New Towns in the Kyoto-Osaka-Kobe Area: Typological Analysis of Regional Characteristics Based on Population Structure and Inflow

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Abstracts
The first inhabitants of new towns in Japan were demographically similar and population inflow occurred within a short period of time. As a result, new towns are currently experiencing population decline and an aging-society. Furthermore, the depopulation is on-going on the national scale and the land use porosity of regions recently occurs irregularly in Japan. On the other hand, previous researches suggest that population inflow is already in progress in some new towns. However, the location of those new towns with new inhabitants are not clarified and analysis of conventional regional characteristics is considered to be limited in the face of changes in regional / population structures across the country. The research seeks to address whether the characteristics of a new town are observable from a typology of its population structure. In addition, we here show the regional characteristics of new towns with the population inflow tendency. Our result elucidates the necessity of regional characteristics analysis of typology by population structure and inflow. Additionally, it also clarifies that the rental housing rate is most relevant to population inflow tendency. Consequently, it is significant to establish the management system of transferring the possession form from self-owned to private rental and to analyze from both aspects of regional characteristics and population composition for properly managing policy and spatial planning, and keep adjusting them depends on the present state.

Keywords
Suburbia, Population Inflow Tendency, Conurbation, Self-Organizing Map, Population Structure

1. Introduction
1-1. Aim of the Paper
This paper examines “new town” population composition in the Kyoto-Osaka-Kobe conurbation. Specifically, it categorizes towns on the basis of population structure and inflow to identify regional characteristics of new towns where signs of generational change have been observed. As national scale depopulation proceeds apace and the absorption of new generations occurs only infrequently, new towns in Japan are experiencing a period of transformation. By observing the regional characteristics of new towns with population re-influxes, predicting the next transformation process of each town is possible, which will help to determine the appropriate political and spatial plans. In addition, this paper suggests an alternative approach to conventional regional characteristic analysis by classifying regions according to demographic structure.

1-2. Social Background
During periods of depopulation, conurbation do not necessarily shrink from the outer edge. The occurrence of “spongy urban areas”—i.e., spaces characterized by the random occurrence of multiple vacant or very low density use areas—is not correlated to distance from city centers.

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Community and area stagnation are not always related to location and scale (Weck & Beißwenger 2014). However, the feasibility of optimizing infrastructures by aligning commercial and public services with society’s needs is subject to a broad planning during transitions of population composition (Gudewer & Utku 2017). Adjusting, updating, refurbishing, and redesigning expanded housing areas constructed during the growth period of the second half of the 20th century is taking on an important role in most cities, metropolitan regions, and suburban areas of developed countries (Dunham-Jones 2011).

In the case of Japan, a number of “new towns” developed in the form of controlled residential areas as part of the process of suburban expansion. The first inhabitants of new towns were demographically similar, and population inflow occurred within a short period of time. As a result, many of these communities are currently experiencing a population decline as the society ages. However, several studies suggested that some new towns have begun to experience a re-influx of population re-influx. Underlying this phenomenon are three factors: 1) the purchase of second homes by residents in adjacent areas (Suzuki & Okita 2005); 2) the inflow of new families with young children (Matsumura 2014); and 3) children living with or close to parents (Hirayama 2011; Matsukawa 2019). Although the phenomenon of re-influx has been documented, the regional characteristics of those towns have yet to be clarified. To inform efforts to achieve feasible town planning, accurately grasping the current demographic structures of new towns and their correlation with broader regional characteristics is necessary.

1-3. Suburban Development in Japan

Japanese suburban development can be divided into three phases based on the trends of those sprawls and associated theoretical frameworks. The first period began at the beginning of 20th century and extended until World War II. The concept of suburbia was introduced as part of the “garden city theory” advocated by Ebenezer Howard in 1902 (Howard 2016). However, the pattern of development of outskirts around urban areas has proceeded uniquely in Japan, where the construction of suburban residential areas was based more on the issue of social enterprise than theories of urban design, and a great deal of land was allocated for residential areas, along with a plethora of office buildings. As such, early Japanese suburban areas developed largely as commuter towns, and most can be better characterized as “garden suburbs” than “garden cities.”

Private railway companies led the construction of the first Japanese suburbs (Oikawa 2016), and their development was planned in alignment with utopian theories. Demanding an escape from deteriorating urban environments, the upper-middle and upper classes used the suburbs as retreats. Thus, suburbs constructed during this period were relatively high-quality areas.

