Spatial Distribution Analysis of Employment in the Great Tokyo Area – Did suburbanization of employment occur from 1985 to 2015?

Program: Spatial Data Science and Visualization

Department: Center for Advanced Spatial Analysis

Word count: 2967

Code used available from: RPubs

Data available from: https://drive.google.com/drive/folders/1xoepVZhRpCyzxXal3-QNOYbRLvcbY5Kw?usp=sharing

1. Introduction

According to the traditional monocentric urban model (Alonso 1964), The Central Business District (CBD) of a city is considered as the economic and political center of the city, and therefore, it is the core are of employment of the city. However, due to the wide spread of private cars, mobile devices, and infrastructure construction during 1980s, there was a phenomenon of suburbanization observed in North American cities such as Los Angeles (Small and Song 1994). As a result, the urban structure of these cities has become polycentric and employment has turned into a decentralized pattern as well.

The Great Tokyo Area, also known as the Capital Region, is one of the world's largest metropolitan area, which consists the Tokyo-to, Chiba, Saitama, and Kanagawa prefectures. The total population of Great Tokyo Area was 36 million with population density of 2662 people per km^2 in 2015, estimated by the United Nations. Previous studies on the Great Tokyo Area mainly focus on its economic efficiency and city growth, few of them concentrate on its employment distribution. Moreover, the Tokyo-to government has formulated several plans on building a city with multiple centers since 1982 (Aoyama, 2008). As a result, this investigation is aimed to analyze changes of the spatial distribution pattern of the Great Tokyo Area from 1985 to 2015, and whether there is an employment suburbanization in the Great Tokyo Area by using spatial autocorrelation analysis.

This investigation is organized as follows: Section 2 will provide reviews of literature on the development of urban structure theory and the employment pattern analysis; Section 3 will briefly introduce the study area and dataset, and the used methodology which is the Moran Index will be introduced in this Section as well. Section 4 will present the analysis results, and they will be discussed in Section 5. Section 6 will draw some conclusions and recommendations.

2. Literature Review

2.1 The Development of Urban Employment Structure

The earlies urban structure model is pointed out by Von Thunen in 1980s. He analyzed German's land use and cost of agriculture and argued that with the distance between an are and city center increases, the cost of land increases. Then, based on his theory, Alonso (1964) developed the traditional monocentric urban structure model, which the CBD has a significant role in economic activities. Between 1970s and 1980s, Guillain et al (2006) argued that the employment suburbanization was widely observed in North America cities such as San Francisco (Cervero and Wu 1997). The same employment pattern has been identified in some European cities like Ile-de-France as well (Guillain et al, 2006).

2.2 Decentralization Plan in Tokyo-to

In 1980s, the Tokyo-to government has established several systems and published several acts to support development of municipalities. For example, a "District Planning System" is established to protect city environment by limiting the construction of road and building in cities. On the other hand, this system provides municipality governments with full decision-making power to have better charge of their municipality (Tokyo Metropolitan Government, n.d.). Moreover, in 1986, the Tokyo-to government has officially put the multiple-core urban structure as the primary goal of urban development (Aoyama, 2008). Moreover, in 2007, 2009 and 2011, the central government has established several councils and published the Decentralization Law to promote the decentralization process in Tokyo, and the City Planning Act was in 2015 was still followed this law (Tokyo Metropolitan Government, n.d.).

3. Data and Study Area

3.1 Dataset and Choice of Variable

The shapefile of Japanese map is available Geospatial Information Authority of Japan. For analysis, only the map of Tokyo-to, Chiba-ken, Kanagawa-ken and Saitama Ken is used and municipalities with the same area code are merged together. The municipalities of Saitama city, Yokohama city, Kawasaki city, Sagamihara city, and Chiba city, and islands of Tokyo-to are excluded as well. These processes are conducted by the QGIS. Finally, 203 municipalities are included for analysis. The dataset used in the investigation is from the e-Stat which is a portal of official Japanese statistics. All municipalities' data is available from

the System of Social and Demographic Statistics (SSDS) on the e-Stat site. The population and employment data used in the SSDS comes from the Japanese population census, which is conducted every 5 years from 1980. However, the employed people data of some municipalities in 1980 is not available. Based on the centralization acting plans of Tokyo-to, year 1985 and 2015 are chosen as the beginning of the study, and setting 2000 as a mid-point, which would fully reflect the changes of distribution pattern of employment in the Great Tokyo Area. Furthermore, according to Guillain's et al approach (2006), the employment-to-population-ratio is used as a measurement of employment centers. Similar to Paris, there are plenty of jobs concentrated in the Tokyo city, especially the 23 special wards, using employment density (employed people per hectare) would exclude some subareas with high employment rate but with small population and large area (Guillain et al, 2006).

