

## Changes in Transportation Behavior in the Tokyo Metropolitan Area based on Person-trip Survey Data

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**Abstract:** Person-trip (PT) surveys, a type of household travel survey used in Japan, have been conducted five times in the Tokyo metropolitan area, in 1968, 1978, 1988, 1998, and 2008. In these five surveys, approximately 2 percent of the metropolitan area inhabitants are surveyed. The Tokyo metropolitan area is the only region in the world where this kind of large-scale survey has been carried out on an ongoing basis.

This study focuses on the Tokyo metropolitan area, arranging 50 years of socioeconomic changes from multiple perspectives. It also analyzes changes in transportation behavior based on the PT surveys of the Tokyo metropolitan area since 1968. Furthermore, it analyzes changes in transportation behavior in the Tokyo metropolitan area suburb Nagareyama City due to the Tsukuba Express railway line, which opened in 2005. We think such knowledge is extremely important when considering the direction of future policies on urban planning and urban transport.

**Keywords:** Person trip survey, Travel behavior, Tokyo metropolitan area, Suburb, Senior citizens

### 1. Background and objectives of this study

Person-trip surveys ("PT surveys") in Japan began in the 1960s with advanced, highly investigational surveys of current conditions. They were followed in 1967 by the first large-scale survey, which was conducted in the Hiroshima metropolitan area. In the Tokyo metropolitan area, a survey was carried out the following year, 1968, and four more surveys have been performed at 10-year intervals. The Tokyo metropolitan area is the only region in the world where this kind of large-scale survey with 735,000 samples for the latest survey has been carried out on an ongoing basis.<sup>1)2)3)4)</sup>

The Tokyo metropolitan area has continuously grown since the postwar period of high economic growth, with a rapid increase in the spread of automobile use bringing about great changes in industry and lifestyles. Now, however, Japan faces an era of population decline due to the rapid development of an aging society with a low birthrate, and the Tokyo metropolitan area is no exception. Understanding the course of the metropolitan area's population and urban transport to date is extremely important when considering the direction of future policies on urban planning and urban transport. Such knowledge will also be beneficial for other Asian countries that face population declines of their own.

This study focuses on the Tokyo metropolitan area, arranging 50 years of

socioeconomic changes from demographic perspectives such as population and aging. It also analyzes the transition in the number of trips and modal share as transportation behavior based on the five PT surveys of the Tokyo metropolitan area since 1968. Moreover, we focused on the elderly as rapid aging is expected in Tokyo metropolitan area.

Furthermore, it analyzes changes in transportation behavior in suburban Nagareyama City with express station of the latest opened Tsukuba Express railway line in 2005 in the Tokyo metropolitan area.

## 2. Socioeconomic change in the Tokyo metropolitan area

Focusing on the Tokyo metropolitan area, various statistical data is used to compare and summarize socioeconomic indicators in the 1960s and the present in order to grasp the changes that have taken place during the previous 50 years.

We define Tokyo metropolitan area as the following areas of the Person Trip survey: Prefectures of Tokyo, Kanagawa, Chiba, and Saitama, and southern Ibaraki prefecture. Due to data limitations, some figures contain data only for 4 prefectures (Tokyo, Kanagawa, Chiba, and Saitama).

### 2.1 Population

#### 2.1.1 Increase in national population and concentration of population in Tokyo and three adjacent prefectures

Japan's population grew from 94.3 million in 1960 to 120.86 million in 2010, an increase of about 40 percent. The population of Tokyo and three adjacent prefectures, meanwhile, approximately doubled, from 17.86 million in 1960 to 35.62 million in 2010. The area's share of the national population increased from 18.9 percent in 1960 to 27.8 percent in 2010 as population concentrated in Tokyo and three adjacent prefectures during those 50 years. Looking at a time series of population change in Tokyo and three adjacent prefectures (Figure-1), one sees that although the increase in its share of the national population has slowed somewhat since 1975, it has remained on a rising trajectory throughout the entire period. Breaking down Tokyo and three adjacent prefectures individually, Tokyo accounted for most of the population increase until 1965, but after that, the populations of Kanagawa, Saitama, and Chiba Prefectures grew as urbanization spread to outlying areas. Since 2000, however, Tokyo's share of the population of the area has increased slightly.

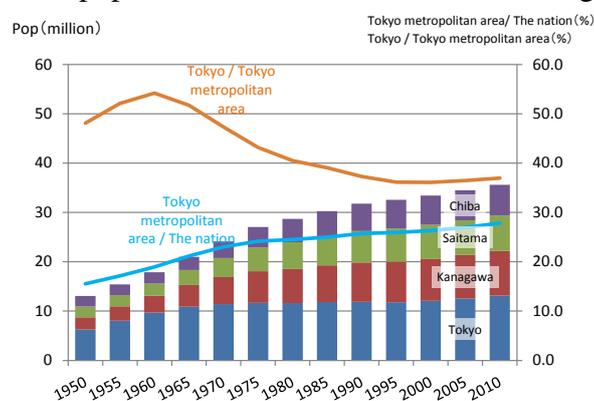


Figure-1 Population change in Tokyo metropolitan area <sup>5)</sup> \*

\* "Tokyo metropolitan area" is made Tokyo and three adjacent prefectures.

### 2.1.2 Aging at a faster pace than the nation as a whole

The population aged 65 and above nationwide in Japan grew by a multiple of approximately 5.4 from 1960 to 2010, from 5.4 million (5.7 percent of the national population) in 1960 to 29.25 million (22.8 percent of the national population) in 2010. In Tokyo and three adjacent prefectures, this age group grew by a multiple of approximately 9.1 times from 1960 to 2010, from 800,000 (4.5 percent of the total population) in 1960 to 7.25 million (20.3 percent of the total population) in 2010. The increase in the 65 and above population and the progressive aging of society have been greatly affected by two causes: a 12–13 year increase in average life expectancy over the past 50 years (males: 67.7 in 1964 to 79.9 in 2012; females: 72.9 in 1964 to 86.4 in 2012) and a 30 percent drop in total fertility rate (from 2.05 in 1964 to 1.41 in 2012).

Table-1 The progressive aging of society

	Area	50 years ago		Nowadays		Rate (Nowadays / 50 years ago)	Source
		Year	Index	Year	Index		
Population age 65 and older (thousand)	Tokyo metropolitan area		799		7,247	9.07	Census
	Tokyo metropolitan area / The nation	1960	5,398	2010	29,246	5.42	
	The nation		14.8%		24.8%	10.0%	
Population age 65 and older rate	Tokyo metropolitan area	1960	4.5%	2010	20.3%	15.9%	Census
	The nation		5.7%		22.8%	17.1%	
Life expectancy (Man)	The nation	1964	67.67	2012	79.94	1.18	Abridged life table
Life expectancy (Woman)	The nation	1964	72.87	2012	86.41	1.19	Abridged life table
Total fertility rate	The nation	1964	2.05	2012	1.41	0.69	Vital Statistics

\* "Tokyo metropolitan area" is made Tokyo and three adjacent prefectures.

## 2.2 Change in population distribution

Having touched on the concentration of population in Tokyo and three adjacent prefectures, we will now address change in the spatial spread of population.

Change in population density in the Tokyo metropolitan area (Tokyo and three adjacent prefectures plus southern Ibaraki Prefecture) over 40 years can be understood by using a 1 km<sup>2</sup> grid from the national censuses of 1970 and 2010 (see Figure-2 and Figure-3). The red grid squares on Figure-2 and Figure-3 represent a density of 4,000 people/km<sup>2</sup>, corresponding to densely inhabited districts (DIDs).

In 1970, grid squares with 4,000 people/km<sup>2</sup> were concentrated in Tokyo wards within 20 km of the city center, with extensions into areas to the west and south such as Tama and Yokohama and around stations on railway lines in suburbs (Figure-2). Forty years later in 2010, grid squares with 4,000 people/km<sup>2</sup> have spread to an area within 50 km, especially to the southwest. Furthermore, in Saitama and Chiba Prefectures, DIDs have expanded in railway-adjacent areas close to Tokyo, and are gradually expanding in suburbs, including Ibaraki Prefecture, in areas surrounding railway stations.