The second phase of suburban development was from after WWII to the end of the high economic growth period (Kadono 2000). In the beginning of this phase, public and social housing were supplied by the government or the Japan Housing Corporation (which was eventually renamed as the Urban Renaissance Agency) as part of the post-war reconstruction effort. When social conditions improved and a period of high economic growth ensued, residential areas were provided as homogenous products in the housing market. Under the government’s conception of new town establishment and the railway companies’ line extensions, suburbs began sprawling further across urban fringes to supply sufficient housing to meet social demand (Kadowaki 2013). As the number of residential areas rapidly increased, more people moved to suburban areas. The new suburbanites were mostly members of the middle classes. As the suburban areas kept expanding, some of areas developed in the first phase became urbanized.
The third phase began around 1980 around the start of the bubble economy period. The forms and functions of suburbs and new towns again shifted, as developers attempted to add value by constructing research installations or business facilities to differentiate them from other suburban areas in a process often called “theme park model development.” However, because of the drastic increase in land prices during the period of the bubble economy, residential areas kept sprawling outward, and more distant provinces were developed as “super suburbs,” thus increasing the number of commuters. However, unlike previous suburbs, these newly developed areas were also positioned far from railway stations and are less suitable for urban commuters. Furthermore, although the rise of poverty in suburban areas, which has been widely documented in the United States and other countries (Elizabeth 2013), has not been widely disclosed in Japan, this has also become an emerging trend, particularly with the decline of the bubble economy. Therefore, fumbling for more suitable spatial structures that provide better access to transportation and conform to various lifestyles became necessary (Kadono 2012).

1-4. Previous Studies

Many previous studies analyzed the regional characteristics of suburbs and new towns; however, most of these have targeted individual suburbs or categorized them primarily according to construction year or distance from urban areas. Akashi defined bi-directional use of urban and outlying areas in people’s daily lives by observing the inner hierarchy of a conurbation. Aizawa classified villages by population dynamics and found that the continued stability of some villages amidst demographic change was related to the elements within the village itself.

A number of studies summarized the transitions of suburban forms and related regional characteristics over time. For example, Kadono’s 2000 study on suburban transitions in Japan examined suburban emergence, growth, and shrinkage according to the needs and impacts of different socioeconomic groups (Table 1). Similarly, Miura charted the transitions experienced by households over the period from suburban emergence to decline, and Matsukawa clarified the recent situation of households in suburban areas and their surroundings in her 2019 study. Figure 1 presents a synthesis of previous research on household transitions in suburban areas and new towns in flow chart form.

Table 1 Transition of Suburbia Based (According to Kadono 2012)

| Phase         | Description                                                                 |
|---------------|-----------------------------------------------------------------------------|
| Born          | Utopian Suburbs — Thought of Healthy Life Close to Resort Club Society Upper Class |
| Grow Up       | Suburbs for Middle Class Railway Company Extension along Railway Inflow of Middle Class Company Housing and Guest House |
| Changes (Adapting) | Suburbs to be Consumed Transformation of retail shops Subject to smaller Lots Transformation into lower density |
| Dormant       | Mixed Use Suburbs Shop, Office, Condo Common District Back to Nature Integrated settlement construction Residential Life Establishment of Village Original Low Style |
| Shrink and Reform | Consistence of Various Suburbs Establish Support System of Connecting Central Urban Area and Suburbs Maintain System of Moving and Distribution |
2. Methodology

This research was focused on the Kyoto-Osaka-Kobe conurbation\(^4\). To target new towns strongly related to any of the three urban centers—Kyoto, Osaka, and Kobe—in this conurbation, municipalities where at least 10% of employees commute to these three urban centers were extracted and designated as the Keihanshin-Employment District. All new towns in this district were then selected from the database of “New Town List”\(^21\) that the Japanese Ministry of Land, Infrastructure, Transport and Tourism (LMIT) has created with the contribution of local public organization and Urban Renaissance Agency (UR).

A total of 248 new towns were found in the Keihanshin-Employment District. Statistical data relating to their population structure were extracted from the Japanese Ministry of Internal Affairs and Communications’ national population censuses of 2005, 2010, and 2015. To identify the boundary of each new town and its surroundings and adapt boundaries of small areas of the census, the following steps were taken: (a) LMIT’s New Town List and GIS were used to identify the location of each new town; (b) the real boundaries of each new town were drawn on the GIS map based on development planning maps and related documents from either private development companies or municipality and aerial photographs; (c) a small census area whose centroid is within each new town’s real boundaries drawn in Step (b) are extracted by GIS and determined as each new town’s boundary for this research. However, 28 new towns were excluded from the analysis due to i) the lack of data on the start or end year of construction; ii) the land was dedicated to industrial rather than residential use; and iii) the boundary between the new town and its surroundings was obscure, although aerial photograph and related documents were used.

To focus on the current situation, census data from 2005 were used to categorize a) demographic change; b) transition and current condition of capital household structures; and c) population inflow tendency. First, typologies were estimated using the self-organizing map (SOM) method\(^5\), which divided new towns into 20 units. Those units encompassing more than ten new towns were selected for a more detailed observation as a basis for which to define their characteristics.
regional characteristics of individual selected units were determined according to i) development year; ii) development organization and scale; iii) distance from an urban area and the presence of a railway station within the new town; iv) possession form of housing; v) housing construction style; and vi) the existing state of economic activities. Finally, the classification tree approach\(^6\) (a type of decision tree method) was used to estimate the critical explanation variables that defined the population re-influxes into the new towns.