3.2 Study Area

Figure 1 shows the composition of the Great Tokyo Area: Tokyo-to, Chiba-ken, Saitama-ken, and Kanagawa-ken, covering 203 municipalities. The total area of the Great Tokyo Area was 1,356,216 hectares in 2015, only for accounting for 3.6 per cent of total area of Japan. However, in 2015, it had 36,130,685 population, representing 28.4 per cent of Japan total population, and the employed people was 16,345,368, occupying 27.7% of national employed people. It also generated about 33.1 per cent of national GDP in 2014. The CBD of the Great Tokyo Area is considered to be the north-west municipalities of Tokyo-to where some famous business areas like Shinjuku are located.

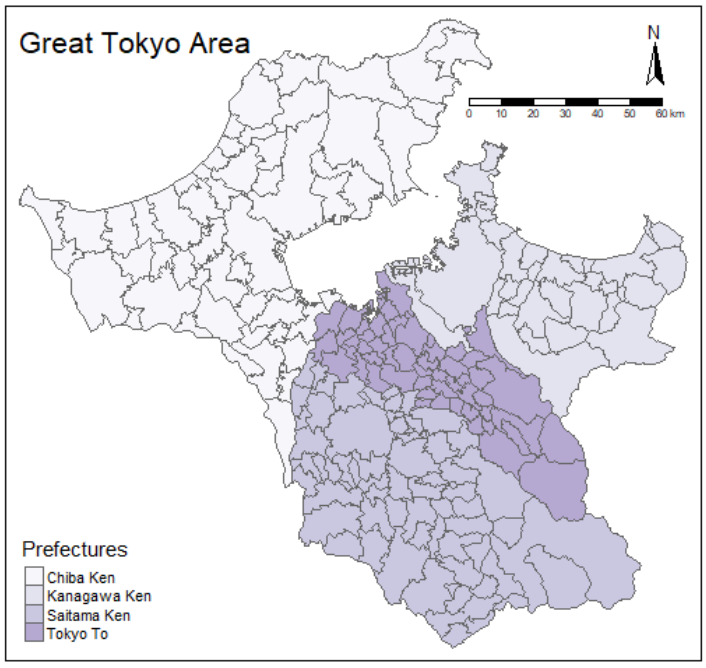

Figure 1: Great Tokyo Area

From 1985 to 2015, the total land area of the Great Tokyo Area almost remains unchanged (1,351,387 hectares in 1985) while the population has increased 19.3 per cent (30,273,178 people in 1985) during this period. The labor force (employed people plus unemployed people) rises 11.8 per cent and the employed people increases by 10.9 per cent in this area as well. More specially on employment, peopled employed in the primary (agriculture, forestry, fishing, etc.) and secondary industry (manufacturing, construction, food industry etc.) falls by 55.8 per cent and 35.7 per cent respectively while employees in the tertiary industry (finance, insurance, hotels etc.) rises 24.4 per cent, which generally reflects the industrial transformation in the Great Tokyo Area during the last 3 decades.

4. Methodology

The main methodology used in this study is the spatial autocorrelation to explore spatial effects of the distribution of employment in the Great Tokyo Area. The spatial autocorrelation is used to identify whether the spatial distribution pattern is cluster, dispersed or random. In other words, it can reflect the similarity of regions of a selected variable (Anselin, 2001). Moreover, the spatial heterogeneity is also studied to check whether the

central role of employment of CBD has been changed from 1985 to 2015. This spatial analysis is carried out by R.

