Evaluating the choice of transportation modes considering the future population structure

Waseda University team C

Outline

01 Introduction

02 Data & Basic analysis

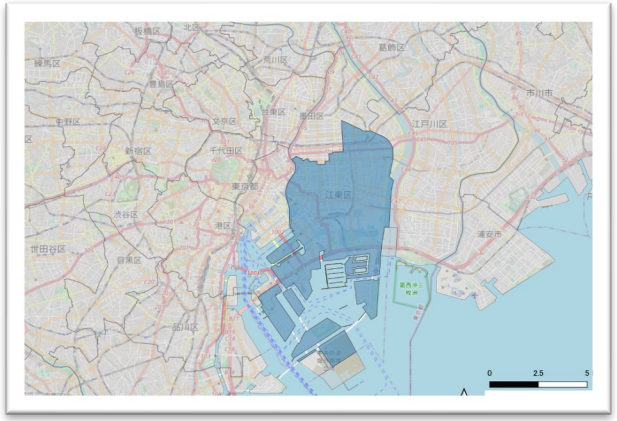
03 Logit model

04 Result

05 Policy evaluation

1. Introduction

1.1 Background



Koto city

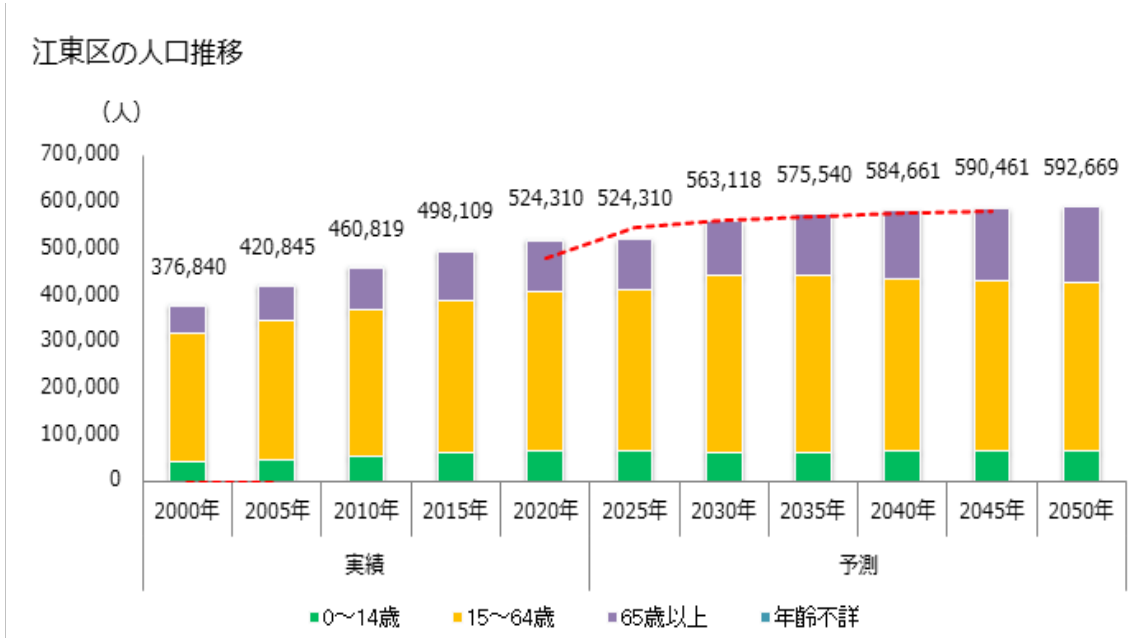


Figure.1 Estimates of population shift in Koto city

In regional city, the proportion of senior citizens in population generally increases by time. However, the population itself **decreases**, so it is doubtful that promoting the use of public transport is effective.

In Koto city, the population **increases** until 2050 because of the excess moving-in, AND the proportion of senior citizens in population also increases.

▷ ▶Therefore, promoting the use of public transport there is also justified!