3. Kyoto-Osaka-Kobe Conurbation and the Keihanshin-Employment District

Kyoto-Osaka-Kobe conurbation is centered on three strongly connected urban centers that were linked by old roads since before the modern era, as well as more recent public transportation, particularly railway lines, which reduced travel between the cities to 30 to 60 minutes.

Since suburban development in the region is strongly related to railroad construction, the focus of city and new town formation has been between the three major urban centers of Kyoto, Osaka, and Kobe. Moreover, residents in the area frequently travel to these three centers for various purposes. Therefore, this paper is not focused on any individual urban area; rather, to secure a cohesive group of samples and analyze the regional characteristics of new towns, integrating the three regions into a single conurbation is necessary.

3-1. Commuting Patterns

The calculation of commuting rates for each municipality is based on the National Population Census of 2015, and Figure-2 depicts the resulting shape of the Keihanshin-Employment District. The coloring of municipalities in Figure-2 represents their relationships to each urban center based on having more than 10% of commuters employed there. Whereas employment and commuting activities in some municipalities were most strongly related to only one of the three urban areas, in others, residents tended to regularly commute to two different cities.
However, according a comparison of commuting destination ratios based on the national population censuses of 2005 and 2015, the municipalities within the Keihanshin-Employment District no longer rely solely on urban centers of the conurbation for employment. Figure-3 shows the increase and diversification of commuting destinations since 2005. In addition to the legends shown in the Figure-3, the commuting destination was divided into their own regions, urban centers—Kyoto, Osaka, and Kobe—and other regions. The municipalities are colored based on the destination that increased its composition ratio of commuting. Some regions had increased commuting ratio at two destinations, and, in a half of them, urban centers are one of the destinations. However, most municipalities increased their proportion of commuters to other regions that are neither urban centers nor their own region. As such, it is inferred that more localized characteristics led to changes in commuting patterns in many suburban residential areas—particularly new towns—that conventionally relied on urban centers of the conurbation.

![Figure-3 Shifts in Commuting Destinations Since 2005](image)

3-2. New Towns in Keihanshin-Employment District

As indicated in section 2, 220 new towns were selected for analysis. New towns were plotted in Figure-4 and classified according to year of establishment, scale, and major development sector, namely private company, administration and government, and UR and Public–Urban Renaissance Agency and Housing Supply Corporation. Sizes are categorized according to small (from 16 to 50 ha), middle (from 50 to 100 ha), and large (over 100 ha) scale developments, and development phases are segmented into the post-war reconstruction period (by the 1950s), the high economic growth period (1960s–1970s), and the bubble economic period and after (1980s–present).

New towns established during the first phase were developed by either the government or UR and Public, and their scale was mostly larger than 50 ha. New towns established in the 1960s and 1970s are mostly located on the railways and vary in scale. Some were constructed 20 km to 30 km away from urban areas. Although there are no differences of location based on the major organization of development, those that were constructed at a larger distance from urban areas are mostly smaller than those located closer to a major center. After the 1980s, new town development led primarily by private companies sprawled into even farther areas more than 30 km away from urban areas, and many were not formed along the railway.
4. Classification of New Towns

4-1. SOM

Targeted new towns were classified by the SOM method\(^{(7)}\), for which the indicators were i) ratio comparison of population and number of households; ii) household composition ratio; iii) increase or decrease of household composition ratio; and iv) ratio of inflowing population to present (Table 2). The explanation variables were based on the National Population Census and aggregated by each new town. Figure-5 illustrates a large circle representing the segmented unit, the small ones within each unit represent each new town, and the number represent the unit’s serial number. While a certain number of new towns with similar demographic characteristics were identified, some new towns with unique demographic characteristics that can be described as outliers were also identified. Similar new towns do not fit into a single pattern (unit) but rather have multiple clusters, creating diversity in demographics. In the following analysis, the characteristics of the new towns belonging to each unit will be considered with the use of percentages. Therefore, to avoid the possibility of calculating extreme ratios for units with a small number of new towns, only units with 10 or more new towns will be considered. As a result, the nine units covered in the subsequent analysis are 4, 5, 8, 11, 13, 14, 15, 18, and 20, which is a reasonable sample given that more than 80% of the 220 new towns used in the SOM are applicable.
Characteristics of Units Segmented by SOM

Population structure and inflow characteristics of the nine units were compared, and the median and first and third quartile of each unit's indicators were aggregated (Figure 6). The targeted units are categorized into different phases based on each demographic characteristic. The procedure is shown in Figure 7, and the median of each explanation variable is used as the criteria. As shown in Figure 8, the modification phases of each unit were defined by collating those units' features with the flowchart of household transition in new towns (see Figure 1). The units are defined as below, and each period of household transition encompasses three phases.

