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**INDUSTRIAL SPECIALIZATION OR DIVERSITY?
HOW HIGH-SPEED RAIL FOSTERS JAPAN'S
REGIONAL AGGLOMERATION ECONOMY**

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Abstract

In this paper, the relationship between high-speed rail (HSR) and agglomeration economy in the scope of specialization and diversity is investigated. The main objective is to answer two questions: first, to determine whether specialization or diversity promotes economic productivity, and second, to determine whether HSR promotes specialization or diversity. Specialization/diversity agglomeration index based on the coefficient of variation of localization agglomeration is proposed to measure city's specialization and diversity. Analyses utilize the data of agglomeration across 17 industrial sectors in Japanese Municipality level. Depending on the definition of agglomeration diversity, one of the results reveals a U-curve relationship as productivity is plotted in Y-axis and specialization agglomeration in X-axis. In other words, both specialization and diversity benefit to economic productivity. Yet, a city which is not specialized and not with a high level of industrial diversity will be the loser in the economy. For the second question, based on the assumption of a quadratic function, HSR could affect city's specialization and diversity based on the distance to HSR service. From the results, HSR promotes industrial diversity in the city with HSR service, and the city located around 540 km away from HSR service, while HSR promotes city's specialization in the city located around 270 km away from HSR service.

Contents

1. INTRODUCTION

Literature regarding agglomeration on specialization and diversity are ambiguous with respect to which is best at contributing to local productivity. Local specialization favors the original idea of Marshall (1920) that better productivity from agglomeration can be expected in areas where firms in similar sectors are located close to each other. Conversely, industrial diversity represents the idea proposed by Jacobs (1969) that innovation growth is stimulated by industrial variety, which better synthesizes diverse ideas and information than specialization. Although empirical analysis from past literature suggests the importance of diversity over specialization, the concept of specialization is still intriguing and should not be ignored. It is interesting to understand why the effects of industrial diversity benefit the overall economy, whereas industrial specialization is rarely suggested in past empirical studies.

Specialization/diversity agglomeration is usually discussed on the basis of the spatial interaction between activities (such as interaction between firms and workers). By taking spatial issues into account, it is certain that transportation improvement can enhance the performance of spatial interaction between activities. Better transportation reduces the cost of travel, encourages more meetings, discussions, and things like workshops between firms, and this hastens the learning process, accelerates firms' technology advances, and results in better productivity. Transportation literature such as that of Graham (2007), Graham et al. (2009), and Melo et al. (2013, 2016) consider transportation as one of the factors for agglomeration economies and show that improvement in accessibility by transportation in terms of "Effective Density" could create a better agglomeration environment. However, deliberation of the transportation effect has only considered the size of agglomeration. Considering the specialization/diversity effect of transportation from a theoretical viewpoint, one fact can be extracted from the New Economic Geography (NEG); lower trade cost resulting from better transportation leads to a greater variety of goods in the economy (Krugman, 1991). Yet, there is a lack of empirical study to support NEG's idea. This is especially true in the case of high speed rail (HSR), which mainly involves passenger transport (in contrast to NEG's focus on freight transport) and thus implies a different effect than that proposed by NEG. This paper addresses two concepts. I explore the relationship between industrial specialization/diversity and productivity, and I empirically analyze how HSR affects local industrial specialization/diversity.

2. LITERATURE REVIEW

Past literature provides many perspectives on agglomeration economies. Rosenthal and Strange (2004) categorized these agglomeration perspectives into four scopes: industrial scope; temporal scope; geographical scope; and organization scope. In this paper, I focus on the industrial scope, which is the most widely discussed topic in the literature regarding agglomeration economies. Within the industrial scope, Rosenthal and Strange (2004) provide two sub-scopes commonly discussed in the literature. The first sub-scope focuses on the size of the industrial agglomeration; whether the size of the agglomeration within same industry (localization agglomeration), or the size of total agglomeration in the economy (urbanization agglomeration), is more beneficial to productivity in the agglomerated area. With the contribution from transportation infrastructures such as HSR, localization agglomeration was shown to produce higher agglomeration benefit to the economy (Wetwitoo and Kato, 2017). However, in this paper, I focus the discussion on another sub-scope; whether an agglomerated area with

more specialization or diversity is more beneficial to productivity. In general, the localization/urbanization agglomeration scope, and specialization/diversity agglomeration scope appear similar, since the concept of Marshall's economy could be applied to both localization agglomeration and specialization agglomeration, while the concept of Jacob's economy could be applied to both urbanization agglomeration and diversity agglomeration. Table 1 provides a further explanation to distinguish the characteristic of the sub-scope within the industrial scope.

