Population Distributions of Mature Mega Regions:

A Case Study of Tokyo and Osaka, Japan

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Abstract:

A region with over 10 million inhabitants can be defined as a "mega region." Tokyo and Osaka mega regions, Japan are categorized as mature mega regions: the rate of their population growth has already become low, and will decrease. Under the situation of a stable or declining population, population increases in one area entail necessary decreases elsewhere, giving rise to uneven and inequitable inter- and intra-regional growth patterns. This paper thus analyzes demographic movements in Tokyo and Osaka mega regions to clarify uneven and inequitable inter- and intra-regional growth patterns in mega region. We analyze population levels and density from 2000 to 2010 using 500m mesh census data; analysis areas are 50 km wide from the center of region, zone data for every 10 km are used for analysis. Results confirm stagnation of the population followed by a decrease. Furthermore, population decline areas tended to decrease in both regions, regardless of current population dynamics. In particular, decrease meshes in areas with increasing population was confirmed in outer mega regions. Population decrease and the reduction of areas with increasing and decreasing populations do not happen equally throughout the whole region, and it is suggested that the difference between the inner and outer regions will grow in the future. Based on these results, it is suggested that a hypodense urban zone without increasing population may be formed throughout the whole region if the local authorities do not act to control areas, centralize population, and draw the population into the regional core.

Keywords:

Population Change, Small-Area Statistics, Tokyo, Osaka

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1. Introduction

Mega-City Regions[1] are aggregations of smaller constituent city regions that are functionally connected by transportation networks, telecommunications technologies, and other infrastructure. (P. Hall and K. Pain 2006)[1)] Mega regions (MRs), which are defined as agglomerations that have more than 10 million people, have various urban forms which are comprised of the conurbation extended from region core and spatially divided form looks like mega-city region and so on. (Y. Uchida and A. Okabe 2012)[2)] In this paper, we would like to treat with MRs as the spatial concept including mega-city region.

MRs that can reallocate capital and creative labor generally experience population growth and have competitive global economic forces. (R. Florida 2007)[3)] However, they will experience key challenges in the coming decades, including: rapid population growth, expansion of suburban landscapes, aging infrastructure, equity, strained ecosystem, and uneven and inequitable inter- and intra-regional growth patterns. To cope with these problems and promote the growth of MRs, multi-jurisdictional efforts crossing traditional jurisdictional boundaries are required.

Worldwide, there were 28 urban agglomerations with more than 10 million inhabitants in 2010, and 41 urban agglomerations will have over 10 million inhabitants by 2030. (UN 2014)[4)] According to the United Nations, the population of almost all of these MRs will increase between 2010 and 2030; only Tokyo MR and Osaka MR will decrease during this period. With a stable or declining population, there is a zero-sum situation: population increases in one area entail necessary decreases elsewhere. As a result, uneven and inequitable inter- and intra-regional growth patterns will occur. When there is too great a difference in population increases and decreases between local municipalities, this may become a barrier to cooperation across jurisdictional boundaries. The larger the difference, the more likely that economic disparities will result in social and political tensions, with a high likelihood of urban unrest in unequal cities.

Y. Uchida and A. Okabe classified 48 global MRs with more than 10 million inhabitants within a 50 km radius into 10 categories by analyzing the diversity of their distributions in terms of population density ranges and two-dimensional distribution patterns. Tokyo and Osaka MRs belong to a typology with "population concentrated in the central of the main urban area, and their urban forms not very diffuse." (Y. Uchida and A. Okabe 2012)[2)]

Both Tokyo and Osaka MRs, which are estimated to see population declines in the near future, are currently experiencing low-level population growth. This paper considers these two MRs in their mature period (i.e., with a stable population) and analyzes demographic movements to shed additional light onto the uneven and inequitable inter- and intra-regional growth patterns experienced in MRs. The next section will discuss the methodology and data, including the study areas. Sections 3-5 present results, while Section 6 concludes the paper.

2. Methodology

2-1. Tokyo and Osaka MRs

According to Y. Uchida and A. Okabe[2)], Tokyo and Osaka are MRs in which the urban zone has conurbated. According to the national census of Japan, population in the Tokyo MR increased by 4.2% between 2005 through 2010[5)], whereas population in the Osaka MR increased by only 0.6%. According to the population predictions of the United Nations (2014)[4)],

population will decrease by about 1.3% and 2.1% in the Tokyo and Osaka MRs, respectively, between 2015 and 2030. In other words, the Tokyo MR is in the late growth period while the Osaka MR is approaching the mature period, and both will be in population decline in the near future.

2-2. Data

This paper uses 500m mesh population data for Osaka and Tokyo MRs from the national census' small-area statistics for 2000, 2005, and 2010[6]. The distribution of population increase and decrease areas is analyzed for the urban area within the jurisdiction of each local municipalities, assumed to be within a 50 km radius of the former Tokyo city hall or the Osaka city hall.

2-3. Analysis methods

This study carries out two analyses to understand the population increases and decreases and the changes in population density for the small-area units within each MR. First, rings are drawn at each 10 km radius from the center of the MR to capture the characteristics of each region of the urban area[(2)]. In this way, the dynamics of the population around the periphery (outer MR) can be compared with those of the central area (inner MR).

Then, to capture whether population increase in a specific district while population decreasing, population change in a specific district is also considered. Actually the uninterrupted area within a 500m radius of a main railroad station is defined as "a railway station sphere,"[(3)] and the possibility that population gathers within these spheres is examined.

**3. Area structure based on the urban zone**

3-1. Tokyo MR

Tokyo MR has a population of over 32 million. Within the 50 km zone, there are approximately 23,000 mesh blocks with a population greater than one. 1,000 people/mesh block is equivalent to 40 people/ha, a density which is considered to be "urban zone" by the national census of Japan. Figure 1 highlights the areas with more than 1,000 people/mesh. Tokyo MR has a conurbated area structure in which the urban zone expands out from the center in every direction.