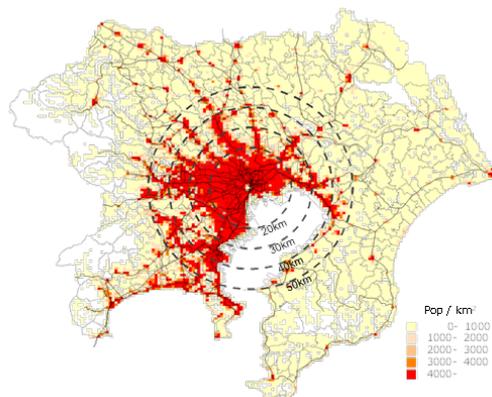


Figure-2 Population density of the Tokyo metropolitan area by 1 km<sup>2</sup> grid (1970)

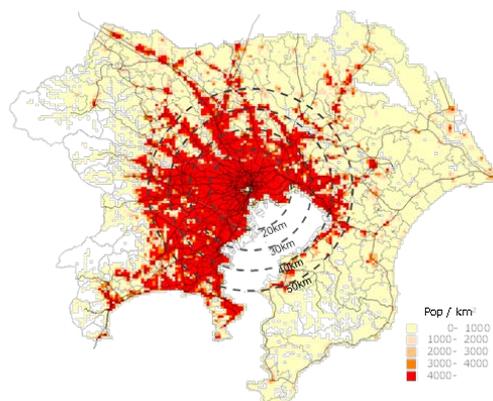


Figure-3 Population density of the Tokyo metropolitan area by 1 km<sup>2</sup> grid (2010)<sup>6)</sup>

### 3. Changes in transportation behavior in the Tokyo metropolitan area as a whole

#### 3.1 Overview of the carrying out of Tokyo metropolitan area PT surveys

Here, we will grasp changes in transportation behavior in the Tokyo metropolitan area based on the Tokyo metropolitan area PT surveys performed in 1968, 1978, 1988, 1998, and 2008. Table-1 shows an overview of the Tokyo metropolitan area PT survey. The survey area of the first survey in 1968 included Tokyo Prefecture, Kanagawa Prefecture, Saitama Prefecture (except Chichibu), and Chiba Prefecture (except Boso). With the expansion of commuting distance, the second survey in 1978 was broadened to include all areas of Tokyo and three adjacent prefectures, i.e. Tokyo, Kanagawa, Saitama, and Chiba Prefectures, plus southern Ibaraki Prefecture. Since then, through the fifth PT survey, the area of southern Ibaraki Prefecture covered has been expanded. With the broadening of the survey's coverage area and the growth of the Tokyo metropolitan area's population, the population of the PT survey's coverage area has increased by about 60 percent, from 21.31 million in the 1968 first survey to 34.62 million in the 2008 fifth survey. About 500,000–800,000 people, approximately 2 percent of the metropolitan area population, are surveyed.

Table-2 Overview of the carrying out of Tokyo metropolitan area PT surveys

		1st	2nd	3rd	4th	5th
Survey year		1968	1978	1988	1998	2008
Survey area		Tokyo, Kanagawa, Saitama(except Chichibu), Chiba(except Boso)	Tokyo, Kanagawa, Saitama, Chiba, South Ibaraki	Tokyo, Kanagawa, Saitama, Chiba, Southern Ibaraki(Add Kashima)	Tokyo, Kanagawa, Saitama, Chiba, Southern Ibaraki(Same 3rd area)	Tokyo, Kanagawa, Saitama, Chiba, Southern Ibaraki(Add Omitama and Namegata)
Pop(million)		21.3	28.8	32.5	34.5	34.6
Sample rate		2.0%	2.4%	Civ:center, Outerperiphery 1% Other Tokyo wards 2% Other 3%	Tokyo wards 1.96% Other 2.85%	Tokyo wards 1.90% Ordinance-designated city 2.53% Other 1.02%
Survey method	Distribution	Visit	Visit	Visit	Visit	Mailing
	Response	Visit	Visit	Visit	Visit	Mailing·WEB
Response rate		86.7%	84.9%	81.5%	71.5%	25.6%
Sample(thousand)		315	588	668	883	735

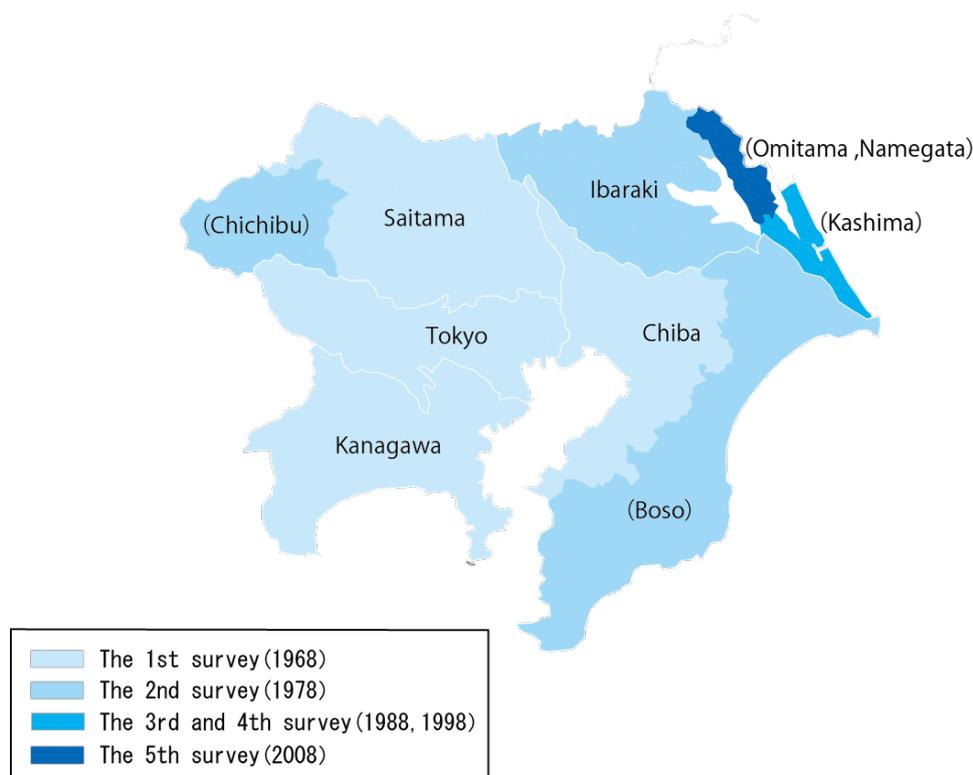


Figure-4 Area of the carrying out of Tokyo metropolitan area PT surveys

### 3.2 Change in number of trips and modal share

As for the results of the Tokyo metropolitan area PT survey, looking first at change in the number of trips in the Tokyo metropolitan area, as illustrated in Figure-5, the number of trips grew from 47.92 million in the 1968 first survey, to 66.67 million trips in the 1978 second survey with its expanded coverage area, and to 83.09 million trips in the 2008 fifth survey. That is an approximate 70 percent increase from the first survey, and an approximate 20 percent increase from the second survey, which covered almost exactly the same area as the fifth. Meanwhile, the number of trips per person (the gross per-capita unit) was about 2.4–2.5 trips/person, while the number of trips per person who went out (the net per-capita unit) was about 2.8–2.9 trips/person, showing little change. Most of the increase in the number of trips was therefore because of population increase in the Tokyo metropolitan area.

Looking next at modal share in the Tokyo metropolitan area, as shown in Figure-6, automobiles accounted for a 17 percent share in the 1968 first survey and a 33 percent share in the 1998 fourth survey. The progress of motorization greatly increased automobile use during the 30 years. On the other hand, walking was the mode for which the share decreased during the 30 years, falling sharply from 43 percent in 1968 to 22 percent in 1998. Thus, from the 1960s to 2000 in the Tokyo metropolitan area, there was an era of expanding automobile use due to the dissemination of automobiles and the expansion of urbanization to the suburbs.

In the 2008 fifth survey, however, the modal share of automobiles fell from 1998's 33 percent to 28 percent, while the modal share of railways rose from 25 percent in 1998 to 30 percent. This may be explained as the combined effect of increased rail ridership in Tokyo wards and other major cities along with a corresponding increase in rail trips with destinations in Tokyo wards, both made possible by improvements to railway service in the Tokyo metropolitan area, including the development of new lines and the connecting of existing lines

through mutual direct service. However, in metropolitan area suburbs such as northern Saitama, southwestern Chiba, eastern Chiba, and southern Ibaraki, the modal share of automobiles continues to increase.

However, one of the reasons of the increase of modal share of “other” in 2008 Survey may be the increase of “unknown” responses due to change in survey method from door-to-door field survey to mail survey.