As mentioned, past empirical literature may favor the benefit from localization agglomeration rather than urbanization agglomeration. However, in the specialization/diversity scope, surprisingly, the positive significance to the economy of diversity agglomeration has been highlighted more than specialization. There are some studies underscoring the benefit of specialization agglomeration, but only in conceptual perspective. Helsley and Strange (1990) provides the model emphasizing the job-matching process, and concludes that more specialization means a larger pool of workers with a similar skill, allows for better matching, and eventually leads to greater productivity. The general equilibrium model proposed in Duranton and Puga (2001) suggests the importance of both specialized and diversified environments, where the diversified city could be suitable for firms in their early stages while matured firms find larger benefit in a specialized city.

In the empirical studies, however, the diversity agglomeration is found to be more beneficial to the economy than specialization agglomeration. Glaeser et al. (1992) analyzes the growth of the top six industries in 1956, concluding that specialization does not encourage growth. Similar interpretation also can be found in Henderson et al. (1995), which concluded that specialization made no positive contribution to growth in high-technology industries in the 1970–1987 period. Henderson et al. (1995) further suggest that employment growth is higher in the area with more employment diversity, which is measured by the Herfindahl-Hirschman Index (HHI) of employment. Thus, results from empirical studies tend to favor the importance to the economy of diversity agglomeration rather than specialization agglomeration.

Nevertheless, from past literature, several issues regarding specialization/diversity agglomeration remain inconclusive. Although, intuitively, the mechanism of diversity agglomeration shares several similarities to urbanization agglomeration, the reason why larger benefit is usually associated with the localization agglomeration effect rather than urbanization is a topic that should be discussed along with the specialization/diversity scope. Another issue for consideration involves the indexes used to measure specialization/diversity. Usually, two types of indexes are utilized to measure the degree of specialization or diversity; first, the index that considers industrial distribution only in its own area, to which HHI is usually applied, and the second type, in which the distribution of each industry across every area is considered, along with distribution across industry in its own area. In the latter type, the indexes derived from Ellison and Glaeser's agglomeration index (Ellison and Glaeser, 1997) are usually introduced in the analysis. The question is which type of index can best explain the condition of industrial synthesis mentioned in Jacob's economy? Furthermore, indexes used in past literature often neglect the neighboring effect, especially the first type of index, in which only activity distribution in its own area is considered. With respect to my assertion that an agglomeration discussion should include spatial consideration, incorporating the neighboring effect shows that the degree of specialization/diversity could be varied across spatial unevenness, too.

**Table 1: Characteristics of the Localization/Urbanization
and Specialization/Diversity Agglomeration**

Concept	Size of Agglomeration	Distribution of Agglomeration
Marshall's economy	Localization agglomeration	Specialization agglomeration
Jacob's economy	Urbanization agglomeration	Diversity agglomeration

Until now, there has been no literature that investigates the effect of transportation on specialization/diversity, especially HSR. Past literature usually assumes that industrial promotion depends on specific policy and is not affected by infrastructure investment such as HSR. Therefore, in this study, I propose a new causal effect assuming that new transportation modes such as HSR service induce a change in the industrial agglomeration structure.

3. METHODOLOGY

Although past literature favors the effect from diversity agglomeration rather than specialization agglomeration, one important issue is how the indexes are selected to explain the characteristics of diversity/specialization. The ideal index should be the index that can best capture the characteristics of Marshall's economy or Jacob's economy. Since Marshall's concept of industrial scale of economies does not mention the interaction of the scale of economies between industries, and vice versa, Jacob's concept does not restrict any industrial specialization, it is possible that diversity and specialization could be considered in separate frameworks. For instance, Batisse (2002) and Thabet (2015) consider specialization as a ratio between a share of industry within a zone and a share of industry from the whole country, while diversity is separately defined as an inverse of normalized HHI of industry concentration. Paci and Usai (1999) and Van Der Panne (2004) measure industrial diversity by index based on a reciprocal of the Gini index. Despite past studies considering specialization/diversity in separate variables, they could be intuitively considered together with the same index, as they can be viewed as opposing factors to each other. The index used in Batisse (2002) and Thabet (2015) shows that diversity is defined as an index of industry concentration, and this concentration can be also considered as specialization.