4.1 Global Spatial Autocorrelation Analysis

This spatial analysis is carried out by Exploratory Spatial Data Analysis (ESDA) tools, and the first step is to build a spatial weighted matrix which is used to identify spatial neighbors and assign weights to these neighbors. The "Queen style" contiguity-based spatial weighted matrix is used in this analysis, which defines spatial neighbors by 2 areas sharing a boundary or a point. With a spatial weighted matrix, several tools can be used analyze spatial autocorrelation and spatial heterogeneity, such as the Moran' I statistic, the Geary's C statistic and the General G statistic. This study focuses on the Moran's I. The Moran's I is developed by Moran (1950), which is defined as follows:

$$I = \frac{N \sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_i \sum_j w_{ij}) \sum_i (x_i - \bar{x})^2}$$

where I is the global Moran's I statistic, N is the number of areas x_i and x_j are values of the variable in area i and j and $\bar{x}$ is the average value of the observed variable, in this study, x is the employment-to-population-ratio, w_{ij} is the spatial weighted index of contiguity.

The value of Moran's I belongs to [-1, 1], 1 means a clustered spatial distribution pattern of the variable, 0 represents a random or no distribution pattern and -1 indicates a dispersed pattern.

4.2 Local Spatial Autocorrelation Analysis

Although Moran's I can provide a spatial distribution pattern of a variable, it cannot show which areas are clustered or dispersed. Thus, local spatial autocorrelation is used to identify economic centers and subcenters in this analysis by calculating the Local Indicators of Spatial Association (LISA). The indicator used is the Local Moran's I (Anselin, 1995) which is defined as:

$$I_i = z_i \sum_j w_{ij} z_j$$

where I_i is the local Moran's I statistic of area *I*, $z_i = \frac{x_i - \bar{x}}{SD}$ is the variable *x* in standardized form, and *SD* is the standard deviation of *x.* Generally, the LISA approach is conducted by calculating the local Moran's I for each region, and then plot the significant level map of regions, which can reflect the employment centers and subcenters in the Great Tokyo Area.

5. Results

5.1 Global Spatial Autocorrelation

Table 1 presents the results of the Global Moran's I statistic of the employment-to-population-ratio in 1985 and 2015.

Variable	Moran's I	p-value
1985 Employment to Population	0.569	0.000
2000 Employment to Population	0.435	0.000
2015 Employment to Population	0.418	0.000

Table 1: Moran's I Statistic of Employment-to-population-ratio in 1985 and 2015 (Queen weighted metrics)

The 0.000 p-values in 1985 and 2015 confirms that there is spatial autocorrelation of employment-to-population-ratio in the Great Tokyo Area between 1985 and 2015. The Global Moran's I statistics in 1985, 2000 and 2015 are, 0.569, 0.435 and 0.418 respectively, all of which indicates a clustering pattern of the spatial distribution of the employment-to-population-ratio in each year. In other words, the employment-to-population-ratio of a municipality is similar to its nearby municipality during this period. Moreover, the decrease trend of Moran's I statistic between 1985 and 2015 indicates the spatial distribution pattern of employment-to-population-ratio becomes more and more random from 1985 to 2015.

5.2 Local Spatial Autocorrelation

As discussed in the methodology part, the local spatial autocorrelation analysis enables to identify the employment centers and subcenters. According to Anselin (1995), the Moran's

scatterplot is a way to study the local spatial autocorrelation. Figure 2 presents the Moran's scatterplot of employment-to-population-ratio in the Great Tokyo Area in 1985 (upper left), 2000 (upper right) and 2015 (lower right).