For the whole Tokyo MR, the number of mesh blocks with more than 1,000 people/mesh block increased by 2.3% over the five year period between 2005 and 2010. In other words, the urban zone of the Tokyo MR has tended to enlarge.
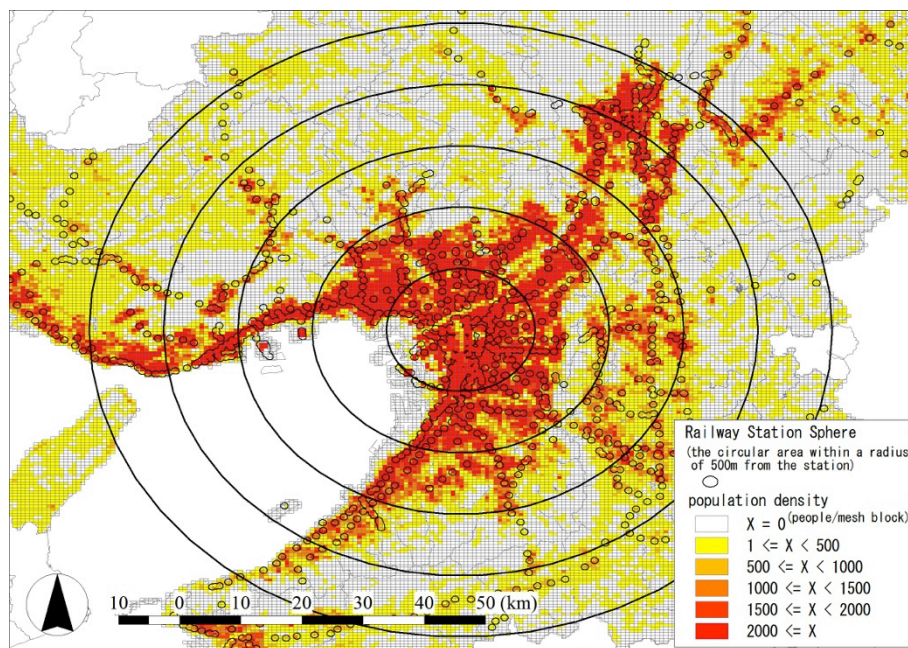
3-2. Osaka MR

The Osaka MR has a population of over 16 million. Within the 50 km zone, there are approximately 17,000 mesh blocks with a population greater than one; 5,709 of these have more than 1,000 people/mesh block, as illustrated in Figure 2. Osaka MR has a conurbated structure with the urban zone expanding out from the center to the northeastern, western, and southwestern directions.

In the full Osaka MR, the number of mesh blocks with more than 1,000 people/mesh block increased by around 1% between 2005 and 2010. This slight change shows that there has been little expansion of the urban zone in Osaka MR over these five years. One could say that the city is almost in its mature period which almost none of urban zones enlarge.
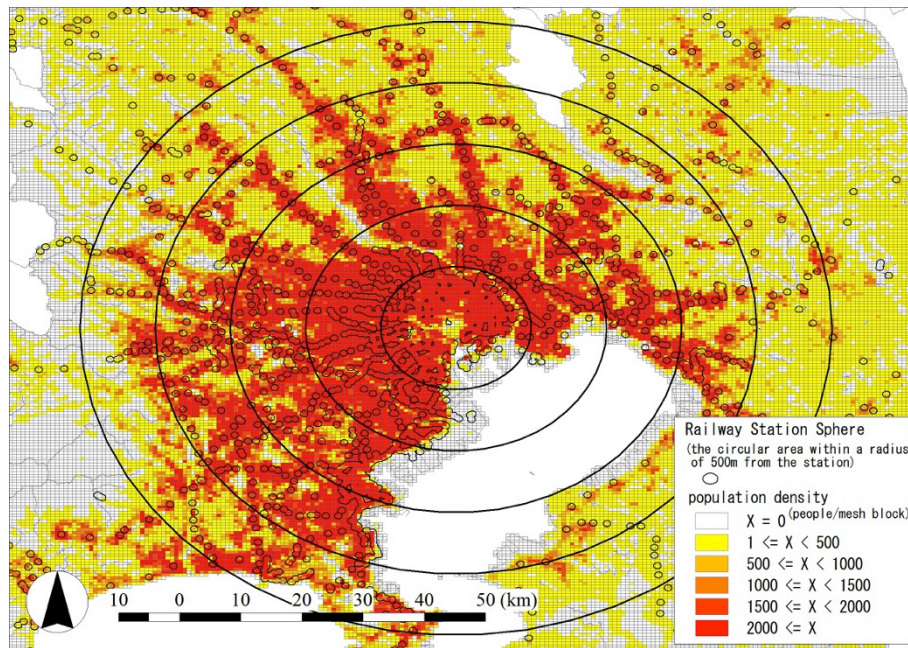
Figure 1. Population Density of the Tokyo MR (2010)

Figure 2. Population Density of the Osaka MR (2010)

4. Population dynamics within the inner and outer regions

Within the 50 km radius zones of the Tokyo and Osaka MRs, population dynamics are examined for five zones, ring-shaped one at every 10 km from the center.

4-1. Tokyo MR

When comparing the total population between 2005 and 2010, a 4.2% increase was shown

in the whole Tokyo MR (Table 1). Considering each zone separately, zones within the 30 km saw an increase of 5.1% - 7.2% over these five years, a high rate of increase. However, the growth rate fell to 1.4% - 2.5% for the zones beyond 40 km. In the region outside of the 40 km zone, the population growth rate decreased further. In other words, a tendency for people to return to the city center was seen for each zone nearest to the center of the region, whereas a slower population growth tendency was seen from the 40 km zone outward.