- **Unit 13**: The attracting new inhabitants phase, as the population re-influx tendency is shown.
- **Unit 4**: The depopulation mitigation Phase A (more mitigation), as relatively higher population inflow ratio and less depopulation tendency exist, although the population does not increase significantly.
Figure 6: Characteristics of Unit Population Structures

| Graph | Ratio Comparison (%) | Household Composition Ratio (%) | Increase/Decrease of Household Composition Ratio | Ratio of Inflowing Population to Present (%) |
|-------|----------------------|-------------------------------|-----------------------------------------------|---------------------------------------------|
| Unit 4 | 100.0 (101.3) | 106.2 (101.5) | 58.0 (25.8) | 41.8 (33.2) | 18.7 (18.8) | 16 (18) | 5 (5) | 15 (15) | 98.5 (28.7) |
| Unit 5 | 96.4 (95.3) | 99.6 (99.4) | 68.2 (25.9) | 26.0 (22.3) | 16 (18) | 16.0 (18.0) | 18.0 (18.0) | 12.0 (12.0) | 92.2 (92.2) |
| Unit 6 | 56.8 (53.7) | 49.0 (46.7) | 27.0 (22.3) | 14.6 (12.2) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 7 | 104.2 (103.8) | 101.2 (101.3) | 23.9 (23.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 8 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 9 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 10 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 11 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 12 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 13 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 14 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 15 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 16 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 17 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 18 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
| Unit 19 | 104.8 (104.8) | 101.2 (101.2) | 27.0 (27.0) | 21.6 (22.7) | 15.9 (16.7) | 18.0 (18.0) | 18.0 (18.0) | 9.8 (9.8) | 100.0 (100.0) |
| Unit 20 | 53.7 (53.2) | 48.0 (47.2) | 22.3 (22.3) | 14.0 (14.0) | 18.0 (18.0) | 18.0 (18.0) | 18.0 (18.0) | 8.8 (8.8) | 100.0 (100.0) |
Unit 18: The depopulation mitigation Phase B (less mitigation), as similar but less depopulation mitigation status is observed against Unit 4.

Unit 14: The single and couple households majority phase, as single and couple households have relatively higher ratio than other units.

Unit 20: The typical new town phase because the in-migration trend has been confirmed, but this trend has subsided in the past five years compared to the past ten years, and the proportion of family households is characteristically higher than other units.

Unit 11: The single household increase phase because the proportion of couple and family households in the household composition ratio is high (similar to Units 5, 8, and 15), and the rate of change is higher for single households than other units.

Unit 15: The outflow of children phase because the rate of increase in couple households and the downward trend in family households is stronger than other units.

Unit 5: The couple household majority phase because the composition of households and the rate of increase in couple households over the past five years is higher than Unit 8.

Unit 8: The single household increase incipient phase because this unit shares an identical status with Unit 5, but with a relatively high rate of single household growth in the past five years and a low rate of change in population and number of households. It is considered to be entering a period of stagnation.

Figure-7 Main Characteristics and Classification Names of Units

Figure-8 Flowchart of Phases
5. Regional Characteristics of New Towns in Each Phase
5-1. Location Characteristics of Each Phase

Figures-9–11 depict maps showing locations of new towns on the map, which are classified according to different colors.

During the “household separation” period (see Figure-8), new towns were generally not positioned around Osaka and Kyoto. Rather, most were established within 10 km radius of Kobe, particularly located along the Kobe Electric Railway line, although a few are located at some distance from railway lines. Among the new towns established during the typical new town phase, the expectation exists that those located farthest from the urban centers are in areas that were developed later in that subphase.

During the “stagnation” period, new towns appeared within a 10–20 km radius of Osaka and Kyoto. During this period, both inland and coastal new towns experienced increases in single household ratios. According to the transition series of new town households, the expectation exists that such settlements were developed earlier. At this point, however, there are few signs of generation change.

It is conventionally supposed that population inflows are more likely to occur into new towns located closer to urban areas. However, although there was a greater tendency of population inflow during the “transformation” period, and new towns settled during such times did not necessarily accumulate around urban areas. Rather, whereas some are located within 10 km of an urban center, others are up to 30 km from the nearest large city. In addition, some new towns belong to the transformation period are contiguous with or very near to others established earlier during the household separation or stagnation periods. Such cases particularly occur along the Kobe Electric Railway line. It is not the case that new towns from each phase are either arbitrarily clustered at a specific point of the Keihanshin-Employment District or at a distance from urban areas. Rather, both types of new towns were established along the railway line during the couple household majority phase and the depopulation mitigation Phase A.