1. Introduction

1.1 Background

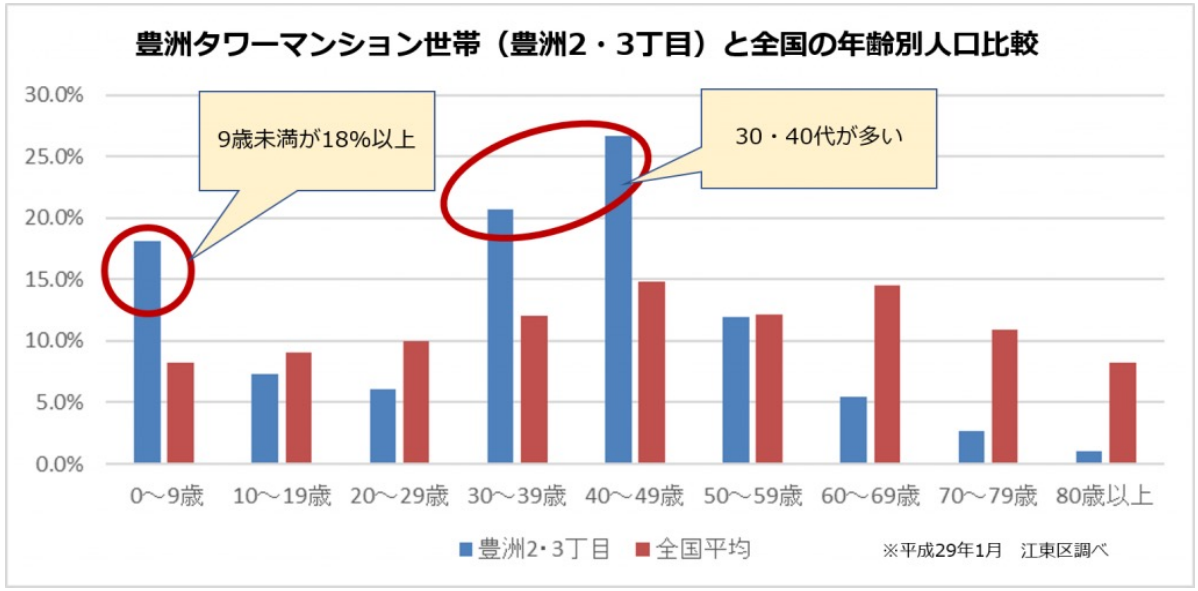


Figure 2. Comparison of population share between 2,3 Chome Toyosu and national AVG

2,3 Chome Toyosu

2,3 Chome Toyosu, which is located in the north-west corner of Koto city, has a number of **high-rise condominium** and main type of resident is nuclear **family**.

However, the **population aging** of new town resident was a crucial problem of urban planning.
The same thing seems to happen in the Toyosu section as well in the future.

Therefore, encouraging and considering the use of public transport in urban area is as important as that in rural area.

1. Introduction

1.1 Background

In Koto city, proportions of people older than 59 who answered "Incovenient to move" were more than 25% in most of areas (especially in Tatsumi/Shiomi area, more than 40%). (From Koto city regional questionnaire)

▼

It seems unexpected to find that there are fair number of unsatisfied senior citizens in urban area.