I have pointed out several other issues, such as incorporation of the neighboring effect, in order to express the actual "agglomeration." Employment growth is the most commonly used indicator for measuring specialization/diversity agglomeration (Glaeser et al. 1992; Henderson et al. 1995; Paci and Usai 1999; Van Der Panne 2004), although other indicators, such as value added, is also applied in studies such as Batisse (2002) and Thabet (2015). These indexes still fail to capture the neighboring effect. In order to capture the neighboring effect, the following indicator is applied to measure the regional agglomeration in this study.

$$A_{i,k} = \sum_j \frac{E_{j,k}}{g_{j \to i}} \tag{1}$$

where $A_{i,k}$ represents the agglomeration of industry k in zone i, $E_{j,k}$ represents the activity of industry k in zone j, and $g_{i \to j}$ represents the generalized cost of transport from zone j and zone i. In this study, I simplify the activity $E_{j,k}$ as industry k employment in zone j, and generalized cost $g_{i \to j}$ is simplified as the Euclidian distance between zone i and zone j. The calculation of activity in zone j includes intra-zone activity, where $j = i$ as

well. This indicator is an application of the gravity model used in past studies, such as in Stewart's (1947) "Population Potential" index, or later in Graham (2007) and other transportation-related studies as an index called "Effective Density."

Index selection with respect to industrial distribution must consider whether agglomeration should be confined to its own zone, or the whole study area. For example, the specialization index used in Glaeser et al. (1992), Paci and Usai (1999), and Batisse (2002) considers agglomeration of the whole study area as a ratio between regional specialization and global specialization. On the other hand, the HHI and Gini indexes considered an agglomeration only in its zone, since the share of industry is considered only within its own region. From these two concepts, we propose two indexes based on coefficient of variation. The first case presents agglomeration only in its own zone:

$$CV_{A_i} = \frac{\sigma_{A_i}}{\mu_{A_i}} = \frac{\sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(A_{i,k}-\mu_{A_i}\right)^2}}{\frac{1}{n}\sum_{k=1}^{n}A_{i,k}} \tag{2}$$

where CV_{A_i} represents the specialization/diversity agglomeration index of zone *i* in the first case, σ_{A_i} represents the standard deviation of agglomeration across every *n* industries in zone *i*, and μ_{A_i} represents the mean of agglomeration across every *n* industries in zone *i*. This index range displays a perfect diversified zone and perfect specialized zone from 0 to ∞, where the *perfect diversified zone means the agglomeration level of every industry is uniformly and equally distributed*, and the perfect specialized zone means there is only one industry agglomerated in the zone.

In the second case, agglomeration of the whole study area is considered and coefficient of variation is determined by the local agglomeration concentration, in contrast to the first case. The local agglomeration concentration is determined by:

$$s_{i,k} = \frac{A_{i,k}}{\frac{1}{n}\sum_{k=1}^{n}A_{i,k}} \tag{3}$$

where $s_{i,k}$ represents local agglomeration concentration of industry *k* in zone *i*, which is determined by the ratio of agglomeration of industry *k* in zone *i* to average agglomeration in zone *i*. The specialization/diversity agglomeration index in the second case is formulated as:

$$CV_{s_i} = \frac{\sigma_{s_i}}{\mu_{s_i}} = \frac{\sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(s_{i,k}-\mu_{s_i}\right)^2}}{\frac{1}{n}\sum_{k=1}^{n}s_{i,k}} \tag{4}$$

where CV_{s_i} represents the specialization/diversity agglomeration index of zone *i* in the second case, σ_{s_i} represents the standard deviation of local share of agglomeration across every *n* industries in zone *i*, and μ_{s_i} represents the mean of local share of agglomeration across every *n* industries in zone *i*. This is the index range of perfect diversified zone and perfect specialized zone from 0 to ∞. However, in the second case, the *perfect diversified zone is achieved if the distribution of industry in such zone is equal to the global industrial distribution*. The perfect specialized zone is the case where there is only one industry agglomerated in the zone, as seen in the first case. Figure 1 shows industrial distribution of five industries in the first and second cases where the zone is perfectly diversified.