Next, we can examine patterns of time-distance from urban areas during each phase. Figure-12 depicts the percentages of new towns with railway stations in each phase, and the box plot represents the time required to commute to the nearest urban area. On the one hand, although the proportions of new towns with railway stations are relatively high during the transformation period, they remain less than 50%, which indicates that proximity to railway stations is not necessarily essential for the re-influx of population to occur. On the other hand, the traveling time to urban areas from the new towns belonging to those phases is within approximately 60 minutes. Similarly, the median time required for new town-to-urban travel was within an hour during all of the other phases except the outflow of children and single household increase periods. However, the commuting threshold of 60 minutes or less is only a guide for measuring trends toward population re-influx. Verifying relationships between other local and regional characteristics during each period is necessary, particularly in phases when re-influxes occurred.
Figure-9 Location of New Towns in the “Household-Separation” Period

Figure-10 Locations of New Towns during the “Stagnation” Period
Figure 11: Locations of New Towns during the “Transformation” Period

Figure 12: Traveling Times to Urban Areas and Ratios of New Towns with Railway Stations

- Typical New-Town
- Outflow of Children
- Couples Household Majority
- Single Household Increase Incipient
- Single Household Increase
- Single and Couples Household Majority
- Depopulation Mitigation B
- Depopulation Mitigation A
- Attracting New Inhabitants

*1 The definition of “New Town with Railway-Station” is the New-Town where there is a Railway-Station in the town area or within 250m away from the area.

*2 The definition of “Required Time to the Urban Area” is the time from Railway-Station or Bus-Stop - the bus stop that is closest to the center of the New-Town in terms of population - to the New-Town to one of Kyoto Station, Osaka Station or Sannomiya Station (in Kobe).

*3 The required time was estimated by using timetable of each public transportation and NavTime - the navigation service of public transportation in Japan.
5-2. Development Year, Major Organization, and Scale

The expectation exists that the older new towns have higher rates of aging and face generational changes earlier than more recently developed settlements. Therefore, we first compared the development year of new towns during each phase. Figure-13 depicts the distribution of start-years for the construction of new towns during each phase, whereby the vertical axis represents each phase and the horizontal axis represents the development time.

The phases of new towns in the stagnation and household separation periods correspond to development years such that generally the earlier the development year the later it occurs in each phase. However, the new towns developed after the 1980s correspond to different phases in the transformation period. Therefore, it can be inferred that population inflows are occurring regardless of the order of development.

Figure-13 also represents the scale by the size of bubble and the organization by its color. When comparing the development organization and the scale of new towns, larger populations are correlated with greater economic development. Therefore, the expectation exists that those are easier areas for redevelopment. Conversely, compared with new towns provided by private companies, those developed by UR and Public or administration supply more rental housing and are more heavily area-managed. Accordingly, the assumption exists that those new towns have more opportunity to increase the inflowing population. However, according to Figure-13, the situation of new towns in the attracting new inhabitant phase and depopulation mitigation Phase A diverge from that expectation. Those phases include not only new towns with more than 100 ha development but also smaller scale new towns. Particularly, during depopulation mitigation Phase A, half of the new towns are under 50 ha. Thus, even small-scale development areas demonstrate a tendency of generation change.

Many of new towns that were developed by private companies belong to the phases in the household separation or stagnation periods. However, later phases associated with a population re-influx tendency also include some of those new towns. In fact, the ratio of population inflows to development agencies is the same for all entities in each phase of the transformation period. It is conceivable that this is related to a relatively large number of privately developed new towns; however, depending on the conditions, those settlements can also expect new population inflows.

Differences between new towns developed by UR and Public and administrative towns can be seen during depopulation mitigation Phases A and B such that those developed by the former are more closely associated with Phase B, whereas those established by the latter are more closely linked to Phase A. New towns developed by governments demonstrate greater potential to increase the population inflow, and it can be seen that such settlements account for the highest ratio during the single and couple majority phase. Thus, it can be stated that new towns developed at the same time by the same organization can exist both in areas of continued population decline and stagnation and areas of new population flows.

Despite the qualification that new towns must be located within 60 minutes from an urban area, the main indicators (distance from urban area and location, development scale, subject, and time) conventionally used to assess the potential for population inflows into new towns do not necessarily correspond with their phases of development. Therefore, 1) possession form of housing; 2) construction style of housing; and 3) the existing state of economic activities are analyzed in the next sections to determine if other characteristics can explain the population re-influxes that occurred in some new towns.
5-3. Possession Form of Housing

Compared with self-owned housing, rental housings present fewer obstacles for relocation; thus, there is likely to be higher population fluidity in towns with higher rental housing rates. Figures 14—16 depict possession forms divided into self-owned, public rental, and private rental based on the National Population Census surveyed in 2015. Each dot at those scatter diagram represents the ratio of each possession form for an individual new town, and the colors represent different development entities. The blue full line denotes the median of each phase, and the dashed lines show the first and third quartiles.
From Figure-14, the ratio of self-owned housing was lower in periods prior to the single and couple household majority phase. Although, this pattern is partly due to the increase in the number of elderly people who dispensed with their houses, the ratio does not increase in phases associated with population re-influxes, and the median of each phase is only around 60 percent. This pattern occurs even in new towns developed by private companies, which appears to be higher in cases when more land and/or houses are primarily for sale.