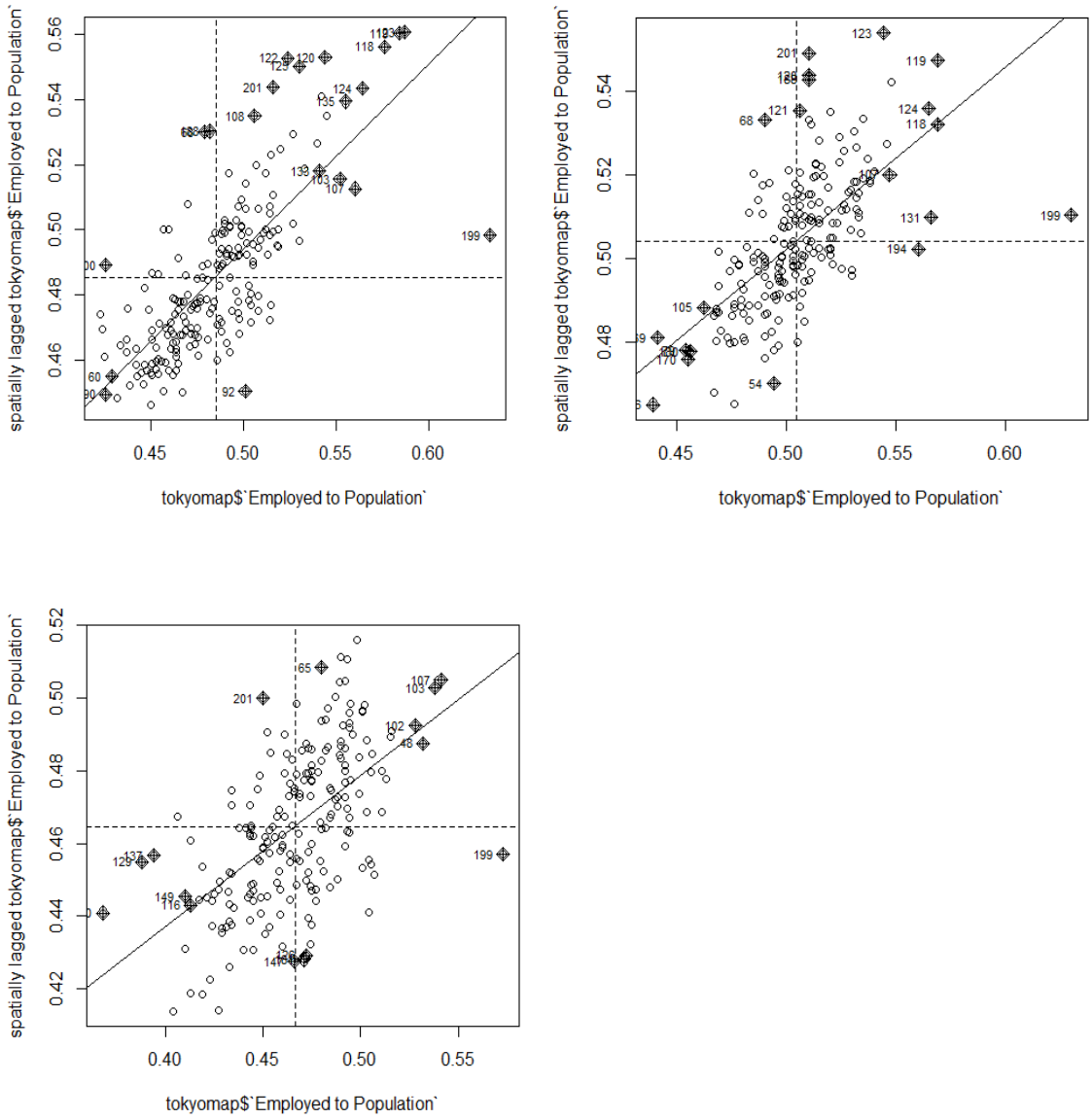

Figure 2: Moran's Scatterplots of Employment-to-population-ratio in 1985 (upper left), 2000 (upper right), 2015 (lower left).

In the scatterplot, the straight line reflects the spatial autocorrelation and the global Moran's statistic becomes the slope of the line. The 2 lines in Figure 2 has a positive slope, meaning that there are positive spatial autocorrelations of employment-to-population-ratio in 1985, 2000 and 2015. Moreover, the 4 areas in the scatterplot presents 4 distribution patterns. For

example, regions that have low values but surrounded by regions with lowers values (LL) are in the lower left area of the plot, and the lower right areas are high vale regions surrounded by low values (HL). Regions with low values but surrounded by high values (LH) are in the upper left quadrant while the upper right quadrant is regions with high values and surrounded by high vale regions (HH) (Anselin, 1995). Thus, the Moran Scatterplot provides a detailed spatial distribution pattern of municipalities; for example, how many municipalities follow the positive spatial autocorrelation pattern (HH and LL) and how many do not (HL and LH) (Rodríguez-Gámez and Dallerba, 2012). Based on the Moran's scatterplot, the LISA statistics