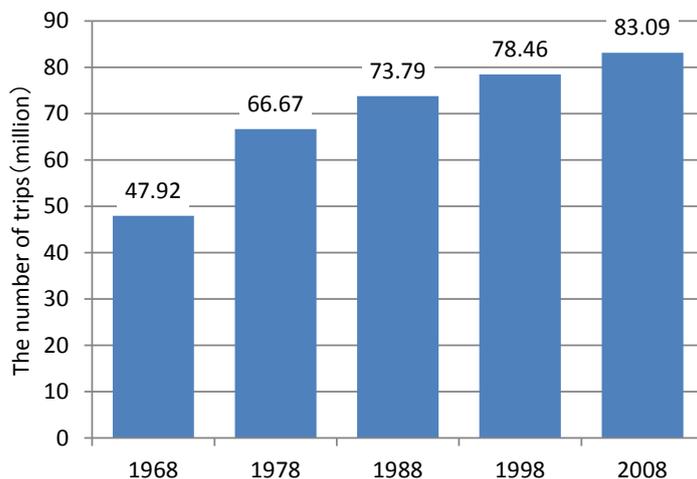


Figure-5 Change in the number of trips in the Tokyo metropolitan area<sup>7)</sup>

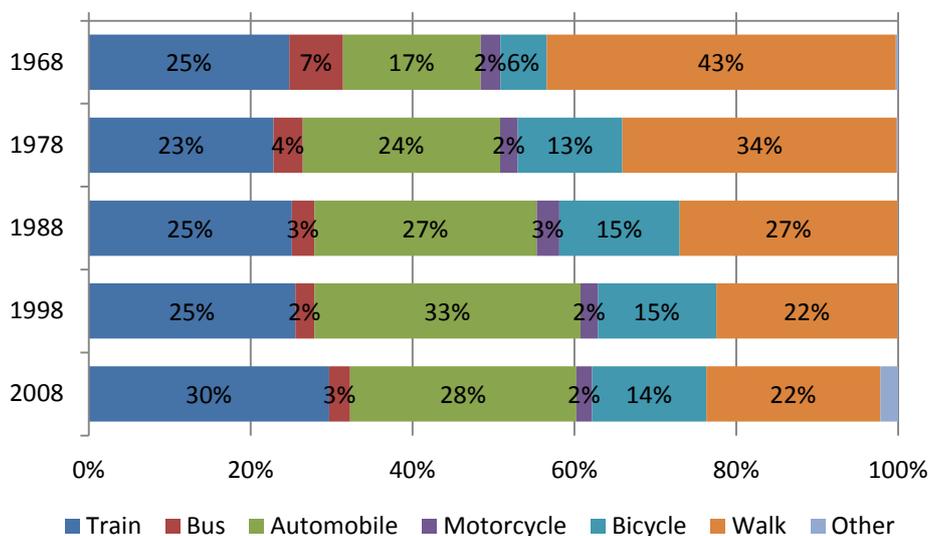


Figure-6 Changes in transportation modal shares in the Tokyo metropolitan area<sup>7)</sup>

Looking at the automobile modal share of transportation volume by destination, in 1968 it was no more than 20 percent in the city center and no more than 40 percent in metropolitan area suburbs. However, the automobile modal share of transportation volume is rising over time for destinations throughout the metropolitan area. In 2008, the automobile modal share remained at 20 percent or below throughout most of the area within 20 km of Tokyo Station, and generally did not exceed 40 percent in the areas within 40 km, but well surpasses 60 percent in areas more than 40 km away, includes Ibaraki Prefecture, the Boso area in Chiba Prefecture, and the Chichibu area in Saitama Prefecture.

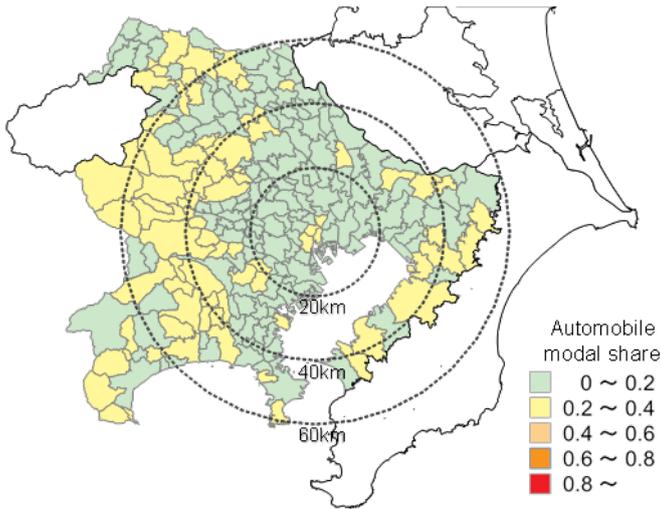


Figure-7(1) Automobile modal share of transportation volume by destination (1968)<sup>7)</sup>

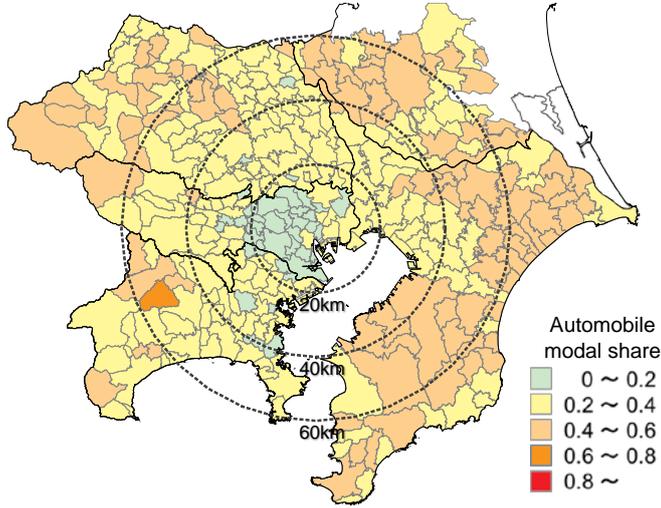


Figure-7(2) Automobile modal share of transportation volume by destination (1978)<sup>7)</sup>

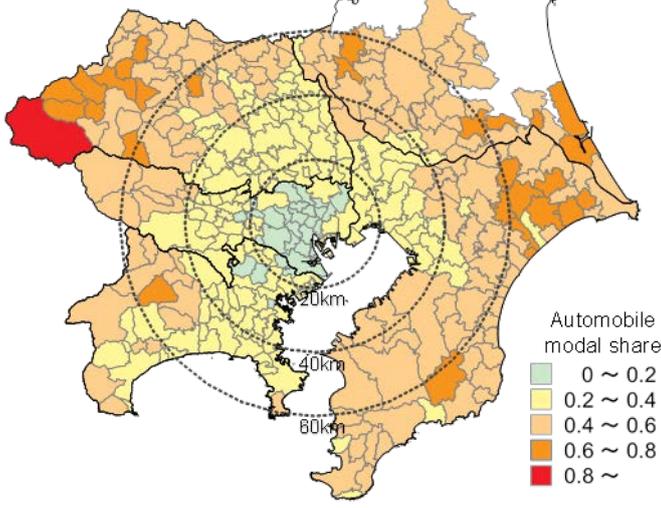


Figure-7(3) Automobile modal share of transportation volume by destination (1988)<sup>7)</sup>

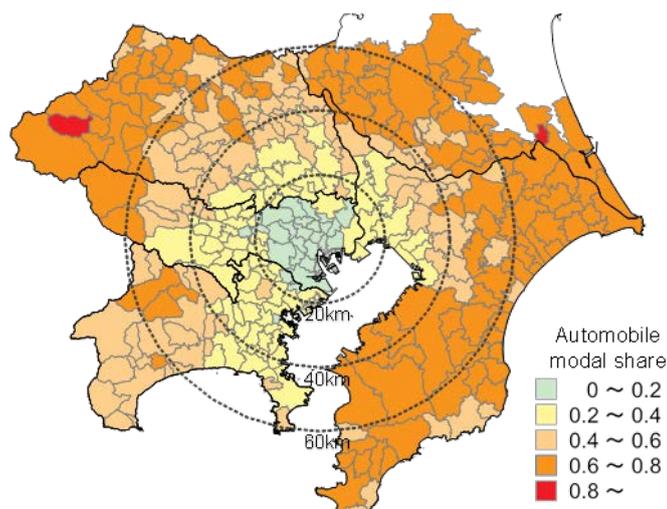


Figure-7(4) Automobile modal share of transportation volume by destination (1998)<sup>7)</sup>