From Figure-15, the depopulation mitigation Phase B and the single and couple household majority phase mark a distinctive feature in the ratio of public rental housing. The ratio of those phases holds higher than other phases. In contrast, new towns with a higher ratio of private rental housing are more closely associated with either the attracting new inhabitants phase or depopulation mitigation Phase A, which also demonstrate higher rates of population re-influx (Figure-16). The rates of rental housing are low during the early phases and start increasing from the single and couple household majority phase and thereafter. Furthermore, the new towns developed by the private sector have high rental housing ratio for those four phases. Even though those four phases have similar status on the rental housing ratio, differences between the phases exist with relatively higher population re-influx tendency and the other two, depending on whether the public or private sector is providing the rental housing.

As a matter of course, new towns developed by the government and UR and Public tend to exhibit a higher rental ratio throughout the whole period. Since there is no significant difference between the development organization ratios across the later four phases including the phases belonging to transformation period (see Figure-13), then increasing the amount of rental housing, particularly private rental housing, would appear to be a key factor in transforming new towns.
5-4. Construction Style of Housing

Detached housing is generally self-owned and sold in lots. As noted in the preceding section, new towns with higher ratios of self-owned housing tend to experience less population inflow. Therefore, the expectation exists that the flowability of population would vary based on the major style of housing construction in new town. The dots in Figure-17—19 represent the ratio of each new towns’ construction style of housing, and colors show the major organization of development, and the blue full line shows the median of each phases. In those scatter diagram, the construction style of housing is classified into three types based on the National Population Census in 2015, namely detached housing, apartment housing, and terrace housing.

With the exception of the attracting new inhabitant phase, the rates of detached housing in individual new towns are evenly distributed in all phases. Although the interval between the first and third quartiles is accordingly long in each phase, a comparison of medians demonstrates the differences in detached housing rates between new towns with and without population inflows (Figure-17). In the phases at the Transition Period, the median of the detached housing rate is reflectively higher during the attracting new inhabitant phase and depopulation mitigation Phase A compared to the depopulation mitigation Phase B. Additionally, the detached housing rate is also lower in the single and couple household majority phase than earlier phases.

In contrast, from Figure-18, the median of the apartment housing ratio shows high value on the depopulation mitigation Phase B, the single and couple household majority phase, and the single household increase phase. Although new towns are developed by the private sector, some of them have higher ratio for the apartment. This might partially reflect the situation that new dwellers cannot be acquired in cases when vacant detached housing has increased due to depopulation or population aging, with the result being a relative rise in the apartment housing ratio.

Although residential changeover might occur more frequently in apartment housing than in detached housing, new towns with higher rates of population re-influx tend to exhibit higher ratios of the latter. Therefore, it is inferred that people looking to move to new towns or suburban areas find more value in detached housing than in other housing forms. Incidentally, since only a limited amount of terrace housing has been supplied in new towns, its ratio remained essentially constant across all phases (Figure-19).
5-5. Existing State of Economic Activities

The numbers of offices and commuters working in each new town were aggregated and compared based on the Economic Census for Business Frames taken in 2009 and 2014. The results show an apparent relationship between population inflow and improvements in economic activity. This aspect increases the demand for mixed land use for area revitalization, as well as the transition from single to double income households. Figure-20 represents the standardized number of offices and commuters per hectare in each new town in the Keihanshi-Employment District. The vertical axis denotes the number of commuters per hectare, and the horizontal axis represents the number of offices per hectare. Dots represent the standardized value of individual new towns. Colors and shapes of dots are according to the phases.

New towns belong to the transformation period demonstrate relatively high numbers of offices and commuters. Even the standardized values of these elements are lower for earlier-developed new towns than for those in the transformation period. There are new towns plotted in the first quadrant of the household separation period; however, all of new towns during the outflow of children phase are in the third quadrant. Therefore, it is considered that the new towns developed in outflow of children phase and the stagnation period phases are primarily designated for residential use and have few workplaces.

