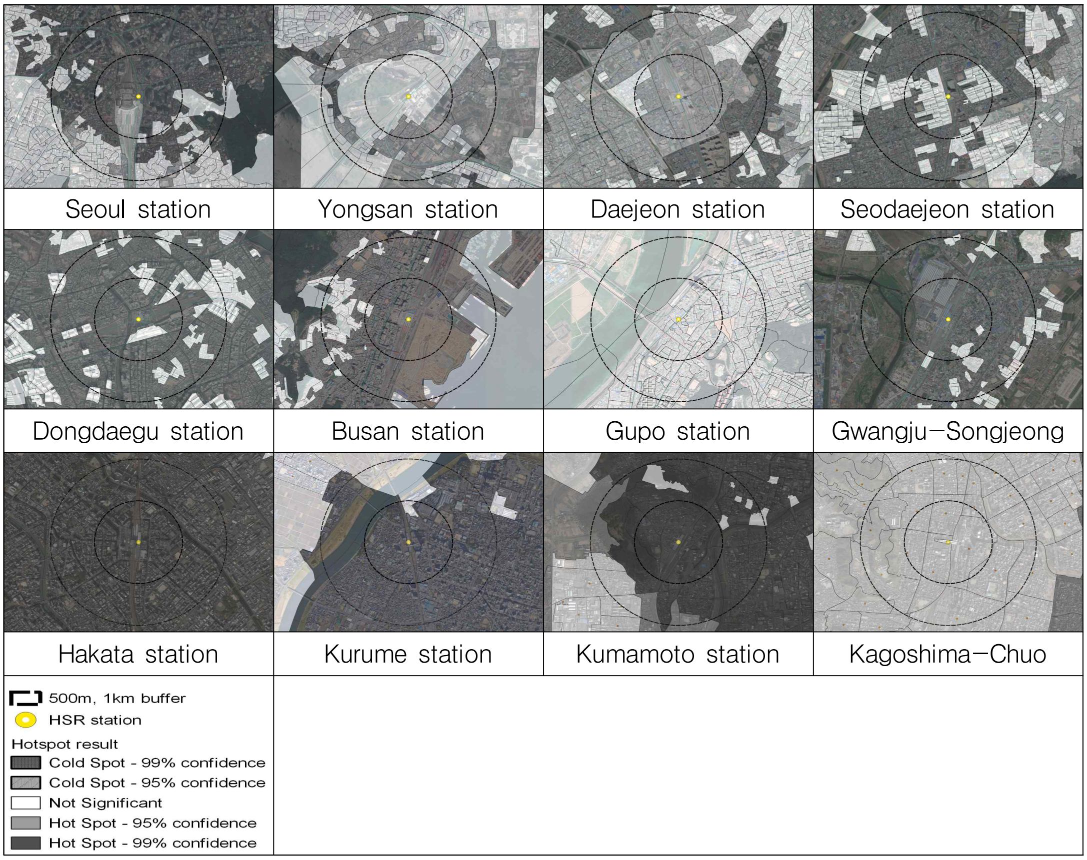

FIGURE 2. Results of hotspot analysis

TABLE 5. Chi–square test for the results of hotspot analysis

Korea				
HSR station–area	Hotspot result		N (%)	x^2
	Unobserved	Observed hotspot		
Non station–area	12,408 (85.3)	2,132 (14.7)	14,540 (100)	869.154*
HSR–station–area	112 (29.2)	271 (70.8)	383 (100)	
Japan				
HSR station–area	Hotspot result		N (%)	x^2
	Unobserved	Observed hotspot		
Non station–area	2,534 (76.3)	788 (23.7)	3,322 (100)	198.471*
HSR–station–area	17 (15.9)	90 (84.1)	107 (100)	
Korea and Japan				
HSR station–area	Hotspot result		N (%)	x^2
	Unobserved	Observed hotspot		
Non station–area	14,942 (83.7)	2,920 (16.3)	17,862 (100)	1,067.489*
HSR–station–area	129 (26.3)	361 (73.7)	490 (100)	