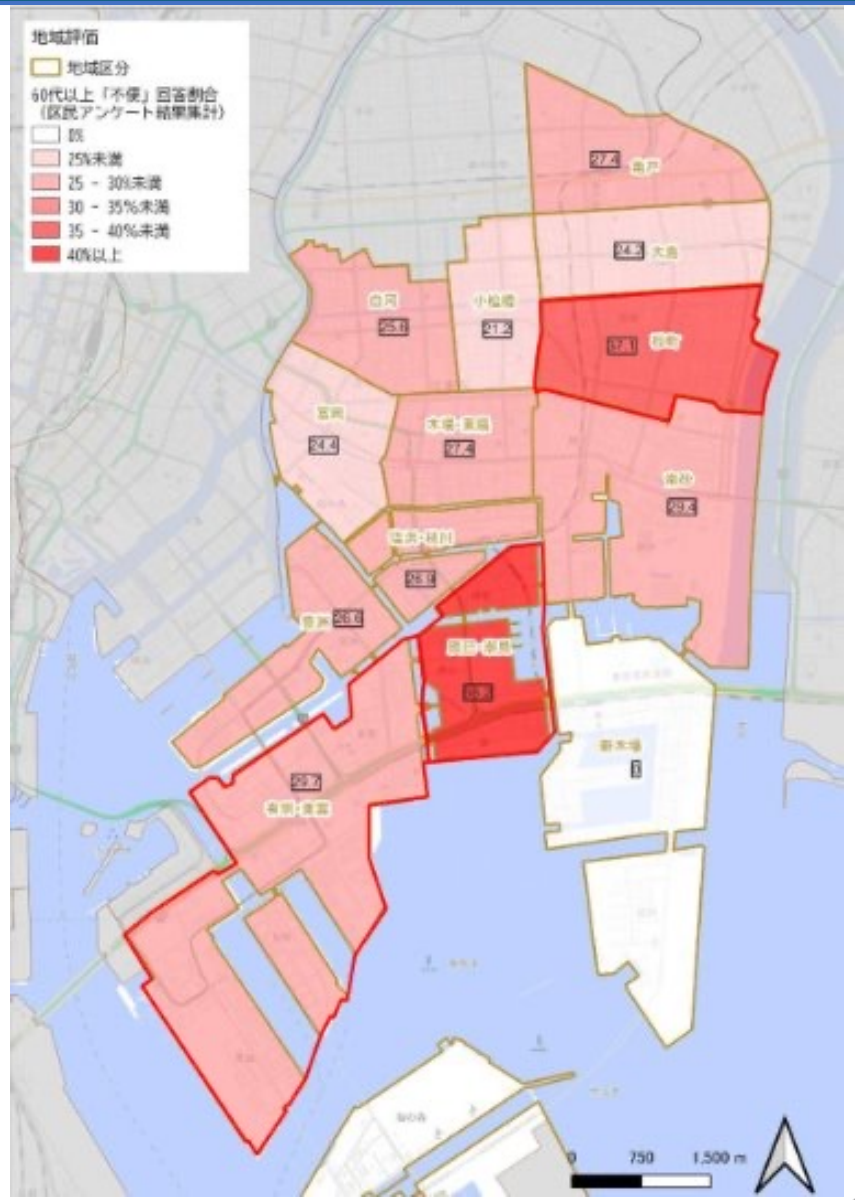


Figure 3. The result of Koto city regional questionnaire indicating the proportion of unsatisfied senior citizens

1. Introduction

1.2 Purpose

Building a transportation mode choice model based on current data
Evaluating future public transportation system considering the expected population structure

As the present situation stated in p.4, fair proportion of senior citizens are not satisfied in current transportation services. Therefore, we also examine what type of transportation system will be needed in the future.

1.3 Flow of analysis

Analysing current situation & Basic tabulation

▼

Model estimation using Multinomial Logit Model

▼

Policy evaluation (measuring the effect of public transport)

2. Data & Basic analysis

2.1 Subject area & Data

<Subject area>

Koto city, Tokyo

<Data>

- Person Prove Survey conducted in 2021
- Digital National Land Information

Digital National Land Information

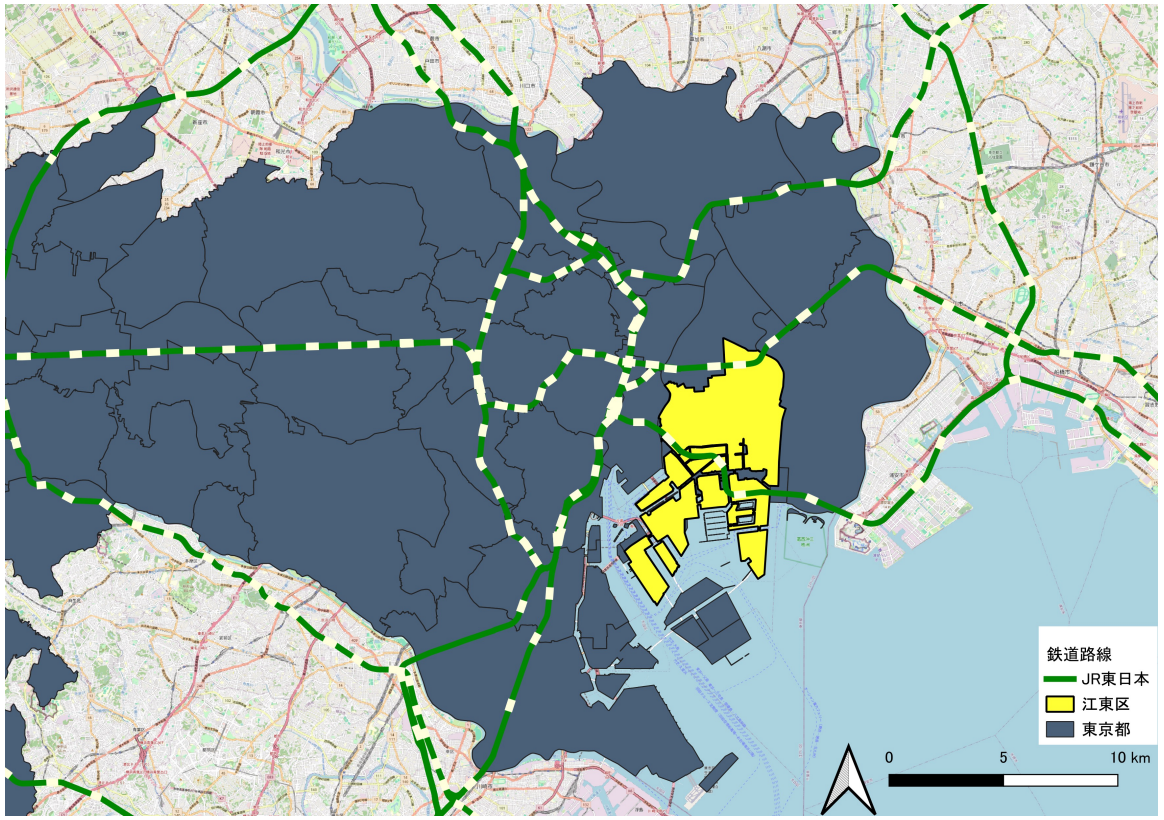


Figure.4 The position of Koto city in Tokyo

2.2 Analyzing current situation

- Displaying population distribution of Koto city (entire population & ↓14y/o)