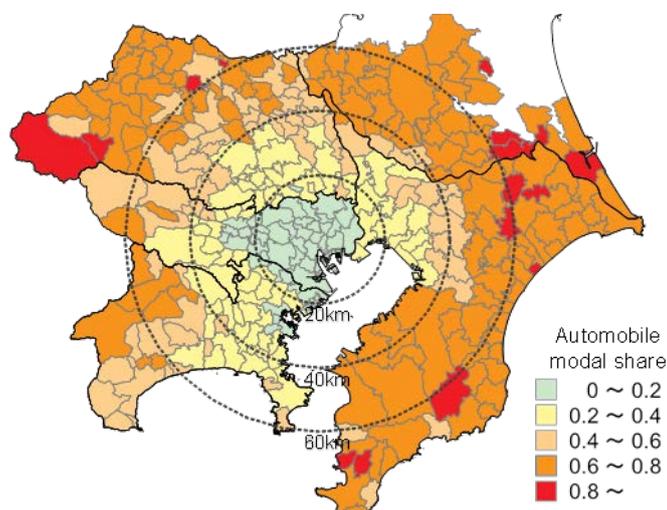


Figure-7(5) Automobile modal share of transportation volume by destination (2008)<sup>7)</sup>

In order to capture the characteristics of the above increase in the use of railways to the city center, Figure-8 shows changes in the number of trips to destinations in Tokyo wards, and Figure-9 shows the modal shares of trips to destinations in Tokyo wards. Looking at the change in the number of trips to destinations in Tokyo wards, there were 3.56 million trips in the 1968 first survey, 4.25 million trips the 1978 second survey with its expanded coverage area, and 6.13 million trips in the 2008 fifth survey. The 2008 number is about 1.7 times as many trips as in the first survey, and about 1.4 times as many as in the second survey, for which the coverage area was almost identical. This increase is greater than the rate of increase for the number of trips in the metropolitan area as a whole mentioned above. In the 10 years from 1998, trips increased by 740,000, or 13.7 percent, an even greater rise. Looking at change in modal share for trips to destinations in Tokyo wards, in the period up to 1998 the railway modal share increased, but the automobile modal share held steady at about 10 percent and walking declined. During the 10 years from 1998 to 2008, however, the railway modal share continued to rise from 74 percent to 79 percent, while automobile modal share fell from 9 percent to 4 percent.

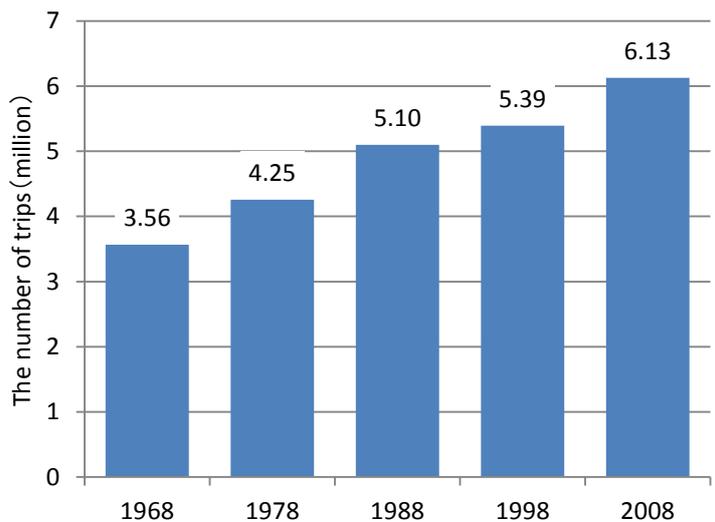


Figure-8 Change in number of trips to destinations in Tokyo wards<sup>7)</sup>

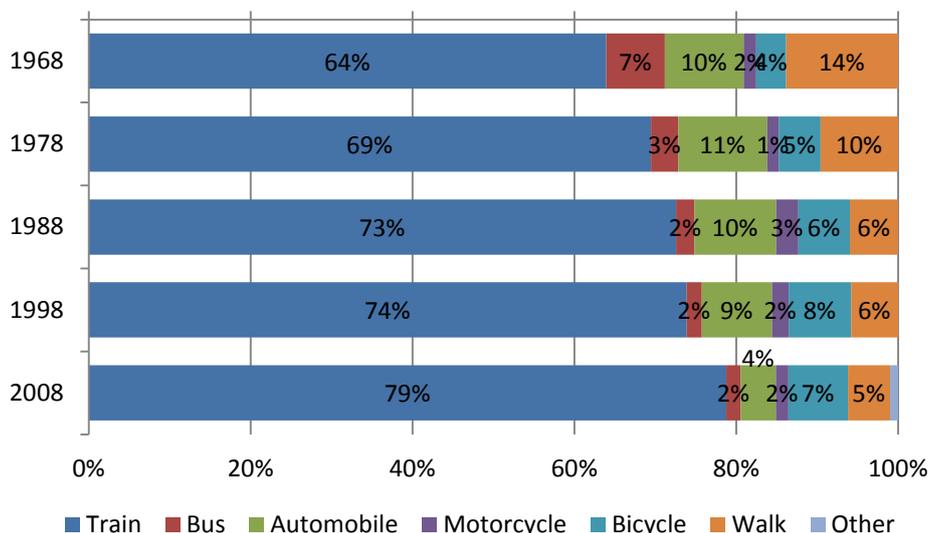


Figure-9 Change in modal share of trips to destinations in Tokyo wards<sup>7)</sup>

Additionally, the time required for commuting to Chiyoda-ku, the urban center of Tokyo, was calculated for years 1968 and 2008 (see Figure-10 and Figure-11). In Figure-10 and Figure-11, the average time required to commute from home (each residential zones) to work (Chiyoda-ku) according to response values in the 1968 first survey and the 2008 fifth survey is calculated, and 60-minute zones and 90-minute zones to Chiyoda-ku are shown. It must be noted that in the 1968 first survey, Chiba Prefecture's Boso area was outside the survey. Comparison of the two figures finds that, with the exception of the above-mentioned Boso area, no major changes are apparent to the area within a 90-minute commute, save for some expansion in the zone at a distance of 40 km from the city center. Meanwhile, the area within a 60-minute commute has expanded to the north and east in the zone at a distance of 20 to 30 km from the city center.

From the 1960s on, efforts were made to improve railway transport service. These included transport capacity increase through Japan National Railways' Five Directions of Commuting Campaign, subway development, and mutual direct service between suburban

railways and subways. Subsequently, detailed service improvements for diverse railway users were implemented, including the introduction of automatic ticket gates, the adoption of IC cards and their interoperability, and, beyond mere transportation, making railway stations barrier-free and developing businesses inside stations. Such multifaceted railway service improvements probably also propelled the increase in railway users in the Tokyo wards and other areas.

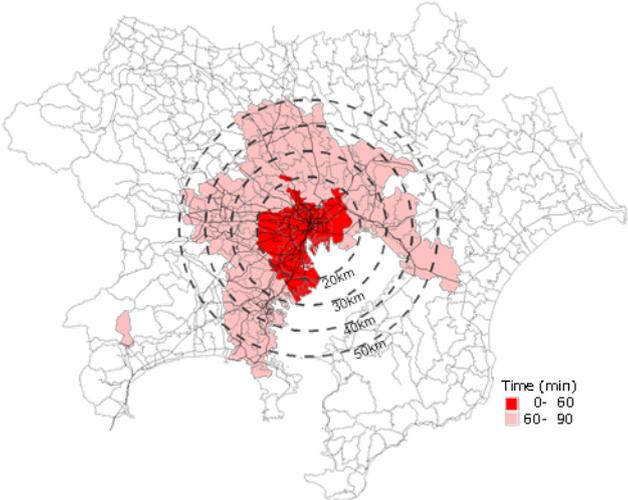


Figure-10 Time required for commuting to Chiyoda-ku (1968) <sup>7)</sup>

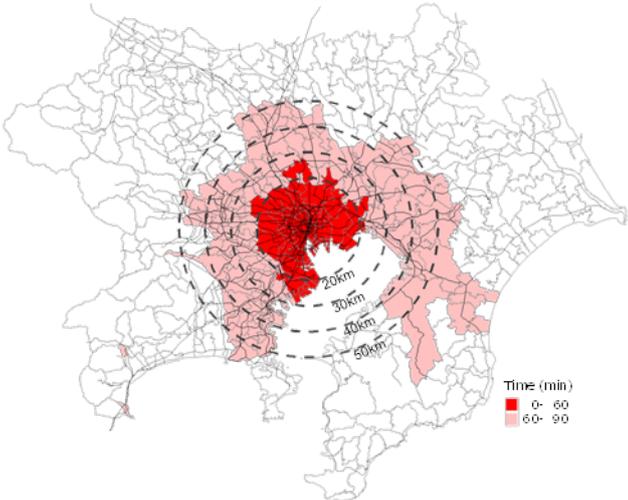


Figure-11 Time required for commuting to Chiyoda-ku (2008) <sup>7)</sup>

### 3.3 Change characteristics of senior citizen trips

The transportation behavior of senior citizens aged 65 and older was also captured. As noted above, the number of people aged 65 and older living in Tokyo and three adjacent prefectures rose from 800,000 (4.5 percent of the population) in 1960 to 7.25 million (20.3 percent of the population) in 2010, 9.1 times as many. This change became more pronounced starting in 1990 (see Figure-12).