Figure 1: Industrial Distribution of Perfect Diversified Zone from the First and Second Case of Specialization/Diversity Agglomeration Index
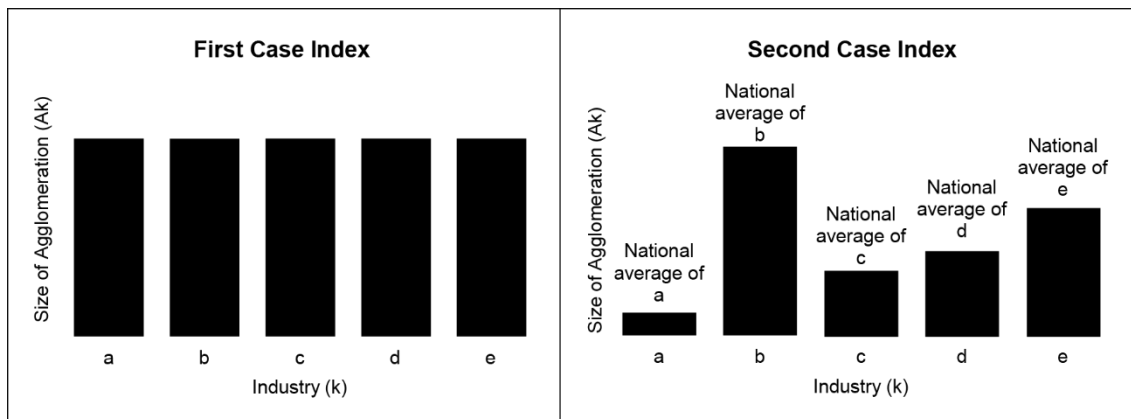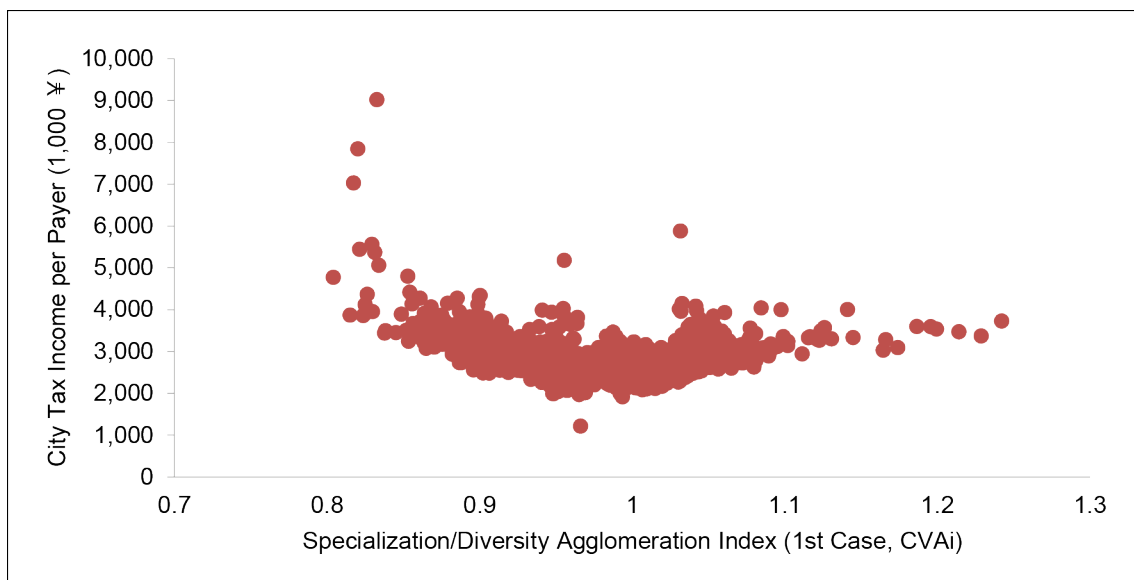