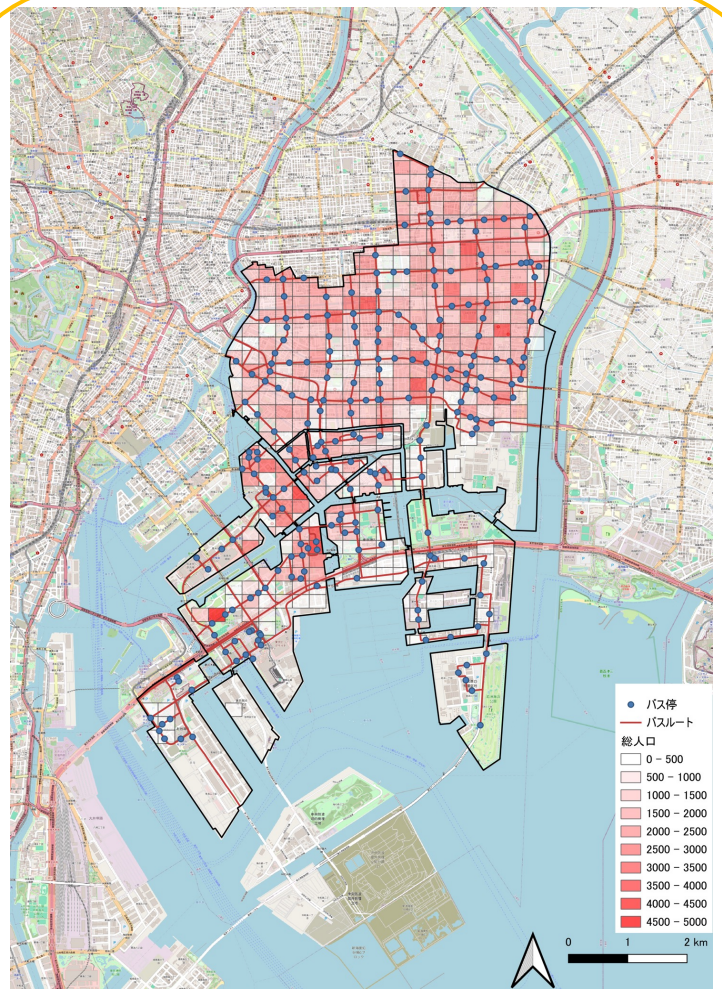


Figure.5 The entire population of Koto City

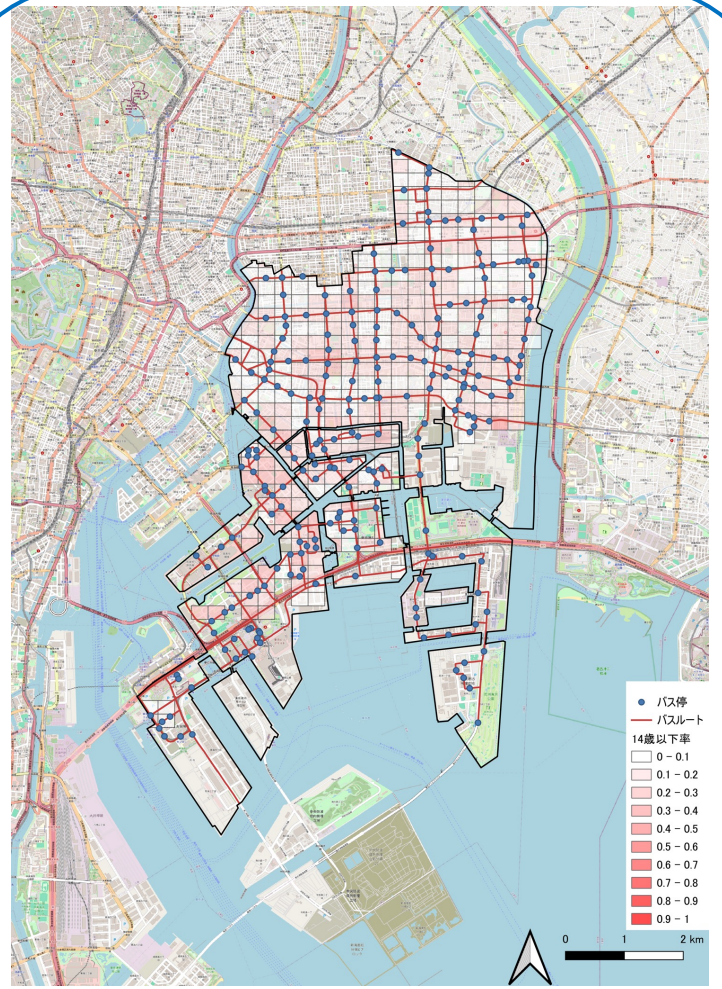


Figure.6 The rate of population under 14 years old

2.2 Analyzing current situation

Displaying population distribution of Koto city(15-64 y/o & ↑60y/o)