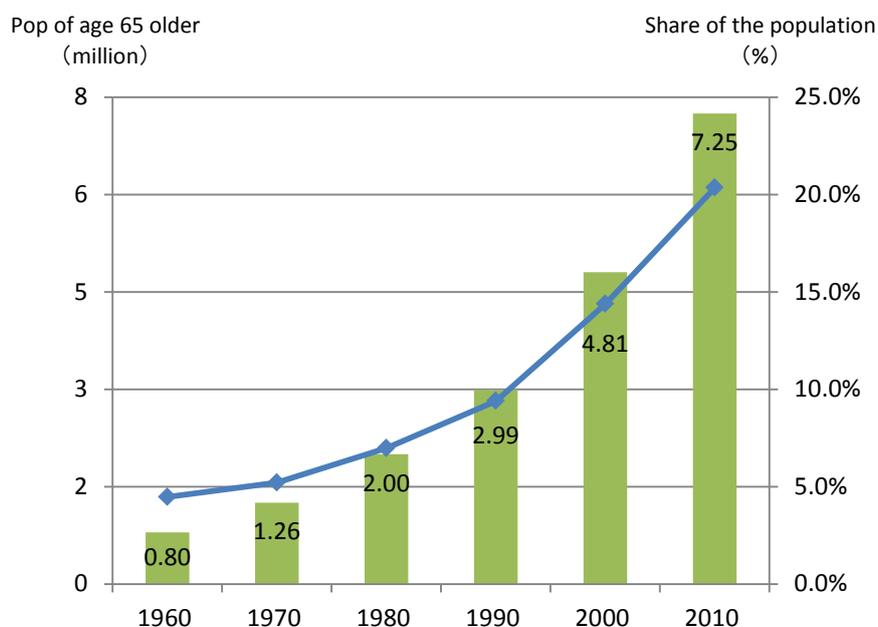


Figure-12 Change in the number of people aged 65 and above and their share of the population in Tokyo metropolitan area <sup>5)</sup>\*

\* "Tokyo metropolitan area" is made Tokyo and three adjacent prefectures.

Based on the results of the PT survey, Figure-13 shows number of trips per person (the gross per-capita unit) by age group in the 1978 second survey. However, as the data of the first PT Survey in 1968 have not been rearranged, so gross per-capita unit cannot be estimated.

In the 1998 and 2008 survey results, the number of trips per person by those aged 65 and older rose greatly. Figure-14 shows changes in modal share among those 65 and older. Automobile use by those 65 and older has increased sharply starting with the 1998 survey. Consequently, although the population age 65 and older is increasing, their transportation behavior differs from those who came before them. They go out more, travel more by automobile, and are increasingly active outside their homes. One may say that senior citizens, formerly seen as a uniform group, are diversifying with the times in terms of work styles, lifestyles, and transportation behavior.

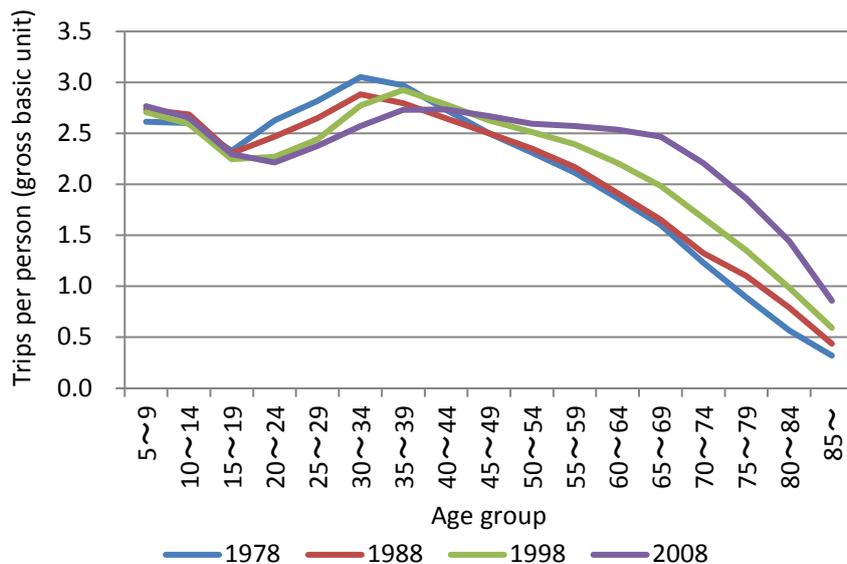


Figure-13 Change in per-capita trips generated, by age group<sup>7)</sup>

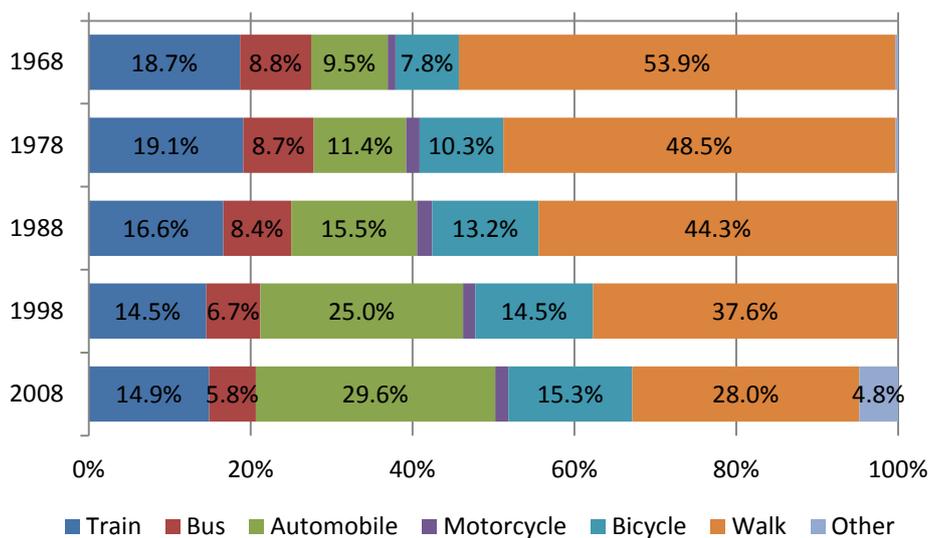


Figure-14 Change in modal share among those aged 65 and older<sup>7)</sup>

The trip attraction rate for senior citizen trips in 1968 was about 40 trips/km<sup>2</sup> in the three central Tokyo wards, and 20 trips/km<sup>2</sup> in surrounding areas. With the number of senior citizens rising, and seniors becoming more active, the volume of senior citizen trips is rising year by year, mainly along railway lines in the metropolitan area. In 2008, the senior citizen trip attraction rate inside the Yamanote Line was more than 50 trips/km<sup>2</sup>, and 40–50 trips/km<sup>2</sup> in other Tokyo wards. Trip density was particularly high in a series of areas along the Tokaido Main Line, and some parts of Yokohama saw more than 50 trips/km<sup>2</sup>.

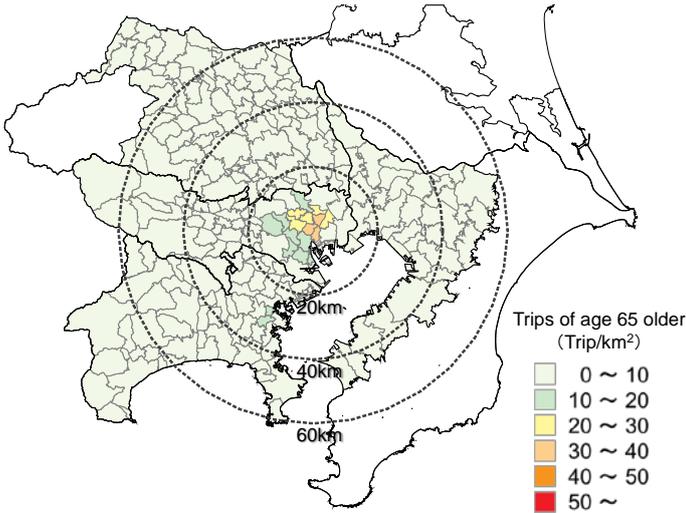


Figure-15(1) Trip attraction rate for trips by senior citizens (age 65 and up) (1968)<sup>7)</sup>