Figure-21 represents the increase and decrease ratio of the number of offices and commuters in each new town from 2009 to 2014. In the scatter diagram, the vertical axis represents the change ratio of commuters, and horizontal axis denotes the change ratio of offices. Based on whether the number of both offices and commuters in each new town is presently higher or lower than it was in 2009, they are classified into four groups: 1) the improving economic activity group (the first quadrant); 2) the increasing larger-scale offices group (the second quadrant); 3) the stagnating economic activity group (the third quadrant); and 4) the increasing small-scale offices group (the fourth quadrant). The bar chart in Figure-21 represents the percentage of new towns belonging to each group in each phase, and it can be seen that the typical new town phase exhibits the highest proportion of new towns plotted in the economic activity improving group. In contrast, the outflow of children phase exhibits the highest proportion of new towns in the economic activity stagnating group. Phases with higher population inflow rates are not necessarily the highest proportion of phases in the first quadrant, which suggests that even with the relatively larger number of offices and commuters, it is not the case that redevelopment for mixed land use rapidly proceeded in the latter years of those phases with population inflow.
Figure-20 Standardization of the Number of Offices in and Commuters to Each New Town of All the Phases

Figure-21 Increase and Decrease Ratio of Offices in and Commuters to Each New Town
6. Critical Explanation Variables by Classification Tree Method

This section presents the analysis of the critical qualitative and quantitative explanation variables that divide new towns into those with and without population re-influx tendencies. The elements are: 1) developed year (quantitative); 2) scale (qualitative); 3) major organization (qualitative); 4) self-owned housing rate (quantitative); 5) public rental housing rate (quantitative); 6) private rental housing rate (quantitative); 7) detached housing rate (quantitative); 8) apartment housing rate (quantitative); 9) terrace housing rate (quantitative); 10) number of office per hectare (quantitative); 11) number of commuters per hectare (quantitative); 12) ratio transition of number of offices (quantitative); and 13) ratio transition of number of commuters (quantitative). All these data are based on the analysis presented in section 5. The aim of this analysis was to identify the regional characteristics of new towns experiencing population inflows rather than the correlations between each element. Therefore, the classification tree method was used to search the critical explanation variables.

Since the population re-influx tendency during depopulation mitigation Phase B is lower than that of the other two phases of the transformation period, two types of classification trees were formed. One tree limited new towns demonstrating tendencies toward population re-influx to the attracting new inhabitant phase and depopulation mitigation Phase A, whereas the other associates population re-flux with all new towns belong to the transformation period.

According to classification tree_1, population re-influx tendency is first determined by private rental housing rate (i) (Figure-22). If the rate is more than 22.488, then it is separated by development year (ii), and new towns developed before 1977 tend to be more likely to be experiencing a population re-influx. In contrast, if the private rental housing rate is less than 22.488, then the self-owned housing rate (iii) is the next explanation variable. When the rate is under 65.061, new town branches depend on the detached housing rate (iv). New towns that exhibit higher detached housing rates are associated with the population re-influx tendency even though their private rental housing rates are lower.

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**ID** | **Explanation Variable**
--- | ---
1 | Private Rental Housing Rate
2 | Development Year
3 | Self Owned Housing Rate
4 | Detached Housing Rate

*Fig. 22 Result of Classification Tree_1*
In the case of classification tree_2, the self-owned housing rate (a) divides new towns based on whether the rate is higher or lower than 65.061 (Figure-23). If the rate is lower, then new towns where private rental housing rates (b) are relatively high and required time to urban area (c) is within 42.5 minutes would probably experience population inflows. In contrast, if the new town’s self-owned housing rate is higher than 65.061, it branches by required time to urban area (d). In this case, 37.5 minutes is the threshold value. If the new town is located near an urban area, then the apartment housing rate (e) becomes the next explanation variable. As a result, even if the new town’s self-owned housing rate is higher than 65.061, the new town can potentially experience population re-influx only if it is located within 37.5 minutes away from an urban area and has less apartment housing.

7. Conclusion
7-1. Insights and Suggestions
This paper analyzed the regional characteristics of new towns according to their population structure and inflow. The results lead to the following insights:

First, identifying new towns belong to the transformation period and clarifying their regional characteristics using conventional typological and research methods is becoming difficulty. The phase of new towns is not related to their distance from urban areas, and there are no specific deviations based on the development scale, year, or major organizations in any of phases. As a result, those conventional indicators appeared as subordinate explanation variables on the classification tree. Additionally, to categorize the demographic structure of a new town from a macroscopic perspective, methods that can handle nonlinearities such as SOM and classification tree analysis rather than conventional statistical methods that assume linearity, are required.

Second, even if new towns are either contiguous with each other or along same railway line, they often belonged to totally different phases of the household transition series. Some new towns demonstrating a population re-influx tendency are located very near others that are experiencing both demographic and economic stagnation.
Third, rental housing rates, particularly those related to private rental housing, are the most relevant factor influencing population inflows. There is a distinct difference between the rental housing rates in new towns belonging to the transformation period and those in towns associated with other phases. Moreover, new towns with higher tendencies toward population re-influx exhibit higher ratios of private rental housing. In fact, this element is the most significant explanation variable on classification Tree_1, and even on classification Tree_2, new towns with low self-owned housing rates and relatively high rental housing rates are expected to demonstrate a greater potential for population re-influx.