Comparing the area within the 30 km radius circle with that outside the 40 km radius thus showed different distributions of urban zones and rates of population change. Therefore, we divide the Tokyo MR into an outer region (from the 40 km radius out) and an inner region (inside of the 30 km radius).

Table 1. Population Change in the Tokyo MR

		2005	2010	Rate of Change
10 km Zone	Pop	3,203,224	3,433,286	7.2%
	Dens.	3,897	4,146	6.4%
	UZ	702	713	1.6%
20 km Zone	Pop	8,565,421	9,004,811	5.1%
	Dens.	3,191	3,300	3.4%
	UZ	2,375	2,404	1.2%
30 km Zone	Pop	7,834,523	8,233,253	5.1%
	Dens.	1,729	1,789	3.5%
	UZ	2,810	2,912	3.6%
40 km Zone	Pop	7,591,936	7,779,663	2.5%
	Dens.	953	968	1.6%
	UZ	2,856	2,925	2.4%
50 km Zone	Pop	4,242,335	4,300,963	1.4%
	Dens.	575	581	1.0%
	UZ	1,591	1,621	1.9%
Total	Pop	31,437,439	32,751,976	4.2%
	Dens.	1,344	1,388	3.3%
	UZ	10,334	10,575	2.3%

UZ: Urban Zone, the number of mesh blocks with more than 1,000 persons/mesh block

Pop: Total population (people), Dens.: Average density (people/mesh block)

4-2. Osaka MR

Within the 50 km zone of the Osaka MR, the total population increased by 0.6%, but decreased from the 40 km zone outwards. Considering population density, inside of the 30 km zone the area with more than 1,000 people/mesh block (= 40 people/ha) grew over this period. The mean population density of the urban zone of the Osaka MR was 2,551 people/mesh block (Table 2), and the urban zone was most concentrated inside of the 20 km zone, in particular. However, population density suddenly decreased from there outwards into the 40 km zone, because these zones have more areas with density lower than 1,000 people/mesh block.

Similarly in the Osaka MR, comparing inside of the 30 km zone with outside of the 40 km zone reveals different urban zone distributions and population changes. As such, the area from

40 km outwards is called the outer region, and that inside of the 30 km zone is called the inner region.

Table 2. Population Change in the Osaka MR

		2005	2010	Rate of Change
10 km Zone	Pop	3,680,436	3,706,296	0.7%
	Dens.	3,159	3,179	0.6%
	UZ	985	984	0.0%
20 km Zone	Pop	4,336,660	4,383,371	1.1%
	Dens.	1,799	1,788	-0.6%
	UZ	1,528	1,546	1.2%
30 km Zone	Pop	2,798,406	2,841,322	1.5%
	Dens.	1,103	1,108	0.5%
	UZ	1,053	1,077	2.3%
40 km Zone	Pop	3,250,997	3,235,234	-0.5%
	Dens.	649	640	-1.4%
	UZ	1,220	1,233	1.1%
50 km Zone	Pop	2,627,857	2,626,176	-0.1%
	Dens.	420	419	-0.2%
	UZ	851	869	2.1%
Total	Pop	16,694,356	16,792,399	0.6%
	Dens.	961	959	-0.2%
	UZ	5,637	5,709	1.3%

UZ: Urban Zone, the number of mesh blocks with more than 1,000 persons/mesh block

Pop: Total population (people), Dens.: Average density (people/mesh block)

5. Area structure in terms of the distribution of areas with population increase and decrease

In this section, the distribution of areas with population increase and population decrease is analyzed in the Tokyo MR during the late growth period and in the Osaka MR for the mature period. Furthermore, the degree of agglomeration (Area Agglomeration Rates) of the population increase and population decrease areas is analyzed.

5-1. Inner MR and outer MR
(1) Tokyo MR

After calculating differences in population growth from 2000 to 2005 and from 2005 to 2010 for each mesh block, areas of the Tokyo MR with population increases of more than 100 people (red) and population decreases of more than 100 people (blue) are shown in Figure 3. Comparing between 2000-2005 (left figure) and 2005-2010 (right figure), the number and portion of mesh blocks that had increased or decreased by more than 100 persons were less in 2005-2010 than in 2000-2005. Because population has increased in the Tokyo MR, the number of mesh blocks with decreasing population fell by about half.

Turning to the comparison of population dynamics in the inner and outer MRs, the number

and portion of mesh blocks that had increased by more than 100 persons rose in the inner MR (Table 3). This is because the population increase was concentrated in the inner MR. In addition, in the outer MR, the number and the ratio of areas with population increase and decrease was much lower, showing that population is stagnant in the outer Tokyo MR.

To summarize, in the Tokyo MR during the late growth period, the area of population increase spreads throughout the inner MR, in which population growth continues. On the other hand, in the outer MR population growth is stagnant, and the number of areas with notable population change decreases.
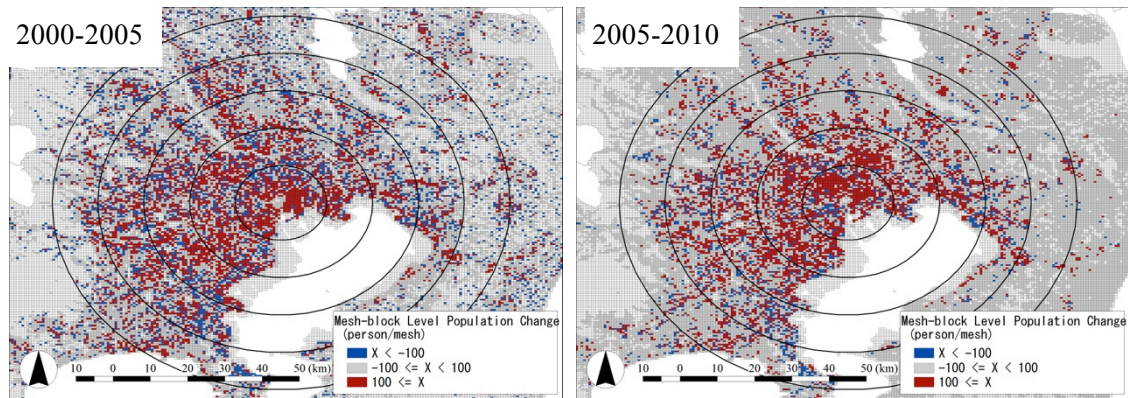