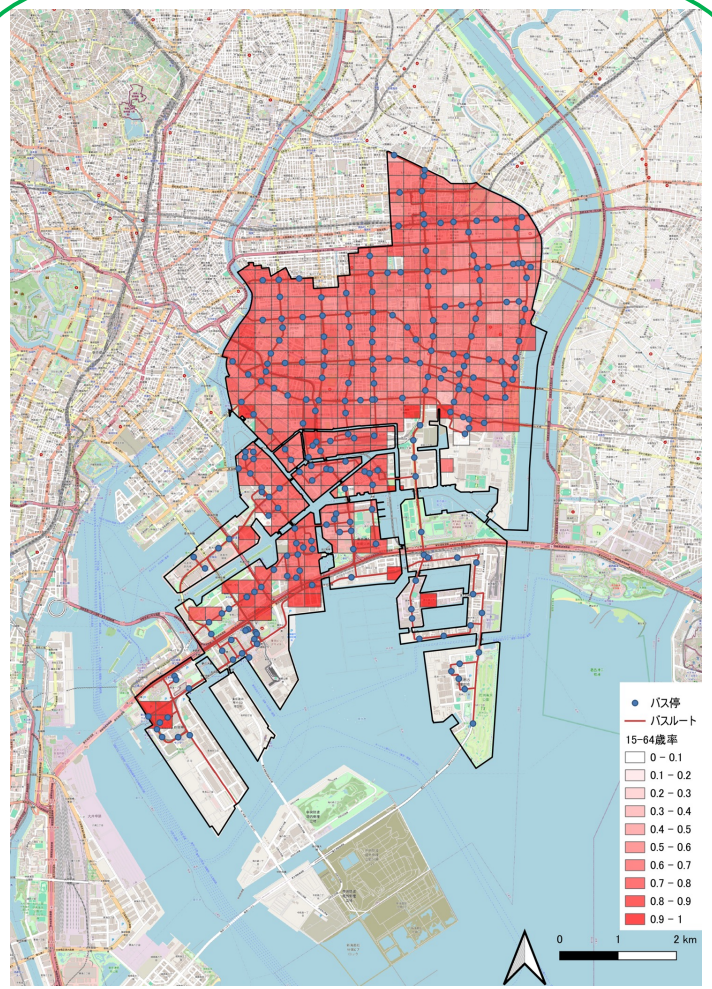


Figure.7 The rate of population 15 to 64 years old

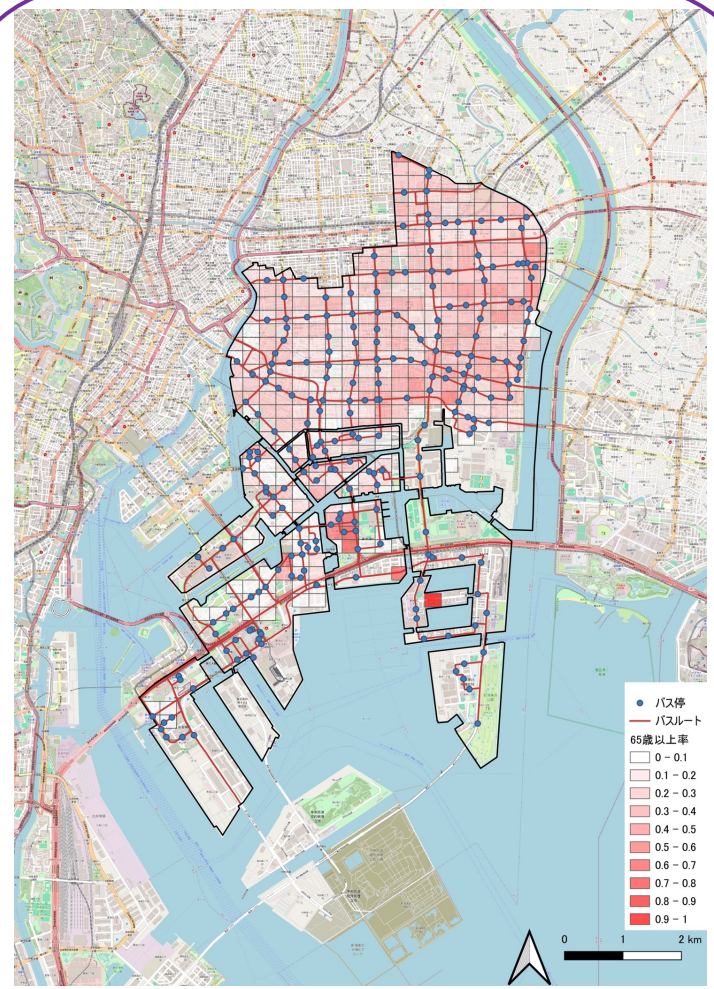


Figure.8 The rate of population over 65 years old

2.2 Analyzing current situation

- Calculating the bus covered rate
  - A buffer is within a 100m/300m radius of the bus stop.