cluster map can be drawn, shown in Figure 3, which is classified by 5 levels, HH, HL, LH, LL and not significant, at the 0.05 significant level. This map reflects the spatial distribution pattern of each and can be used to define the employment centers and subcenters. According to previous literature, the employment subcenter is defined as "it is a municipality or a set of municipalities whose employment-to-population-ratio is significantly higher than the average employment-to-population-ratio in the Great Tokyo Area". It also needs to be "a municipality or a set of municipalities surrounded by municipalities with significantly low value of employment-to-population-ratio". Thus, the HH quadrant classified by the LISA cluster is used to identify the employment centers and subcenters. (Baumont et al. 2004; Guillain et al, 2006; Rodríguez-Gámez and Dallerba, 2012). Table 2 presents the number of the 5 quadrants (HH, HL, LH, LL and Not Significant) classified by the LISA cluster in 1985, 2000 and 2015.

Year	HH	HL	LH	LL	Not Significant
1985	25	0	27	0	151
2000	20	0	23	0	160
2015	17	0	27	0	159

Table 2: Results of LISA Cluster in 1985, 2000 and 2015

The LISA cluster results show a decrease trend of the number of employment centers and subcenters (HH municipalities) from 1985 to 2015, which indicate a more random distribution of the employment-to-population-ratio from 1985 to 2015. Then, a LISA cluster

map for year 1985 (upper left), 2000 (upper right), 2015 (lower left), shown in Figure 3.