4. SPECIALIZATION/DIVERSITY AGGLOMERATION AND LOCAL PRODUCTIVITY

Past studies tend to consider specialization and diversity in separate contexts. This separate framework could be logical from the perspective of agglomeration of small industry (e.g., in terms of employment). For example, in a region with a high concentration of IT industry, such region could be considered highly specialized in the IT industry. Still, the region maintains a high level of diversity because its share of IT employment is relatively low compared to industries such as manufacturing and other general services. However, from the perspective of large industry, this separate framework may not be effective since a high concentration of large industry always leads to lower diversity. A marginal increase of specialization of any industry might lead to an increase or decrease in marginal diversity, depending on the original size of agglomeration. Thus, it depends on how specialization and diversity are defined to best match the concepts of Marshall's and Jacob's economies. In this study, I define "specialization" as a city's specialization, not industrial concentration, as defined in other studies. In other words, if the city has a high concentration of any industry, regardless of which industry, such city will be defined as a specialized city by my definition. Using this definition, it is possible to investigate specialization agglomeration and diversified agglomeration as opposing factors with the same index.

Here, I investigate the effect of specialization/diversity agglomeration on local productivity in a Japanese municipality (city). I measured the agglomeration level from the number of employees across 17 industrial categories from 1,907 Japanese municipalities and the Euclidian distance between the city hall of each municipality. Local productivity is measured by municipality corporate tax income per number of taxpayers. The cross-sectional data is based on 2014 Economic Census for Business Frame from the Japanese Ministry of Economy, Trade and Industry (METI). Figure 2 shows the relationship between specialization/diversity agglomeration indexes and local productivity in the first case, where only agglomeration in its own zone is considered.
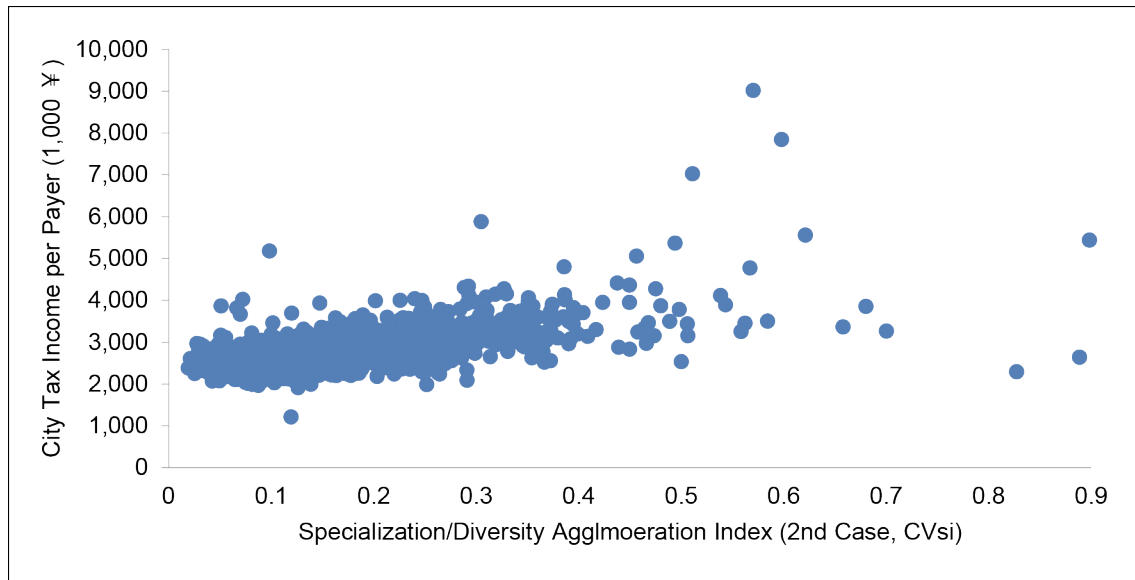
Considering the relationship between the index and the productivity from the specialization/diversity agglomeration index, I found the u-shape relationship in the first case index (Figure 2). By assuming that uniform distribution of agglomeration size across industries is the perfect diversity case, the u-shape relationship could be explained through both Marshall's economy and Jacob's economy in the same time. Plots on the left half of Figure 2 could follow the explanation of Jacob's economy, where cities with more diversity (although not perfectly diversified or $CV_{Ai} = 0$) have more opportunity to obtain the spillover effect from different businesses. Marshall's economy could explain the situation of cities in the plot on the right half of the figure, where benefit from specialization agglomeration within a few industries becomes significant. However, cities situated along the middle of the plot are the losers; diversification of industry is not large enough nor is the specialization of any dominant industry strong enough to enjoy an agglomeration benefit. Therefore, according to this plot, temporal shift of level of specialization (CV_{Ai}) should be planned carefully. For example, if the city on the right half of the plot wishes to increase its productivity in the next 10 years, changing its industrial distribution to be more specialized (at least more than the average global trend in the next 10 years) should guarantee better productivity. Otherwise, it should implement aggressive plans to promote more diversity in the city in order to shift its position from the right half to the left half of the plot.