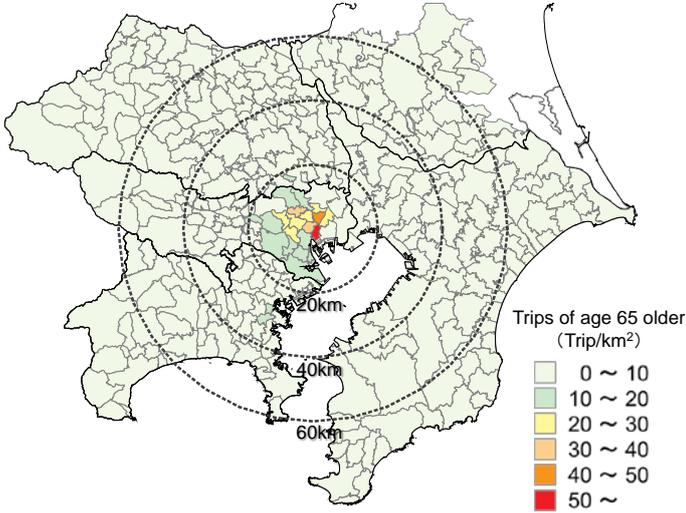


Figure-15(2) Trip attraction rate for trips by senior citizens (age 65 and up) (1978)<sup>7)</sup>

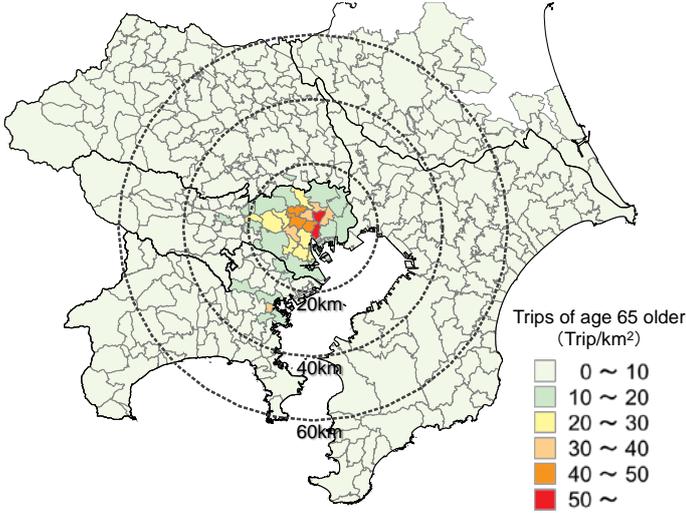


Figure-15(3) Trip attraction rate for trips by senior citizens (age 65 and up) (1988)<sup>7)</sup>

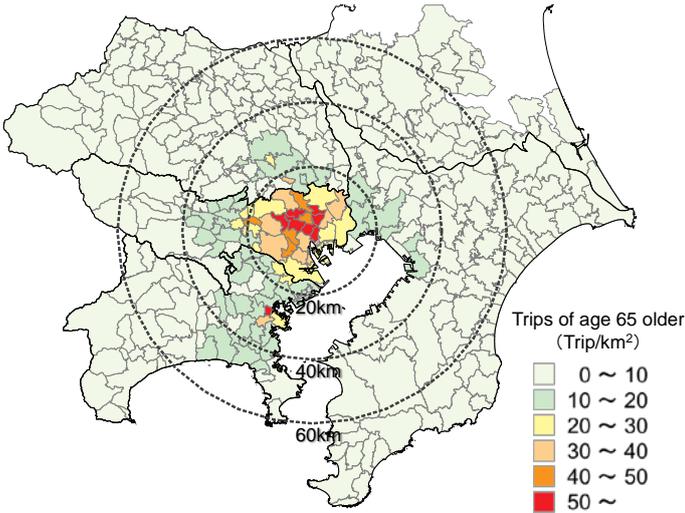


Figure-15(4) Trip attraction rate for trips by senior citizens (age 65 and up) (1998)<sup>7)</sup>

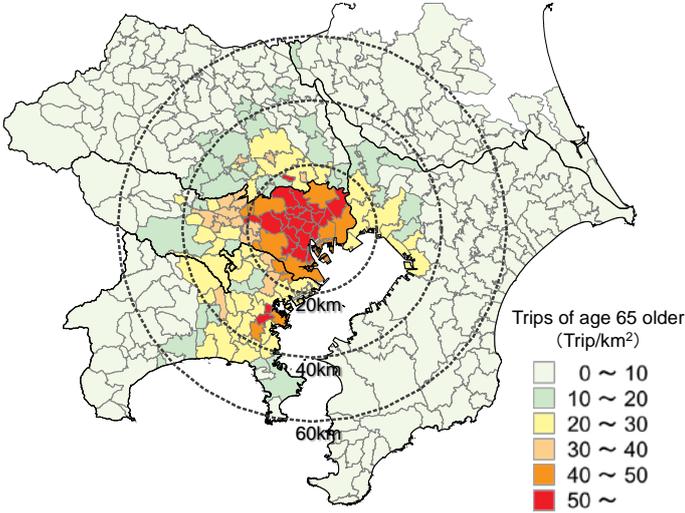


Figure-15(5) Trip attraction rate for trips by senior citizens (age 65 and up) (2008)<sup>7)</sup>

#### 4. Changes in transportation behavior in Nagareyama accompanying the opening of the Tsukuba Express

Since the period of high economic growth, urban areas in the Tokyo metropolitan area have been expanding to the suburbs mainly along railway lines. Populations have grown in urbanized suburbs that serve as bedroom communities from which workers commute to central Tokyo. Rush hour congestion because of railway users commuting between bedroom communities and the city center was remarkable. Steps such as shifting to quadruple tracks on suburban lines and building new subways in the city center have been taken in response. The Tsukuba Express opened in 2005 as the latest developed line linking the Tokyo metropolitan area's city center with suburbs. The opening of Tsukuba Express caused decrease in number of changing travel modes for passengers and travel time, along with encouraging development along the line. Here, we discuss an express station, Nagareyama, one of the largely affected commuter towns by the opening of Tsukuba Express within 30 km from central Tokyo in Tokyo metropolitan area, and capture changes in transportation characteristics.

##### 4.1 Trends in Nagareyama's industrial and social infrastructure

In order to grasp changes to Nagareyama's population, industry, and lifestyles since Tokyo metropolitan area suburbs became bedroom communities, it is important to summarize the historical background behind its previous industry and social infrastructure. In order to understand conditions that existed before statistics and other quantitative data existed, literature such as the official history of Nagareyama was summarized.

During the Edo period, shipping developed as the Edo River was improved, and the mirin industry flourished in Nagareyama, which grew as a commercial city. Starting in the Meiji period, when railways began to appear, shipping began to fade away, and the Nagareyama Light Railway opened between Nagareyama and Mabashi.

As for Nagareyama's infrastructure, the opening of Minami-Kashiwa Station on the Joban line in 1953 and of Edogawadai Station on the Tobu Noda Line in 1958 precipitated the development of residential districts. Subsequently, the opening of Minami-Nagareyama Station on the Musashino Line in 1973 and the completion of the Tsukuba Express in 2005 followed, further reinforcing the town's nature as a bedroom community.

Table-3 Trends in Nagareyama's industrial activity and infrastructure <sup>9) 10)</sup>

Year - AD:	Events
1914	Nagareyama Light Railway opens between Nagareyama and Mabashi
1953	Joban Line Minami-Kashiwa Station opens
1956	Matsugaoka Apartment Complex is constructed
1958	Edogawadai Station opens Edogawadai Apartment Complex is constructed
1971	Mutual direct service between the Joban Line and Chiyoda Subway Line begins
1973	Musashino Line Minami-Nagareyama Station opens
2005	Tsukuba Express Line opens

### 4.2 Change in Nagareyama's population

Figure-16 shows Nagareyama's population over time based on the national census. The population has increased since around 1960 along with the suburbanization of Nagareyama. As mentioned above, the successive development of railway infrastructure and housing complexes led to the rapid growth of Nagareyama's population until the 1990s. The population growth rate was even higher than in Tokyo's wards. With the opening of the Tsukuba Express in 2005, Nagareyama's population growth rate increased for the first time since 1970. Figure-17 shows population increases in half grid squares (fourth-order grid: 500 m squares) of the standard regional grid system from 1970 to 1975 and from 2005 to 2010. Looking at the results for 1970 to 1975 in Nagareyama, one can discern population increases brought on by the opening of the Musashino Line and the development of housing around Edogawadai. The results for 2005 to 2010 show population increases due to the development of housing around Nagareyama-otakanomori Station accompanying the opening of the Tsukuba Express. Clearly, the successive development of railway infrastructure and residential areas in Nagareyama has maintained its nature as a bedroom community through the present day.