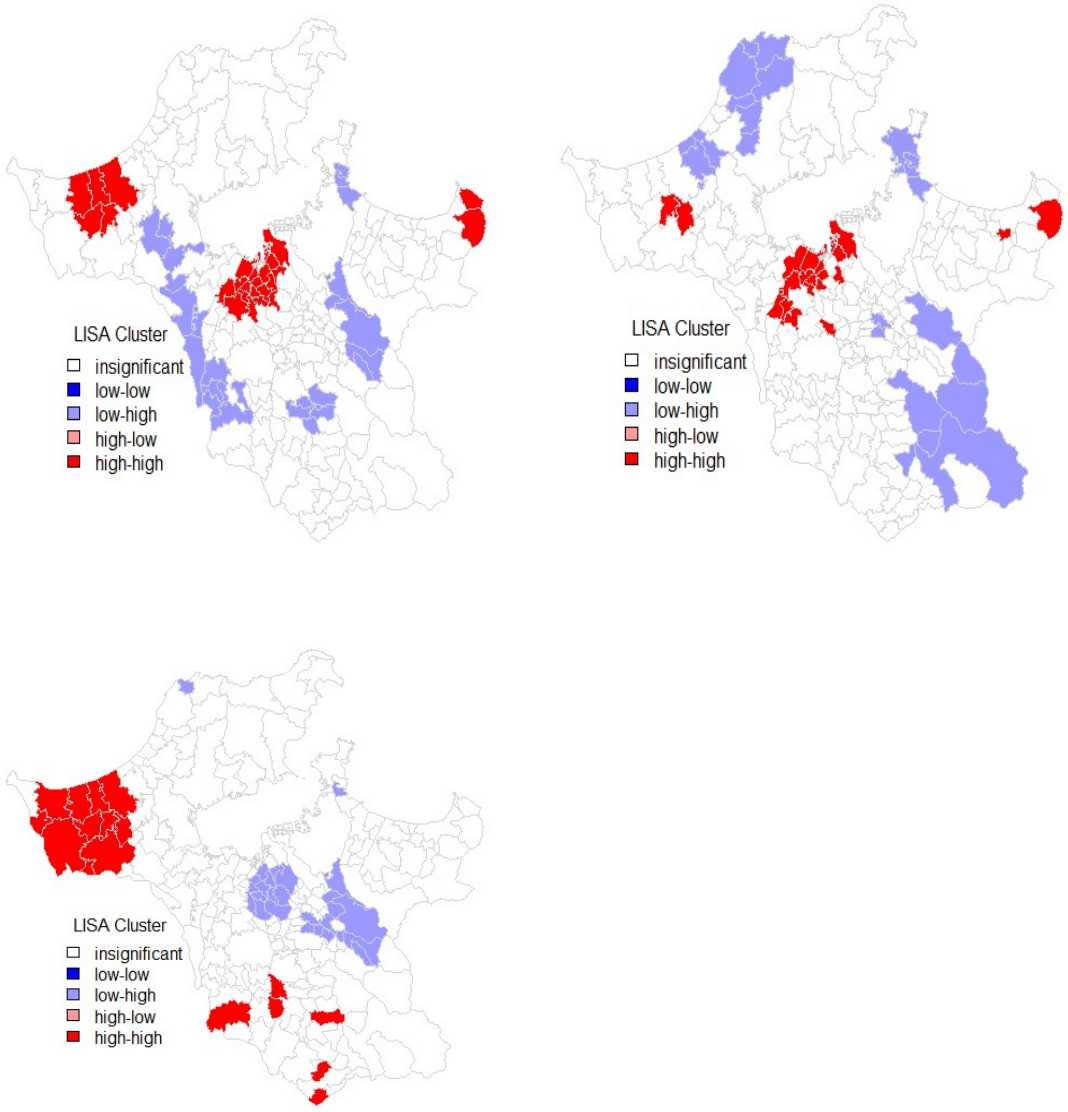

Figure 3: LISA Cluster Maps of Employment-to-population-ration in 1985 (upper left), 2000 (upper right) and 2015 (lower left)

According to Figure 3, in 1985, the Tokyo-to CBD (middle red areas) was the employment center, covering 18 municipalities while in 2000, the CBD was still an employment center but its size decreased to 15 municipalities. Finally, in 2015, the Tokyo-to CBD was not a HH area, therefore, it was no longer an employment center. Moreover, in 1985 there were 2 employment subcenters located in Chiba prefecture (red areas on the left) and Kanagawa

prefectures (red areas on the right) while in 2000, the employment subcenter in Kanagawa prefecture (red areas on the right) remained its employment subcenter role but its size decreased to one municipality and another area in Kanagawa became an employment subcenter (small red area on the right of the map). Moreover, the size of the subcenter in 1985 in Chiba prefecture decreased to 1 municipality and it merged with a nearby municipality into a new employment subcenter (red areas on the left) in 2000. In 2015, the subcenter in Kanagawa prefecture (red areas on the right) vanished while the subcenter in 1985 appeared again and its sized increased to 11 municipalities. Furthermore, there were 5 new employment subcenters appeared in Saitama prefecture, covering only 1 or 2 municipalities.

6. Discussion of Results

The results of the Global Moran's I statistics indicated that there is a positive spatial autocorrelation of employment-to-population-ratio in the Great Tokyo Area. In other words, the spatial distribution pattern of employment-to-population-ratio is clustered. However, the Global Moran's I decrease by 26.6 per cent from 1985 to 2015 (fall by 23.6 per cent between 1985 and 2000), which indicates that the urban decentralization plans began in 1980s has significant effects on the employment in the Great Tokyo Area, especially between 1985 and 2000. Moreover, the LISA cluster map of local spatial analysis identifies the change of employment centers and subcenters, the Tokyo-to CBD were the employment centers from 1985 to 2000 while between 2000 and 2015, its central role in employment gradually decreased until this role disappeared in 2015. As a result, the effects of spatial heterogeneity in the Great Tokyo Area became less and less from 1985 to 2015. Between 1985 and 2000, the urban structure is more like a concentric structure as 18 out of 25 HH municipalities merged into an employment in Tokyo-to CBD in 1985 and the same pattern was found in 2000, with 15 out of 20 HH municipalities in the employment center, which is constant with Li and Monzur's (2017) study from 1986 to 1994 in Tokyo. However, from 2000 to 2015, the urban employment structure in the Great Tokyo Area presents a polycentric and decentralization pattern as the Tokyo-to CBD lost its role of employment center. The suburbanization observed in North American cities usually presents a polycentric structure

according to Cervero and Wu's (1997) research on San Francisco, but the CBD is still the most concentrated employment centers (Bogart and Ferry, 1999). The phenomenon that less employed people in Tokyo-to CBD in 2015 may be caused by the revised City Acting Plan in 2006 and 2007, which strengthened regulations on building construction in urban areas; and the 2 urban decentralization councils may have a significant role on this process (Tokyo Metropolitan Government, n.d.). Moreover, the employed people in the subcenters tend to concentrate on a typical industry. For example, in the employment subcenter of Kanagawa prefecture, 87.9 per cent of employed people were in the service industry in 1985. This is because these municipalities tend to have a specific and well-developed industry chain. The municipality in Kanagawa is famous for the hot spring, thus, the tourism and services are the main industry of the municipality.