* p–value < 0.000

test are statistically significant in p−value 0.000, and it explains that there is a relation between HSR station−area and hotspot observation. We can be assured that the probability of hotspot district could be higher within the HSR station−area than the outside of the HSR station−area. Although the number of hotspot districts is large in the non HSR−station, it is resulted from the larger number of districts outside the station−area compared to the HSR station−area. In the case of Korea, a proportion of the hotspot observation within the HSR station−area is 70.8%, which is higher than 14.7% of the non HSR station−area. Japan shows 84.1% hotspot observation within the HSR station−area as well, while the hotspot observation of non HSR station−area is about 23.7%. Finally, the proportion of the hotspot observation within HSR station−area in the aggregate of Korea and Japan is about 73.7%, which is higher than 16.3% of non HSR−station area.

The results of service industry include the hotspot district within 1km from 10 HSR stations except for Gupo station of Korea and Kaghoshima−Chuo station of Japan. The service industry is an aggregated industry with recreation, business support and personal service, so business activity related to recreation and business support could congregate in the district showing hotspot. What should be carefully discussed is a possibility of the subordinate structure occupying the most composition. Personal service consists of diverse small business activity related to living industry, which are mainly located in the residential land−use. Given the targeting HSR station located in a central urban area, these business activities could be mistaken for the overestimation near the HSR station. However, it is still encouraged that the service industry is clustered near the HSR station, except for the personal or living−related service, which covers tourism related business such as arts, sports and amusement. The inflow of HSR passengers to the city, who is particularly attracted by the business, accelerates the relocation to the HSR station as well.

The result of hotspot analysis cannot be solely argued to be affected by HSR only under that other variables are controlled, since the business activities are affected by other variables and they are entangled with each other. For example, a location of the HSR station in the built−up area affects the hotspot results. Further, there is a time−lag between the analyzed data of this study and the HSR station opening. However, the consideration of the proximity to the HSR station could complement the limitation, since the direct distance to the HSR station from a centroid of each areal unit also explains how a proximity to the HSR station affects the spatial pattern of each industry as well. Therefore, we could examine the spatial structure near HSR station−area by the service industry and HSR station.

Conclusion

This study explored the spatial agglomeration structure of the service industry between the districts within 1km from 12 HSR stations of Korea and Japan. For this, hotspot analysis was employed, and the results are organized according to whether hotspot census is observed or not within 1km from HSR station. The result suggests that 10 HSR stations have hotspot districts, but Gupo station of Korea and Kagoshima-Chuo station of Kyushu Shinkansen does not show hotspot districts. Overall, we can be assured that the proximity to the HSR station could have an effect on the location of the service industries. Although 10 HSR stations having hotspot districts have a different socioeconomic backgrounds, the similar spatial pattern of the service industry is observed. Considering that HSR operation for passenger travels have an immediate relation with service industry such as leisure and business support industries, the agglomeration near the HSR station could be resulted from benefits of the proximity to the HSR station. From these discussions, it is required to build up a supportive policy to maximize the HSR' s impact on the service industry when considering the HSR station-area development. Further, it may be also needed to concern the proximity to the HSR station in the urban planning of regional level, not only the station-area.

However, it is still left behind to study the changed pattern through the time-series: for example, as mentioned above, the relocation of existing company after HSR opening, and HSR' s impact on the spatial pattern under control of the exogenous socioeconomic condition. In addition, it is also required to verify statistical significance between the accessibility to HSR and the industrial location. These tasks should be achieved in the next step to shed light on HSR' s impact on urban spatial structure. Further, it should be carefully considered to investigate the socioeconomic background of each HSR passing through the city at the same time to consider the diverse socioeconomic factors affecting the service industry. KAGIS

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