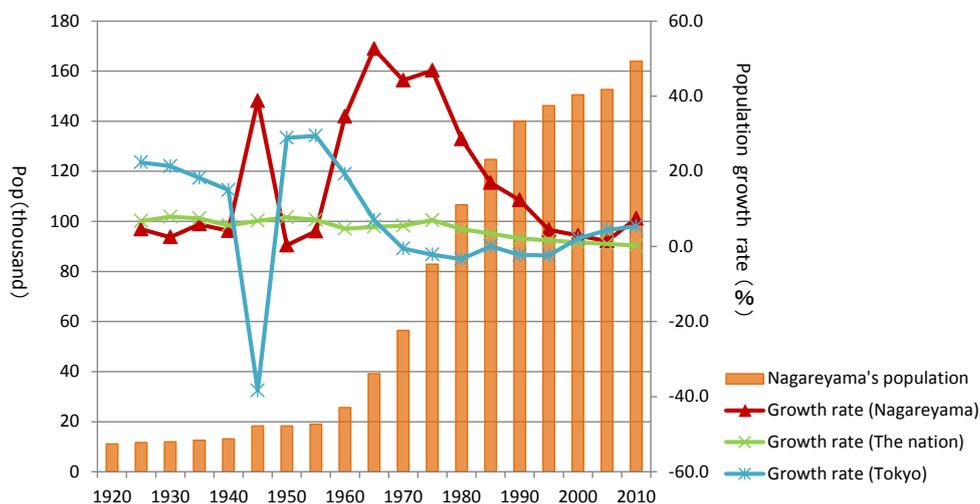


Figure-16 Change in Nagareyama's population<sup>6)</sup>

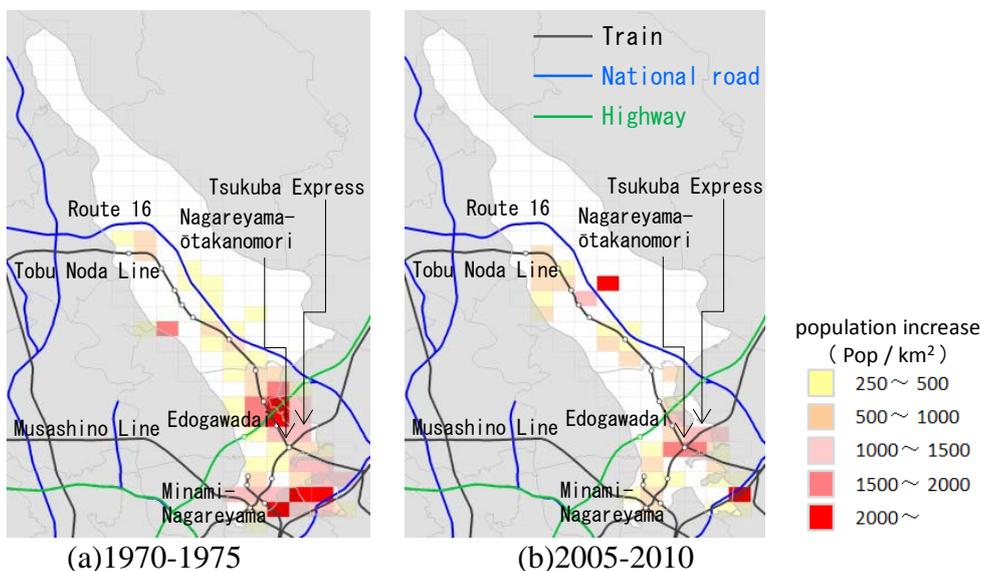


Figure-17 Trends in population increase in by fourth-order grid squares<sup>6)</sup>

### 4.3 Analysis focused on Nagareyama's commute

The change in Nagareyama's number of trips for commuting purposes from 1968 to 2008 is shown in Figure-18. With Nagareyama's population growing, the total number of commuting trips also rose over time. In order to grasp commuting destinations, they were divided into in-town, Tokyo wards, and other areas. The largest number of Nagareyama commuters travel to Tokyo wards. Their number has increased over time, and the increase in recent years is striking. As with the analysis in previous sections, these results speak to the strength of Nagareyama's nature as a bedroom community.

Figure-19 shows Nagareyama's number of trips for commuting purpose by transportation mode used, and Figure-20 shows the modal share of trips for commuting purposes. Modal share refers to the percentages of each transportation mode used, when all trips belonging to a given area are set to equal 100 percent. This study uses six categories: railway, automobile/motorbike, bus, bicycle, walking, and other.

Because Nagareyama has a high rate of commuting to Tokyo wards and other areas, the modal share of railways is high.

Since 1968, several rail improvements, including mutual direct service between the Joban and Chiyoda Lines beginning in 1971, Minami-Nagareyama Station on the Musashino Line opening in 1973, and the Tsukuba Express opening in 2005, combined with infrastructure and housing development to rapidly increase Nagareyama's users of railways for commuting purposes.

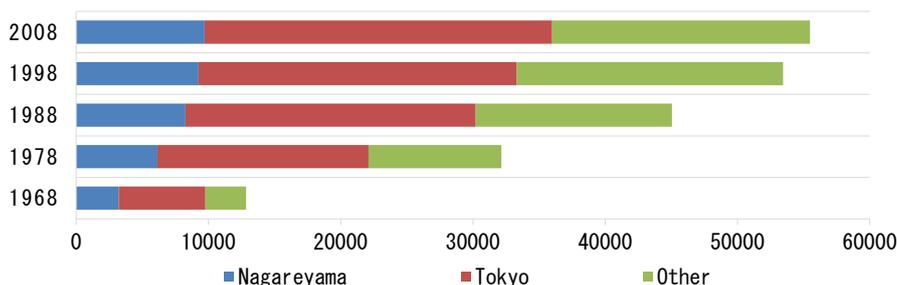


Figure-18 Commuting trips in Nagareyama (by destination)<sup>7)</sup>

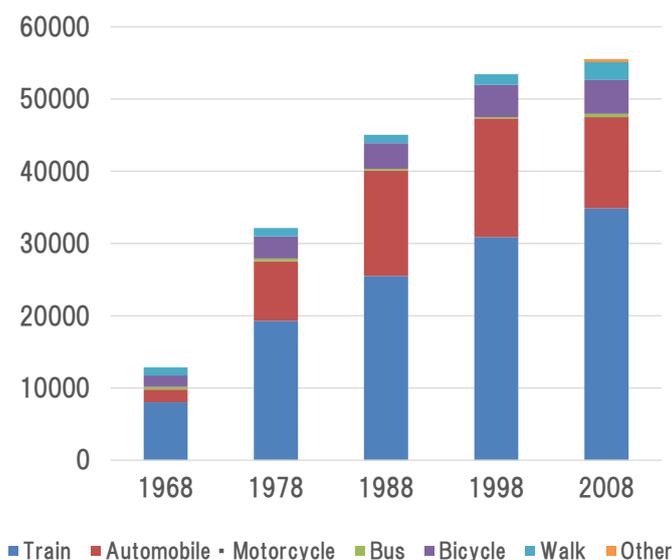


Figure-19 Nagareyama's trips by commuting mode<sup>7)</sup>

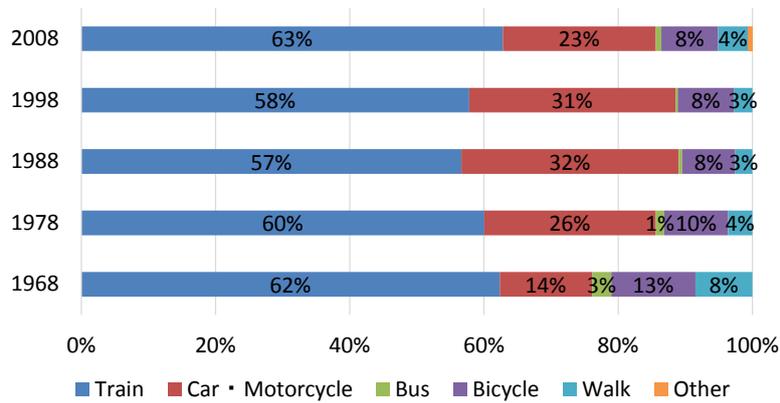


Figure-20 Modal share of commuting trips in Nagareyama<sup>7)</sup>

Because suburbs in major metropolitan areas are characteristically bedroom communities, journeys between home and work or school predominate. By looking at purposes, departure times, arrival times, and length of travel time, four variables which are captured in person-trip survey data, the state of the activities in people's lives can be brought out. From such a perspective, this study focused analysis on commuting in particular.