  - The bus covered rate is calculated as follows; dividing the sum area of buffers by the entire area of Koto city

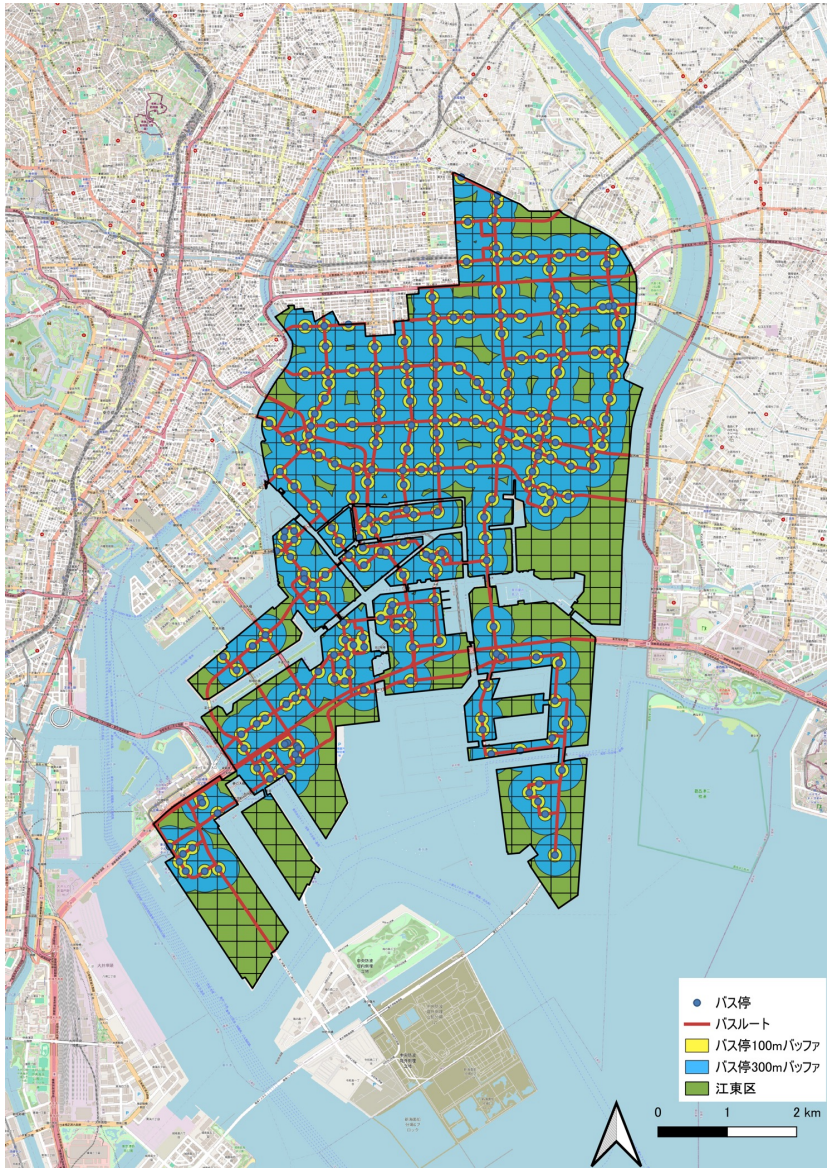


Figure.9 Illustration of buffers used to calculate the bus covered rate

2.2 Analyzing current situation

- Calculating the bus covered rate

	The bus covered rate
Within **100m** buffer	0.17885
Within **300m** buffer	0.74889