Figure 3. Distribution of Population Change in the Tokyo MR

Table 3. Mesh Block-level Population Change in the Tokyo MR

2000-2005	Population Change (persons/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Inner MR	1,318	732	1,193	1,036	776	2,755	7,810
	16.9%	9.4%	15.3%	13.3%	9.9%	35.3%	100%
Outer MR	2,025	1,878	3,040	2,391	1,162	2,046	12,542
	16.1%	15.0%	24.2%	19.1%	9.3%	16.3%	100%
Total	3,343	2,610	4,233	3,427	1,938	4,801	20,352
	16.4%	12.8%	20.8%	16.8%	9.5%	23.6%	100%

2005-2010	Population Change (persons/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Inner MR	795	580	1,529	1,377	801	2,916	7,998
	9.9%	7.3%	19.1%	17.2%	10.0%	36.5%	100%
Outer MR	912	1,100	6,674	3,899	988	1,604	15,177
	6.0%	7.2%	44.0%	25.7%	6.5%	10.6%	100%
Total	1,707	1,680	8,203	5,276	1,789	4,520	23,175
	7.4%	7.2%	35.4%	22.8%	7.7%	19.5%	100%

Note: Table cells show the changes in population in both the number of mesh blocks and the percentage of the overall area.

Based on a distribution map of mesh blocks that had increased or decreased in population by more than 100 persons, the agglomeration rates[4] are calculated to quantitatively capture the

degree to which increasing population mesh blocks and decreasing population mesh blocks are clustered. Table 4 thus compares the agglomeration rates of mesh blocks with population growth and population decline for the Tokyo MR. The portion of mesh blocks with population increases is high in the inner MR, but there is no difference across the two areas for population decrease.

When comparing the overall agglomeration rates between 2005-2010 and 2000-2005 for the whole region, the agglomeration rate for areas with increasing population grows from 40.3% to 42.2%, but the agglomeration rate for mesh blocks with decreasing population almost does not change. This tendency is common to both the inner and outer MR.

In other words, in the Tokyo MR during the late growth period, the population growth districts tends to cluster, but the population decline districts are not clustered but instead spread across the whole region. The Tokyo MR continues to enjoy population growth; as a result, the population growth districts spread and overlap with the existing urban zone. However, the population growth districts may not continue to cluster if the population declines in the future.

Table 4. Area Agglomeration Rates in the Tokyo MR

	2000-2005		2005-2010	
	Increased Mesh Blocks (+100~)	Decreased Mesh Blocks (~-100)	Increased Mesh Blocks (+100~)	Decreased Mesh Blocks (~-100)
Inner MR	46.7%	20.4%	49.3%	19.9%
Outer MR	27.9%	18.7%	29.5%	17.8%
Total	40.3%	19.6%	42.3%	18.8%

(2) Osaka MR

Using the same methods that were applied to the Tokyo MR for the Osaka MR results in Figure 4; mesh blocks where the population increased by more than 100 persons are shown in red and those where the population decreased by more than 100 persons are shown in blue. Comparing between 2005-2010 (right figure) and 2000-2005 (left figure), fewer mesh blocks, both in number and percentage, increased or decreased by more than 100 persons in 2005-2010 than in 2000-2005. This indicates that both districts experiencing population growth (via development) and population decline (due to depopulation) decreased for the region as a whole. In other words, it suggests that Osaka MR is in its mature period.
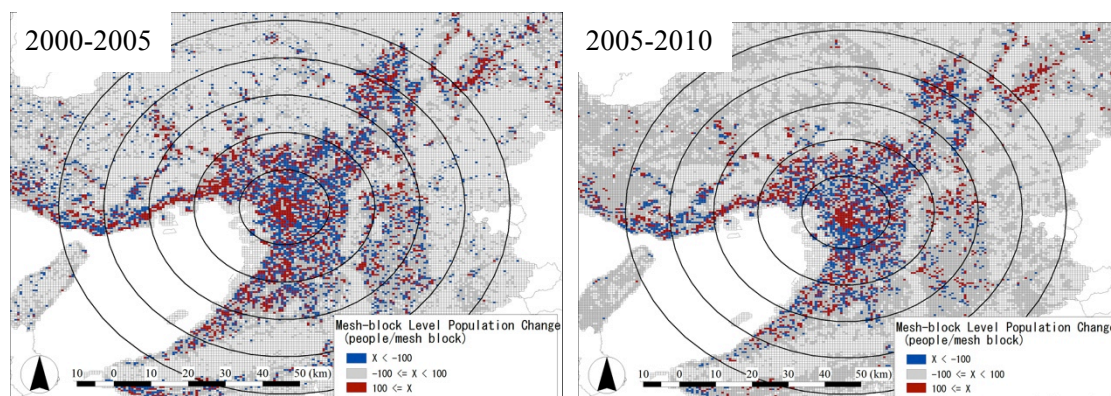
Figure 4. Distribution of Population Change in the Osaka MR

Next, population dynamics are compared between the inner MR and outer MR. Comparing 2005-2010 with 2000-2005 in the Osaka MR, the number and percentage of mesh blocks in which population increased or decreased by more than 100 persons decreased in both areas (Table 5). Further, the number and percentage of mesh blocks with only slight population changes (less than a +/-50 person change) increased. This tendency is particularly remarkable in the outer MR, where the portion of mesh blocks that increased or decreased by more than 100 people was halved.