Fourth, new towns with higher ratios of self-owned housing need to be located closer to urban areas than those with lower ratios. According to classification Tree_2, the threshold value of the required travel time to urban area varies according to the ratio of self-owned housing. When the ratio is higher, the threshold value of required travel time becomes lower.

Fifth, it appears that detached housing has a high attraction for new inhabitants. New towns established during the attracting new inhabitants phase and depopulation mitigation Phase A demonstrate higher ratios of detached housing compared to those experiencing stagnation. Furthermore, the classification trees showed a relationship between higher detached housing rates or lower apartment housing rates and higher population re-influx tendencies.

In conclusion, the following four suggestions are offered:

1) It is important to establish a management system for transferring the primary form of housing possession from self-owned homes to private rentals. When homeowners decide to move from a new town or their relatives inherit a vacant home, they largely seek to sell the house. Based on economic conditions and lifestyle changes, the need for rentals is expected to be higher than that for self-owned. Additionally, if it is possible to maintain housing stock that does not rely on self-ownership, then it is expected to increase population inflow in relatively distant new towns.

2) In spatial planning, maintaining a proper environment for detached housing besides proceeding to mixed land use is still important. Detached housing remains a significant feature of new towns.

3) Including policies for mutual use of contiguous new towns in regional planning is necessary. In the current situation of national depopulation, there are certainly several new towns that experienced difficulties in transferring housing possession forms or maintaining an environment with sufficient detached housing. In fact, there are already gaps between the phases of adjacent new towns. Therefore, it is suggested that rather than concentrate on individual new towns, it is best to overview and construct a complementary system that incorporates mixed land use in these plural new towns.

4) The analysis of both regional characteristics and population composition is essential to properly manage policy and spatial planning and to continue adjusting them depending on the present state.

7-2. Future Research Prospects

The data used in this study are primarily based on the National Population Census, and the Economic Census for Business Frame limits the analysis of regional characteristics. Therefore, it is necessary for future studies to add more elements for investigation, such as the spatial structures of new towns, types of commercial facilities, the present status of self-government association activities, and real consumption expenditure per household. In addition, the relationships between new towns and their surroundings is critical for clarifying regional characteristics.

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Notes
(1) New town as defined by the LMIT comprises (a) projects initiated after 1955, (b) projects with more than 1,000 planned units or planned population of more than 3,000 people and a district area of 16 ha or more; (c) development projects in the suburbs (projects that were not in the Densely Inhabited District when the project commenced).
(2) The high economic growth period in Japan was between 1955 and 1973.
(3) The bubble economic period in Japan was between 1986 and 1990.
(4) This is Japan’s second largest conurbation. From the late 1950s to the 2000s, varied new towns were developed. However, if we observe the demographics, the population has been declining since the late 1970s. Therefore, it is one of the most suitable areas to seek the typification of new towns based on population dynamics and analyze the geographic characteristics of new towns, which have relatively high population growth and immigration.
(5) In this study, because of the large amount of data and the fact that some of the variables have nonlinear relationships, the SOM, which can perform nonlinear analysis, was used instead of the hierarchical cluster analysis (Ward), which assumes linearity. The nonhierarchical cluster analysis (k-means) requires setting the number of clusters to be classified by initial parameters, which is difficult to use in an analysis where the number of classifications is difficult to define from the beginning. Additionally, as the subject of this study is a typology based on the demographics of each new town, a principal component analysis that simplifies the explanatory variables by dropping them to a lower dimension is not appropriate. This study also follows previous studies that suggest the suitability of SOM for spatial analysis (Li, 200922)
(6) A classification tree approach was used rather than a multiple regression analysis due to the assumption that the results of the analysis could exhibit a nonlinear relationship. In fact, the “required time” is twice represented as an explanatory variable in the Classification Tree_2. Such a result can only be obtained through this method. The purpose of this study is to extract the explanatory variables and their values that relate to branching rather than the degree of influence by the size of the variables. Additionally, this paper follows previous studies that suggest the suitability of the classification tree analysis for spatial analysis (De’ath & Fabricius, 2000 23); Tehrany et al., 2013 24).
(7) In this paper, we use R to perform a SOM analysis based on the variables in Table 2. The parameters were set in advance to (a) Number of output units = 20 and (b) “4 × 5” for the aspect ratio at the time of outputting units. This assumes a percentage analysis so that even if 220 new towns are evenly distributed, then there are more than 10 new towns per unit. Additionally, several patterns of output with different parameters were tried, and it was judged that the parameter settings used in this study are empirically reasonable.

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