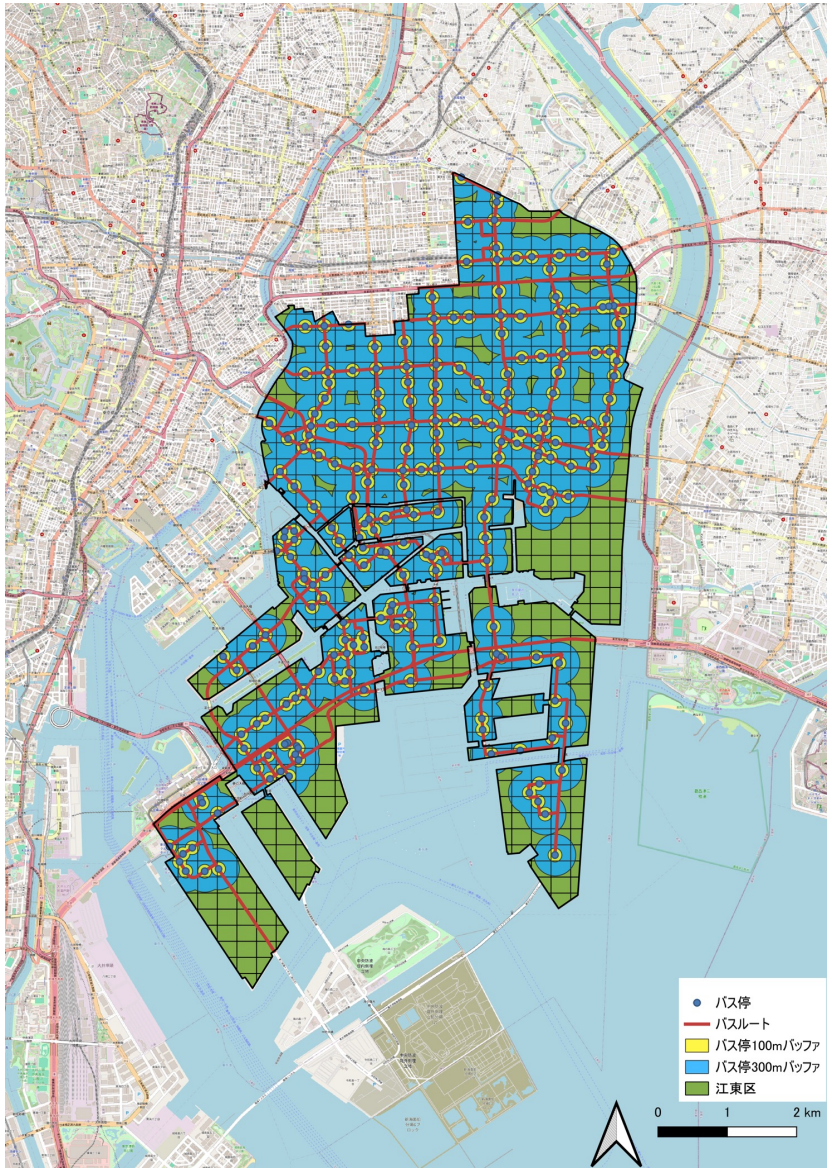


Figure.9 Illustration of buffers used to calculate the bus covered rate

2.2 Analyzing current situation

- Displaying the bus covered rate of Koto city

Figure.10 The bus covered rate within 100m buffer