Figure 2: City Productivity and Its Specialization/Diversity Agglomeration Index (First Case)

As for the second case, where agglomeration of the whole study area is considered, the relationship between specialization/diversity agglomeration indexes and local productivity is portrayed in Figure 3.

Figure 3: City Productivity and Its Specialization/Diversity Agglomeration Index (Second Case)


Considering the relationship between the index and the productivity from specialization/diversity agglomeration index, we found a linear relationship in the second case index (Figure 3). By assuming that average national distribution of agglomeration size across industries is the perfect diversity case, it could be interpreted that the national average distribution is not the productive distribution. This could further explain why the unevenness of spatial concentration can be observed across the country as firms might avoid locating their industries where the industrial agglomeration distribution is close to average national distribution. Viewed with this index, as a city develops its specialization, it can enjoy more clustering benefit through the concept of Marshall's economy. However, the ideal concept of Jacob's economy may not be explained by this index, as average national distribution is not the ideal industrial distribution portrayed by Jacob's economy. Therefore, if a city wishes to improve its productivity, it should try to avoid composing its industries along the lines of the national average. Since the index in the second case (CV_{Si}) presents only a one-way relationship, going forward I focus on only the first index (CV_{Ai}) so that the dynamics of productivity with respect to specialization can be discussed.

5. HIGH-SPEED RAIL AND SPECIALIZATION/ DIVERSITY AGGLOMERATION

In this section, I investigate the relationship between HSR and the level of specialization agglomeration in order to link the effect of HSR to productivity through specialization agglomeration. First, I present the discussion of the specialization/ diversity situation and HSR in Japan. Then I further analyze the effect of HSR and specialization agglomeration through regression analysis. CV_{Ai} used in both discussions are based on the data presented in earlier sections.