7. Conclusion

This study analyses the spatial distribution of employment by measuring the employment-to-population-ration in the Great Tokyo Area from 1985 to 2015. It confirms the presence of a positive spatial autocorrelation in the Great Tokyo Area while the degree of clustering presents a decreasing trend over this period by the global Moran's I statistic. Moreover, the LISA cluster map demonstrates a relatively concentric employment structure with employment concentrating in the Tokyo-to CBD, while from 2000 to 2015, the employment structure became polycentric and decentralized due to Tokyo's urban decentralization and suburbanization acting plans. Thus, from 1985 to 2015, the employment in the Great Tokyo Area has distributed more and more randomly, and the suburbanization of employment has been observed as well. One of the limitations of this analysis is that it only provides a general employment distribution, the sectoral analysis conducted Rodríguez-Gámez and Dallerba (2012) and Guillain's et al (2006) study is excluded due to the data availability. Moreover, further analysis could include the transport and buildings data, which could reflect the change of the employment distribution in more details.

References:

Alonso, W. (1966). *Location and land use: toward a general theory of land rent*. Honolulu: East-West Center.

Anselin, L. (1995). *Local Indicators of Spatial Association-LISA*. Available at: https://dces.wisc.edu/wp-content/uploads/sites/128/2013/08/W4_Anselin1995.pdf [Accessed 04/01/21].

Aoyama, Yasushi. (2008). Urban policy in postwar Tokyo: Features and issues. *Governance Research,* Available from: https://m-repo.lib.meiji.ac.jp/dspace/bitstream/10291/6994/1/gabanansu_5_1.pdf [Accessed: 02/01/21].

BOGART, W. T. and FERRY, W. C. (1999) Employment centers in Greater Cleveland: evidence of evolution in a formerly monocentric city, *Urban Studies*, 36, pp. 2099–2110.

CERVERO, R. and WU, K.-L. (1997) Polycentrism, commuting, and residential location in the San Francisco Bay area, *Environment and Planning*, 29, pp. 865–886.

Guillain, R., Le Gallo, J. and Boiteux-Orain, C. (2006). Changes in Spatial and Sectoral Patterns of Employment in Ile-de-France, 1978-97. *Urban Studies*, 43(11), pp.2075–2098.

Li, Y. and Monzur, T. (2017). The spatial structure of employment in the metropolitan region of Tokyo: A scale-view. *Urban Geography*, 39(2), pp.236–262.

Moran, P.A.P. (1950). Notes on Continuous Stochastic Phenomena. *Biometrika*, 37(1/2), p.17.

Small K., and Song S. (1994) Population and employment densities: structure and change, *Journal of Urban Economics*, 36, 292-313.

Rodríguez-Gámez, L. and Dallerba, S. (2012). Spatial Distribution of Employment in Hermosillo, 1999–2004. *Urban Studies*, 49(16), pp.3663–3678.

Tokyo Metropolitan Government A. (n.d). *District Plans,* Available from: https://www.toshiseibi.metro.tokyo.lg.jp/eng/pdf/index_04.pdf?2009 Accessed: [03/01/21].

Tokyo Metropolitan Government B. (n.d). *Transition of Tokyo's Urban Planning,* Available from: https://www.toshiseibi.metro.tokyo.lg.jp/eng/pdf/index_01.pdf?2009 Accessed: [03/01/21].

Declaration of Authorship

I, Qingyan Liu, confirm that the work presented in this assessment is my own. Where information has been derived from other sources, I confirm that this has been indicated in the work.

[Qingyan Liu]

Date of signature: 11/01/2021

Assessment due date: 11/01/2021