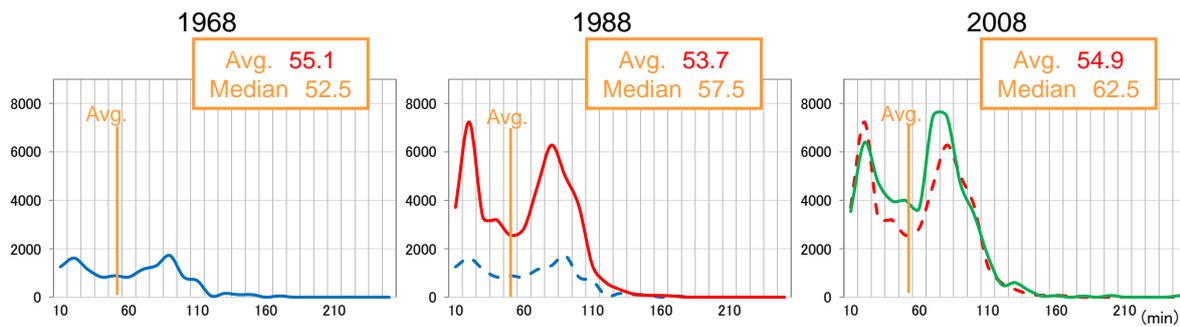


Figure-21 Nagareyama's distribution of commuting times<sup>7)</sup>

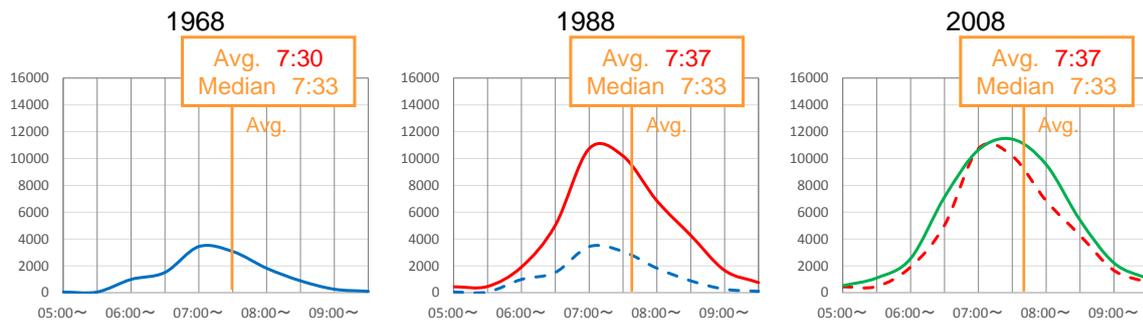


Figure-22 Nagareyama's distribution of departure times<sup>7)</sup>

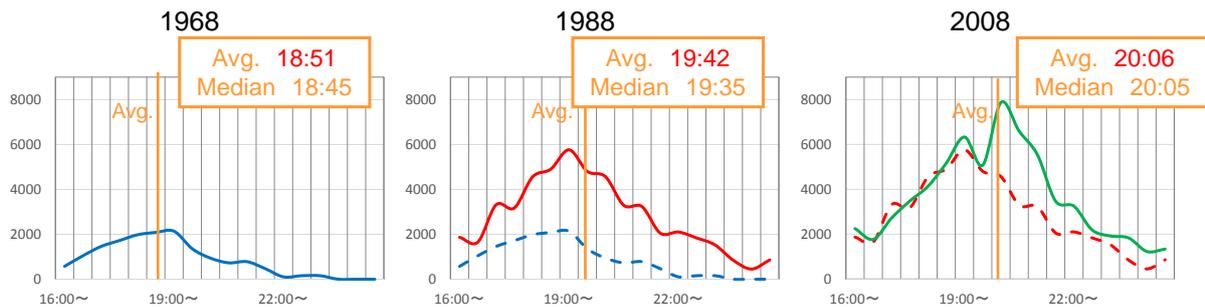


Figure-23 Nagareyama's distribution of arrival times<sup>7)</sup>

Figure-21 through Figure-23 show Nagareyama's distributions of commuting times, home departure times, and home arrival times. Commuting time is calculated as the difference between departure time and arrival time on trips for commuting purposes.

1) Distribution of commuting times

Looking at the distribution of commuting times (Figure-21), Nagareyama has two peaks. Looking at 2008, Nagareyama's two peaks around 15 minutes and 70 minutes are about equal.

Looking at change over time in Nagareyama since 1968, the share of commuting times of 60 minutes or more have increased greatly. This is likely due to the effects of the Tsukuba Express and other developments in the railway network.

2) Distribution of departure times

Looking at the distribution of departure times (Figure-22), the average and median departure times for Nagareyama are around 7:30, with no major change observed over the years.

3) Distribution of home arrival times

Looking at the distribution of home arrival times (Figure-23), the average and median home arrival times for Nagareyama have been growing later over the years. Nagareyama's average home arrival time has moved from 18:51 in 1968 to 20:06 in 2008, a change of about one hour and five minutes over 40 years. It is now later than 8:00 p.m.

## 5. Summary of this study

### 5.1 Findings of this study

This study confirmed socioeconomic change in the Tokyo metropolitan area, changes in transportation facilities development and transportation behavior based on the Tokyo metropolitan area PT survey carried out five times since 1968, and changes in transportation behavior in the Tokyo metropolitan area suburb of Nagareyama due to the influence of the opening of the Tsukuba Express in 2005.

This study confirmed that the zone of densely inhabited areas with a population densities of 4,000 people/km<sup>2</sup>, which in 1970 was concentrated in Tokyo wards within 20 km of the city center with extensions to Tama, Yokohama, and other areas in the west and south of the metropolitan area as well as around suburban railway stations, had by 2010 expanded out to 50 km in the metropolitan area's southwest and elsewhere.

This study confirmed that in suburban regions of the metropolitan area where the population increased, the automobile modal share has tended to rise. On the other hand, it confirmed that railway development increased the railway modal share for trips to destinations in Tokyo wards. This study also found that among senior citizens, the transportation behavior of people age 65 and older differs from that of the past. They tend to go out more often, and are increasingly active outside the home, including traveling via automobile.

This study confirmed that commuting time from Nagareyama, a city served by the Tsukuba Express line, has changed since the line opened.

## 5.2 Future issues

The findings of this study will be very important for consideration of the future direction of policies on urban planning and urban transport. For example, the work styles, lifestyles, and transportation behavior of senior citizens are diversifying with the times, and the opening of railways affects lifestyles and transportation behavior even in the suburbs. Meanwhile, although dependence on automobiles is growing year by year in outlying areas of the Tokyo metropolitan area and land use there is automobile-dependent, those regions are aging and already face declining population. The findings of this study should be utilized to help solve the problems of increasingly complex urban areas. It is to be hoped that the results will be beneficial to other Asian countries as well.

## REFERENCES

- 1) Stopher, P. R. Stecher, C. (2006) *Travel Survey Methods: Quality and Future Directions*. Elsevier.
- 2) Michel, V. (2011) *Travel/ Mobility Surveys: Some Key Findings*. Statistical Paper 2011-2, OECD.
- 3) Tokyo Metropolitan Region Transportation Planning Council. (2010) *Tokyo Today as seen by the Movements of People*. (in Japanese)
- 4) Nakano, A., Morio, J., Ichikawa, H., Yoshida, T. (2010) *Analysis of Transport Behavior based on Tokyo Metropolitan Region Person Trip Survey and Needs of Data Utilization*. Proceedings of Infrastructure Planning, Japan Society of Civil Engineers, vol.41. (in Japanese)
- 5) Statistics Bureau, Ministry of Internal Affairs and Communications. (annual) *Population Census*.
- 6) Statistics Bureau, Ministry of Internal Affairs and Communications. (annual) *Grid Square Statistics*.
- 7) Tokyo Metropolitan Area Transport Planning Council. (years surveyed) *Tokyo Metropolitan Area Person Trip Survey*.
- 8) Inoue, T., Watanabe, M. (2014) Aging population in Capital Region. *Demographic Library vol. 14*. Hara Shobo. (in Japanese)
- 9) Nagareyama City Museum (2001) *Nagareyama City History: Comprehensive History I* (in Japanese)
- 10) Nagareyama City Museum (2005) *Nagareyama City History: Comprehensive History II* (in Japanese)
- 11) Nagareyama City (annual) *Nagareyama City Statistics*
- 12) Yamada, Ryo. (2014) *Study of Effects on Daily Activities Caused by Individual Values in Developing Countries in Southeast Asia*. Master's thesis. (in Japanese)
- 13) Research Institute for High Life. (2014) Japan-Asia Collaborative Research Project Study report. *The New Trends in Asian Urban Lifestyle*. Executive Summary. (in Japanese)