**Figure 4: Specialization/Diversity (First Case) Agglomeration Index
in Japan (2014)**

Lines and dots represent HSR routes and stations
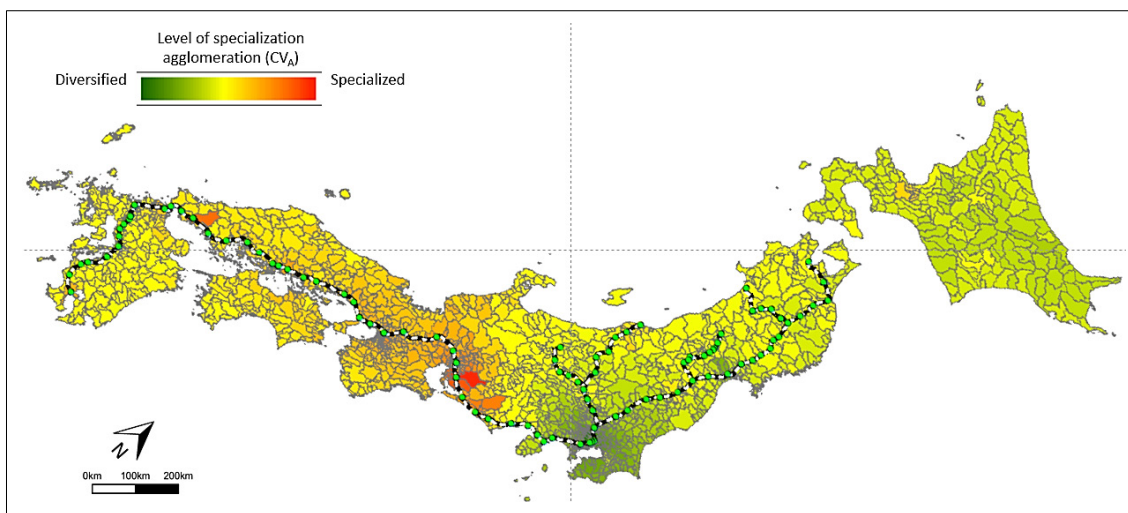
Several findings can be drawn from the plot of CV_{Ai} in the first case, at the Japanese municipality level (Figure 4). Comparing the east and the west regions, the west side tends to be more specialized than the east side, due in large part to the high industrial diversity in the Tokyo metropolitan area. To be precise, specialized industries with a lower share of workers, such as the finance and IT sectors, are concentrated in Tokyo. This makes our index more diversified because the share of small industry is larger in Tokyo than other regions. It is also possible to say that Tokyo is a highly specialized area for such industries. However, the index used in this study defines specialization as applying to the whole economy, not any specific industry. This index also considers the neighboring effect, so regions close to Tokyo are highly affected by the agglomeration in Tokyo, especially when the agglomeration level in their own regions is significantly smaller than that of Tokyo. In addition to the distinction between west and east, the difference between regions located along HSR routes and those located farther away can be observed as well. The regions along HSR lines tend to be more specialized, although there might be some exceptions. Nevertheless, more analysis is needed to explain the relationship between HSR and level of specialization agglomeration.

To reach a better understanding of the relationship between HSR and level of specialization agglomeration, CV_{Ai} is applied as a dependent variable for regression analysis. Dependent variables consist of HSR-related variables and other socio-economic variables. The general model specification can be defined as follows:

$$CV_{A_i} = f(\alpha(HSR), \gamma(\phi)) \tag{5}$$

Where:

CV_{Ai} : Specialization/diversity index (first case)

$\alpha(HSR)$: Function of HSR-related variables

$\gamma(\phi)$: Function of other socio-economic-related variables

Here, the effect of HSR ($\alpha(HSR)$) is determined as a function of the distance from the concern city *i* to the nearest HSR station. Furthermore, I assume the effect of HSR to specialization in quadratic function. This assumption is based on the three cases of trade cost proposed in Ottaviano et al. (2002). Also, I applied the technique of spatial lag and time lag to this estimation. Spatial lag term incorporates the effect of specialization agglomeration level in neighboring cities weighted by distance. Time lag takes into consideration the level of specialization agglomeration in lagged year. In summary, the function to be estimated is structured as follows:

$$CV_{A_i} = \beta_0 + \beta_1 HSR_i + \beta_2 HSR_i^2 + \beta_3 \mathbf{WCV_A} + \beta_4 CV_{A_{i,2012}} + \beta_5 U_i + \beta_6 U_i^2 +$$

$$\beta_7 DID_i + \beta_8 DID_i^2 + \beta_9 PD_i^2 + \beta_{10} OH_i + \beta_{11} TW_i + \beta_{12} DC_i + \beta_{13} MF_i \qquad (6)$$

Where:

HSR_i : Distance from city *i* to the nearest HSR station (km)

$\mathbf{WCV_A}$: A matrix of product between reciprocal of distance between city *i* to other cities and specialization index of other cities in year 2014

$CV_{A_{i,2012}}$: Specialization agglomeration of city *i* in year 2012

U_i : Unemployment rate in city *i*

DID_i : Percentage of Densely Inhabited District of the prefecture in which city *i* is located

PD_i : Population density of city *i* (person/km^2)