Therefore, in the Osaka MR population hardly increased at all over these five years; the phenomena of population migration within the region, such as suburbanization and re-urbanization, were not confirmed. If this trend continues in the future, changes in the overall population distribution for the whole region will disappear and population will gradually trend towards lower density.

Table 5. Mesh Block-level Population Change in the Osaka MR

2000-2005	Population Change (persons/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Inner MR	1,507	648	1,014	798	455	1,320	5,742
	26.2%	11.3%	17.7%	13.9%	7.9%	23.0%	100%
Outer MR	1,372	1,252	2,457	1,455	582	905	8,023
	17.1%	15.6%	30.6%	18.1%	7.3%	11.3%	100%
Total	2,879	1,900	3,471	2,253	1,037	2,225	13,765
	20.9%	13.8%	25.2%	16.4%	7.5%	16.2%	100%

2005-2010	Population Change (persons/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Inner MR	1,273	620	1,476	1,088	451	1,117	6,025
	21.1%	10.3%	24.5%	18.1%	7.5%	18.5%	100%
Outer MR	775	735	5,633	2,720	449	657	10,969
	7.1%	6.7%	51.4%	24.8%	4.1%	6.0%	100%
Total	2,048	1,355	7,109	3,808	900	1,774	16,994
	12.1%	8.0%	41.8%	22.4%	5.3%	10.4%	100%

Note: Table cells show the changes in population in both the number of mesh blocks and the percentage of the overall area.

Table 6 compares the agglomeration rates between the inner MR and outer MR of Osaka MR. The higher agglomeration rate of population increase mesh blocks and population decrease mesh blocks in the inner MR indicates that, in the area with high population density, there is a tendency for population increase and decrease districts to be clustered together. When comparing the agglomeration rate between 2000-2005 and 2005-2010, the agglomeration rate of the increasing population mesh blocks drops from 32.8% to 28.9% for the region as a whole. On the other hand, the agglomeration rate for decreasing population mesh blocks is almost unchanged.

Furthermore, in the inner MR, the agglomeration rate falls for both increasing population mesh blocks and decreasing population mesh blocks. In addition, in the outer MR, the

agglomeration rates do not change for either type of mesh block. In other words, in Osaka MR in the mature period, the number of districts experiencing population growth decreases and tends to become less clustered in the inner MR. If this trend continues, within both the central and peripheral parts of the region, increasing and decreasing population areas will not be gathered together; this may result in an urban structure in which population density is equalized.

Table 6. Area Agglomeration Rates in the Osaka MR

	2000-2005		2005-2010	
	Increased Mesh Blocks (+100~)	Decreased Mesh Blocks (~-100)	Increased Mesh Blocks (+100~)	Decreased Mesh Blocks (~-100)
Inner MR	35.9%	35.2%	31.9%	32.7%
Outer MR	23.1%	25.2%	23.8%	26.6%
Total	32.8%	29.7%	28.9%	30.4%

5-2 Railway Station Spheres

(1) Tokyo MR

The area within a 500 m radius of a railroad station could be defined as a railway station sphere, and the dynamics of population within these areas were analyzed. In the inner MR of the Tokyo MR, the entire 10 km zone are covered by the railway station sphere. In addition, the railway station spheres touch along the traffic artery because the distances between stations are short within the 30 km zone. In the outer MR, the railway station sphere disperses.

Considering population change from 2005 through 2010, the rate of population increase in the railway station sphere is higher than that outside the railway station sphere (Table 7). This characteristic is particularly strong within the range of the 30 km zone. Similarly, the values for population density and rate of growth in population density are higher within the railway station sphere.

The 2010 population density within the railway station sphere of the Tokyo MR was 2,946 people/mesh block. This is similar to the 2,802 people/mesh block value for the population density of the whole conurbated area (1,000 people/mesh block). In addition, when comparing with Table 1, this value is approximately equivalent to the population density of the 20-30 km zone.
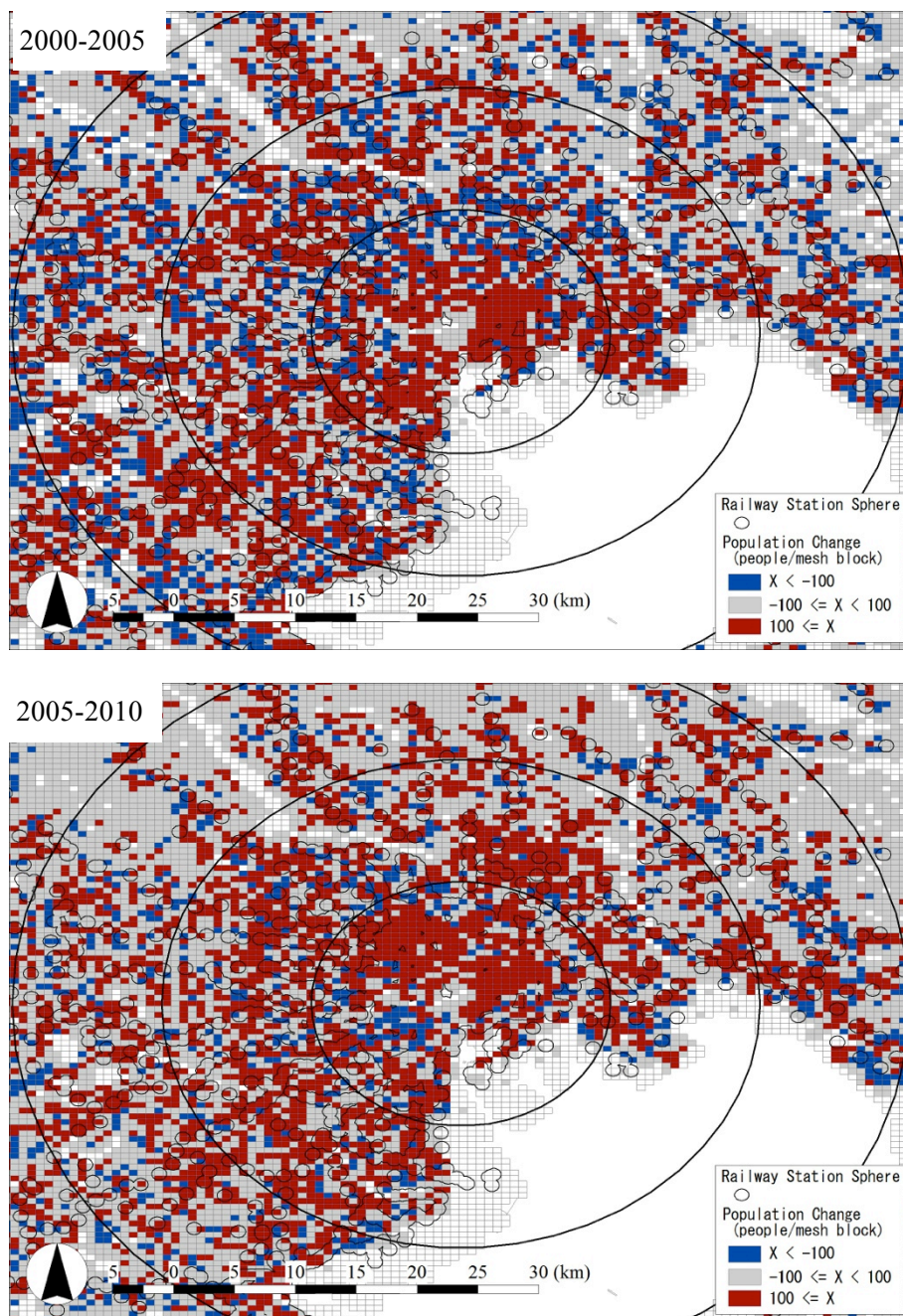
Table 7. Population Change in the Railway Station Sphere of the Tokyo MR

		2005	2010	Rate of Change
Railway Station Sphere	Pop	10,421,704	11,011,045	5.7%
	Dens.	2,808	2,946	4.9%
Outside Railway Station Sphere	Pop	21,015,735	21,740,931	3.5%
	Dens.	1,068	1,095	2.5%
Total	Pop	31,437,439	32,751,976	4.2%
	Dens.	1,344	1,388	3.2%

Pop: Total population (people), Dens.: Average density (people/mesh block)

The distributions of increasing population and decreasing population mesh blocks within the railway station sphere are shown in Figure 5. As mentioned above, blocks in which population grew by more than 100 people are in red; those where it decreased by more than 100 persons mesh are shown in blue.

In the Tokyo MR, the mesh blocks representing approximately 16% of the whole region become the railway station sphere. Using the data from 2005-2010, the portion of mesh blocks with increasing population in the railway station sphere is 41.7%. Conversely, the portion of mesh blocks with decreasing population is 11.6%, lower than that with increasing population. In other words, population is generally becoming more concentrated in the railway station sphere.

Figure 5. Mesh block-level Population Change in the Tokyo MR Railway Station Sphere

When comparing the data for the railway station sphere between 2000-2005 and 2005-2010 (Table 8), the number of mesh blocks with increasing population grows from 1,461 to 1,542, and the percentage grows from 40.4% to 41.7%. Furthermore, the number of mesh blocks with population decreases falls from 654 to 428, and the percentage falls from 17.9% to 11.6%.

On the other hand, outside of the railway station sphere, the number and the percentage of increasing population mesh blocks falls, as do the number and percentage of those with decreasing population. In other words, in the Tokyo MR in the late growth period, population concentration continues in the railway station sphere after 2000, showing a trend towards re-urbanization. However, areas with decreasing population do not increase outside the railway station sphere. As a result, while the Tokyo MR as a whole sees population growth, the population concentrates within the railway station sphere. However, Tokyo MR could become a region where the population is not concentrated within the railway station sphere during the mature period, when the population will be decreasing.

Table 8. Mesh Block-level Population Change in the Tokyo MR Railway Station Sphere

2000-2005	Population Change (people/mesh block)						Total
	~ -100	-100 ~ -50	~ -100	-100 ~ -50	~ -100	+100 ~	
Railway Station	654	335	456	389	358	1,461	3,653
Sphere	17.9%	9.2%	12.5%	10.6%	9.8%	40.0%	100%
Outside Railway	2,689	2,275	3,777	3,038	1,580	3,340	16,699
Station Sphere	16.1%	13.6%	22.6%	18.2%	9.5%	20.0%	100%
Total	3,343	2,610	4,233	3,427	1,938	4,801	20,352
	16.4%	12.8%	20.8%	16.8%	9.5%	23.6%	100%

2005-2010	Population Change (people/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Railway Station	428	295	560	488	389	1,542	3,702
Sphere	11.6%	8.0%	15.1%	13.2%	10.5%	41.7%	100%
Outside Railway	1,279	1,385	7,643	4,788	1,400	2,978	19,473
Station Sphere	6.6%	7.1%	39.2%	24.6%	7.2%	15.3%	100%
Total	1,707	1,680	8,203	5,276	1,789	4,520	23,175
	7.4%	7.2%	35.4%	22.8%	7.7%	19.5%	100%

Note: Table cells show the changes in population in both the number of mesh blocks and the percentage of the overall area.