OH_i : Rate of owned house in city *i*

TW_i : Percentage of workers in tertiary industry in city *i*

DC_i : Designated city dummy; equals 1 if city *i* is designated city, 0 if not

MF_i : Male-to-female population ratio in city *i*

Table 2 shows the estimation result based on Eq. 6. The estimate of HSR parameters shows positive value in β_1 and negative value in β_2. In other words, the inverse u-shape parabolic curve is found if the distance to the HSR station is plotted on the X-axis and the specialization index is plotted on the Y-axis. Based on this relationship, the result can be interpreted into three cases. First, cities along the HSR lines receive agglomeration benefit, which is strengthened by HSR. This agglomeration benefit attracts firms from other regions to relocate in order to enjoy the agglomeration benefit. Thus, cities along HSR lines tend to be more diversified because various types of business relocate to those cities. However, cities located further away from HSR lines (those on the apex of the inverse u-shape parabolic, according to the estimation, located approximately 270 km away from HSR lines) tend to be more specialized because many businesses relocated to cities along HSR lines. Only the business that is not affected by agglomeration impact remains in the city. This industry eventually becomes the dominant industry, which causes the index to be more specialized. In cases where cities are located very far from HSR (according to the estimation, those located approximately 540 km away from HSR lines), firms may decide not to relocate because agglomeration benefit could be less than the trade cost. If firms relocate, the premium from agglomeration could be less than the cost to transport their products from a city along HSR lines to a city very far from HSR lines. Thus, it could be better to produce and sell in the same area. This situation causes cities that are very far from HSR to diversify,

because they do not relocate, although in our dataset, the level of diversity in these regions is still smaller in comparison to regions along HSR lines.

Table 2: Estimation Result

	Estimates	SE	t-stat	p-value
Constant	–0.9747	0.0028	–343.735	0.000
HSR	2.16E-05	4.48E-06	4.814	0.000
HSR²	–3.94E-08	7.59E-09	–5.194	0.000
WCV$_A$	0.9979	0.0015	673.697	0.000
$CV_{A_{2012}}$	0.9894	0.0033	300.525	0.000
U	0.0155	0.0023	6.621	0.000
U²	–0.0017	0.0003	–5.113	0.000
DID	4.11E-04	8.08E-05	5.085	0.000
DID²	–4.26E-06	6.53E-07	–6.523	0.000
PD²	–73.9864	6.8397	–10.817	0.000
OH	–1.76E-06	1.64E-07	–10.740	0.000
TW	–7.73E-05	2.12E-05	–3.649	0.000
DC	0.0060	0.0009	6.435	0.000
MF	–2.87E-04	3.02E-05	–9.519	0.000
R²				0.9913

6. CONCLUSION

The analysis in this chapter aims to answer two questions related to specialization agglomeration: how does industrial specialization agglomeration affect a city's productivity and how does HSR affect industrial specialization agglomeration? The answers to these questions can be drawn from the analyses in this study as follows:

- Specialization agglomeration benefits productivity, but diversity agglomeration benefits productivity, as well. The loser in this productivity competition is the city whose industry diversification is not large enough, or whose specialization in any dominant industry is not strong enough to enjoy the agglomeration benefit.

- The introduction of HSR could shape the spatial distribution of specialization agglomeration into the case where a city is diversified, or specialized, depending on the distance to HSR service.

The concept of specialization agglomeration is quite straightforward; a single dominant industry leads to more agglomeration benefit. However, the concept of diversity agglomeration still remains unclear. What is the best combination of industry to maximize the diversity agglomeration as defined in Jacobs' economy? This study only assumed two types of perfect diversity agglomeration: uniform distribution and national average distribution. This study proves that national average distribution is the ideal diversity agglomeration. However, it remains unclear whether or not uniform distribution is the best answer for diversity agglomeration. Further analysis and discussion are needed. I suggest that the distribution of agglomeration (specialization/diversity) and the concept of the size of agglomeration (localization/urbanization) should be employed together to identify the best industrial combination to achieve Jacob's agglomeration.

This empirical result from Japan could be one piece of the evidence of how HSR shapes the new spatial distribution of industrial agglomeration. For countries who wish to introduce HSR service, one of the possible policy implications is that cities could prepare for the change of industrial distribution, into a diversified city or a specialized city, according to the new HSR service. Case study of Japan is advantageous because there is very little intervention from government policy and changes in industrial distribution are supervised mainly by the private sector. However, central and local government could signal the change of industrial distribution in order to capture the best agglomeration benefits along with HSR investment. Thus, this result could be one of the possible references for the public sector to guide the private sector in the best direction.

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