(2) Osaka MR

About half of the 10 km zone in the Osaka MR belongs the railway station sphere, which also touch along the traffic artery because the distance between stations is short into the 20 km zone, where there are subway lines. However, these become less continuous in the 30 km zone. Overall approximately 15% of the mesh blocks in the region belong to the railway station sphere.

Considering population change between 2005 and 2010, the rate of population increase within the railway station sphere is higher than that outside the railway station sphere (Table 9). This is particularly noticeable within the 30 km zone. Similarly, the values for population density and its growth rate are higher within the railway station sphere. The 2010 population density in the railway station sphere of Osaka MR was 2,226 people/mesh block. This is at about the same level as the population density of the entire conurbated area: 2,551 people/mesh block. When comparing with Table 2, the value for the railway station sphere is approximately equivalent to the population density of the 10-20 km zone. Like the Tokyo MR, the railway station sphere is an area with high population density, particularly in the conurbated area.

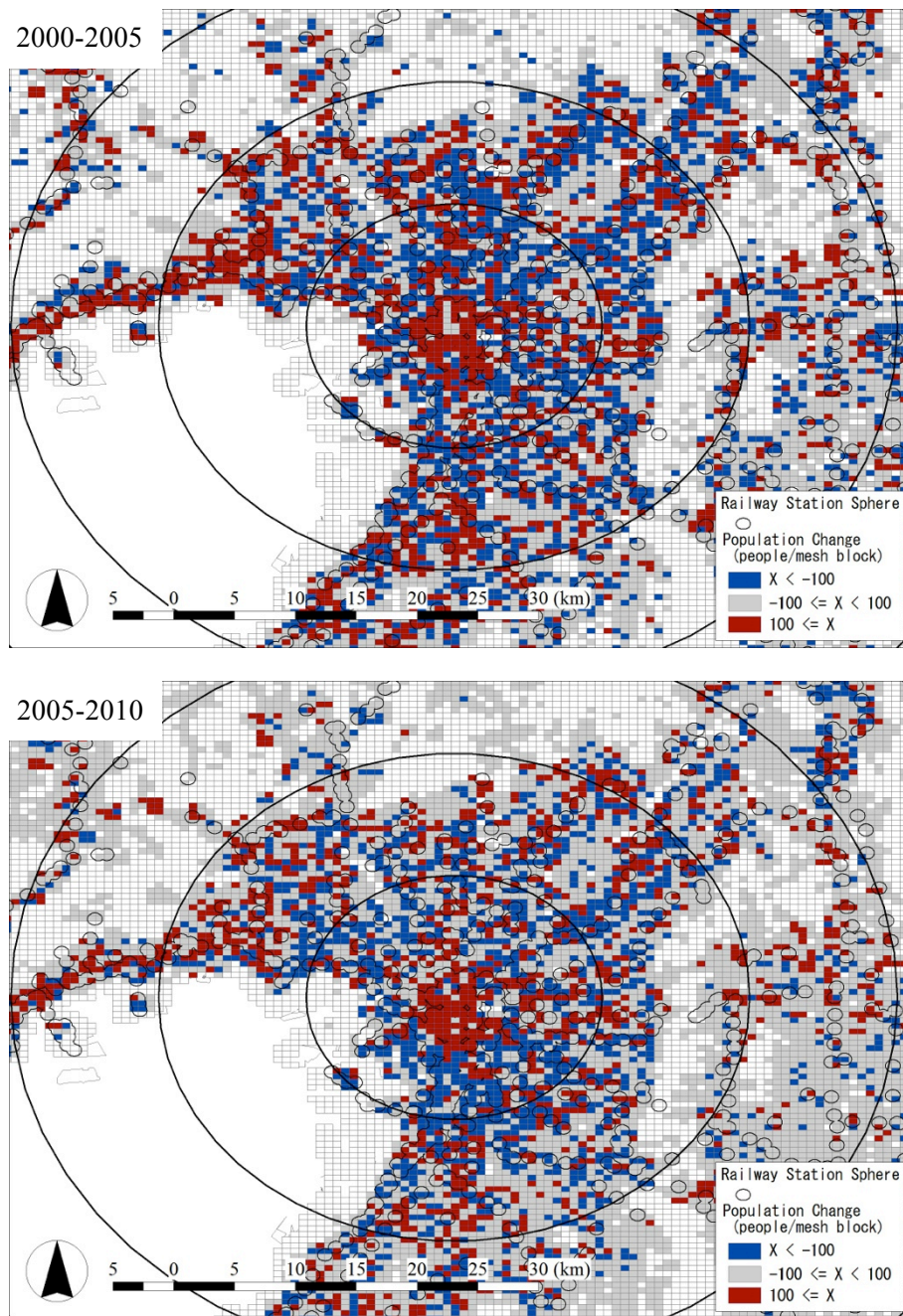**Table 9. Population Change within the Railway Station Sphere of the Osaka MR**

		2005	2010	Rate of Change
Railway Station Sphere	Pop	5,681,986	5,791,796	1.9%
	Dens.	2,196	2,226	1.3%
Outside Railway Station Sphere	Pop	11,012,370	11,000,603	-0.1%
	Dens.	745	738	-0.9%
Total	Pop	16,694,356	16,792,399	0.6%
	Dens.	961	959	-0.2%

Pop: Total population (people), Dens.: Average density (people/mesh block)

Figure 6 shows the characteristics of the distribution of mesh blocks with increasing and decreasing population within the railway station sphere; areas with population growth of more than 100 people are in red and those with decreases of more than 100 people are shown in blue. When comparing the area inside the railway station sphere with that outside it, the portions of mesh blocks with increasing or decreasing population is higher within the railway station sphere than outside the railway station sphere. In other words, districts with population increases and decreases tend to concentrate within the area around the railway stations.

Using the data from 2005-2010, the portion of mesh blocks in the railway station sphere with increasing population was 23.9%, a fairly high value when compared to the whole region. The portion of mesh blocks with decreasing population is 22.6%. Although the railway station sphere is the area within which public transport use is the most convenient, the population increase districts do not necessarily cluster together.

Figure 6. Mesh block-level Population Change in the Osaka MR Railway Station Sphere

When comparing the data between 2000-2005 and 2005-2010 (Table 10), the number and portion of mesh blocks with increasing population decline both within and outside of the railway station sphere. Furthermore, the number and the ratio of mesh blocks with decreasing population also declines. In other words, in the Osaka MR in the mature period, population in the region as a whole tends not to be concentrated. Even within the railway station sphere, population is not necessarily clustered. This tendency becomes more pronounced as the maturity of the city progresses.

Table 10. Mesh Block-level Population Change in the Osaka MR Railway Station Sphere

2000-2005	Population Change (people/mesh block)						Total
	~ -100	-100 ~ -50	~ -100	-100 ~ -50	+50 ~ +100	+100 ~	
Railway Station	700	257	343	305	201	730	2,536
Sphere	27.6%	10.1%	13.5%	12.0%	7.9%	28.8%	100%
Outside Railway	2,179	1,643	3,128	1,948	836	1,495	11,229
Station Sphere	19.4%	14.6%	27.9%	17.3%	7.4%	13.3%	100%
Total	2,879	1,900	3,471	2,253	1,037	2,225	13,765
	20.9%	13.8%	25.2%	16.4%	7.5%	16.2%	100%

2005-2010	Population Change (people/mesh block)						Total
	~ -100	-100 ~ -50	-50 ~ 0	0 ~ +50	+50 ~ +100	+100 ~	
Railway Station	582	299	501	367	212	617	2,578
Sphere	22.6%	11.6%	19.4%	14.2%	8.2%	23.9%	100%
Outside Railway	1,466	1,056	6,608	3,441	688	1,157	14,416
Station Sphere	10.2%	7.3%	45.8%	23.9%	4.8%	8.0%	100%
Total	2,048	1,355	7,109	3,808	900	1,774	16,994
	12.1%	8.0%	41.8%	22.4%	5.3%	10.4%	100%

6. Conclusion

(1) The difference between MRs in the mature and late growth periods

In Osaka MR in the mature period, when regional population has already begun to decrease, the expansion of the conurbated area with high population density has stopped, and the population has not increased. As a result, population density has begun to decrease and the number of areas with population increases or decreases has fallen.

In Tokyo MR in the late growth period, when the regional population is still increasing, population continues to increase in the central area, but population stagnation has already begun in the peripheral area. Meanwhile, the area of increasing population continues to spread within the city center, but the areas of population decrease have reduced throughout the whole region.

In other words, in a region transitioning from the late growth period to the mature period, the areas of population increase tend to change depending on population dynamics, but the areas of population decrease tend to decline equally. If the area of population decline does not spread and concentrate in the mature period, the conurbated area will not be reduced. If this trend continues, the result will be a regional structure in which population density is scattered and low.

(2) The difference between the inner MR and outer MR

In the analysis, it was confirmed that in an outer MR in the mature period, population dynamics change from late growth period stagnation to decreasing population. Furthermore, the area with declining population tended to decrease in both regions, regardless of current population dynamics. A reduction in the area of increasing population was also confirmed in the outer MR. Population decrease and a reduction in the areas of population increase and decrease are not experienced equally throughout the whole region; the difference between the inner and

outer regions will likely enlarge in the future.

(3) The agglomeration of population increase and decrease areas

The agglomeration rate was calculated to confirm whether population increase and decrease areas are concentrated together. The results indicate that the agglomeration rate is high for increasing population areas during the population increase phase, but it is low in the population stagnation or decrease phase. This tendency is particularly noticeable in the inner MR.

In the outer MR, the change in the agglomeration rate is small in both population increase and decrease areas, regardless of the population dynamics. Considering the railway station sphere as the core area of population concentration, the portion of mesh blocks experiencing increasing population is high, and population growth areas tends to be concentrated in the railway station sphere in the late growth period. In the mature period, however, even within the railway station sphere, the portion of areas experiencing increasing population is not very high and the increasing population areas are not concentrated.

Based on these results, it is suggested that a hypodense urban zone without increasing population may be formed throughout the whole region if the local authorities do not act to control areas, centralize population, and draw the population into the regional core.

Acknowledgment

Notes

(1) Peter Hall describes the urban form of an Mega-City Region (MCR) as a series of anything between 20 and 50 cities and towns, physically separate but functionally networked, clustered around one or more larger central cities, and drawing economic strength from a new functional division of labor. In the POLYNET study, MCRs were defined as "aggregations of smaller constituent city regions: Functional Urban Regions, or FUR. These comprise a core defined in terms of employment size and density, and a ring defined in terms of regular daily journeys (commuting) to the core" (P. Hall 2009). [7]

(2) The zone of the local government, to distinguish it from the site of the city hall.

(3) Any mesh block with a center within a 500m radius of the railroad station is chosen.

(4) The agglomeration rate is the ratio of the number of mesh blocks around a given mesh that are similar divided by the total number of neighboring mesh blocks.

References

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7) P. Hall (2009): Looking Backward, Looking Forward: The City Region Of The Mid-21st Century, Regional Studies, 43 (6), pp.803-817 (In English)