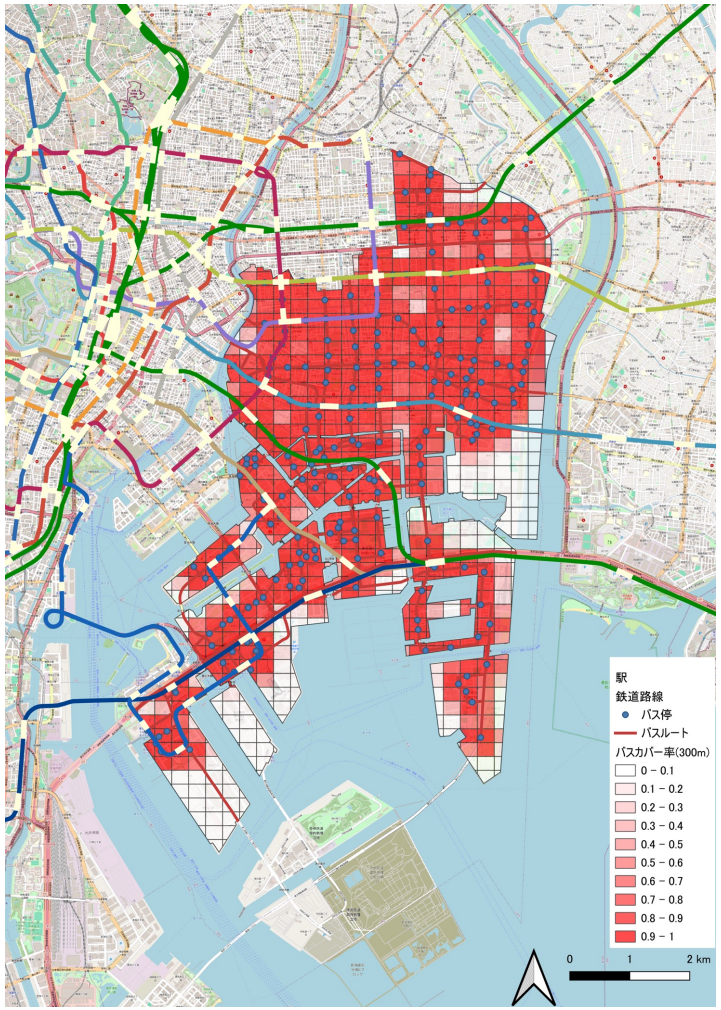
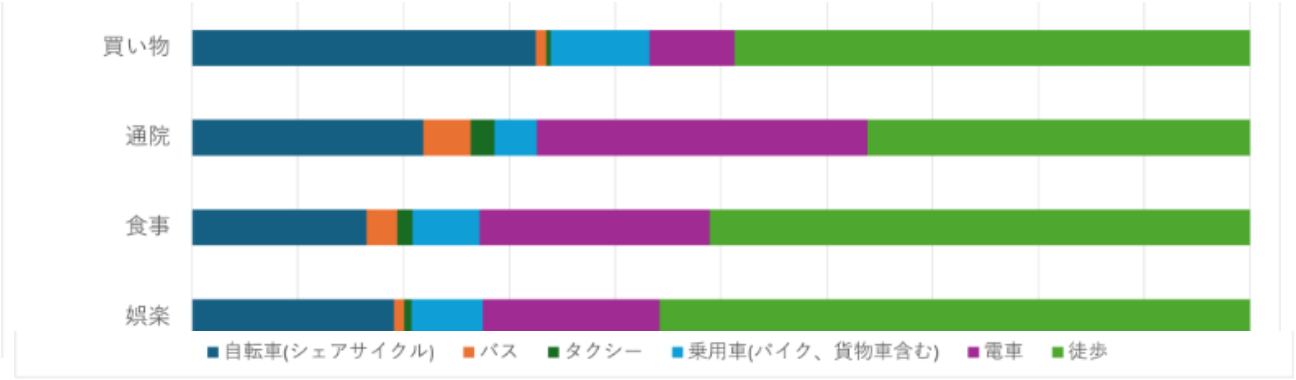


Figure.11 The bus covered rate within 300m buffer

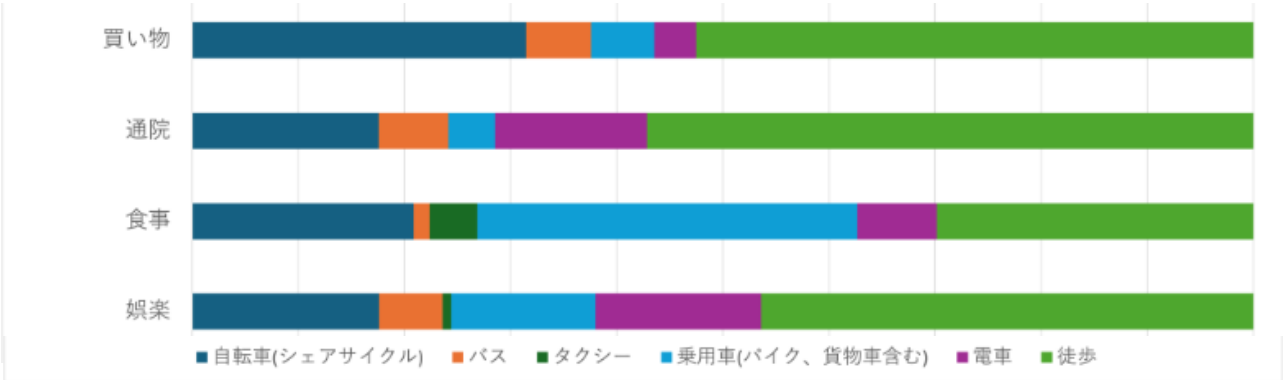
2.3 Basic analysis

The distribution of means of transportation by purposes

20-50 age



Over 60 age



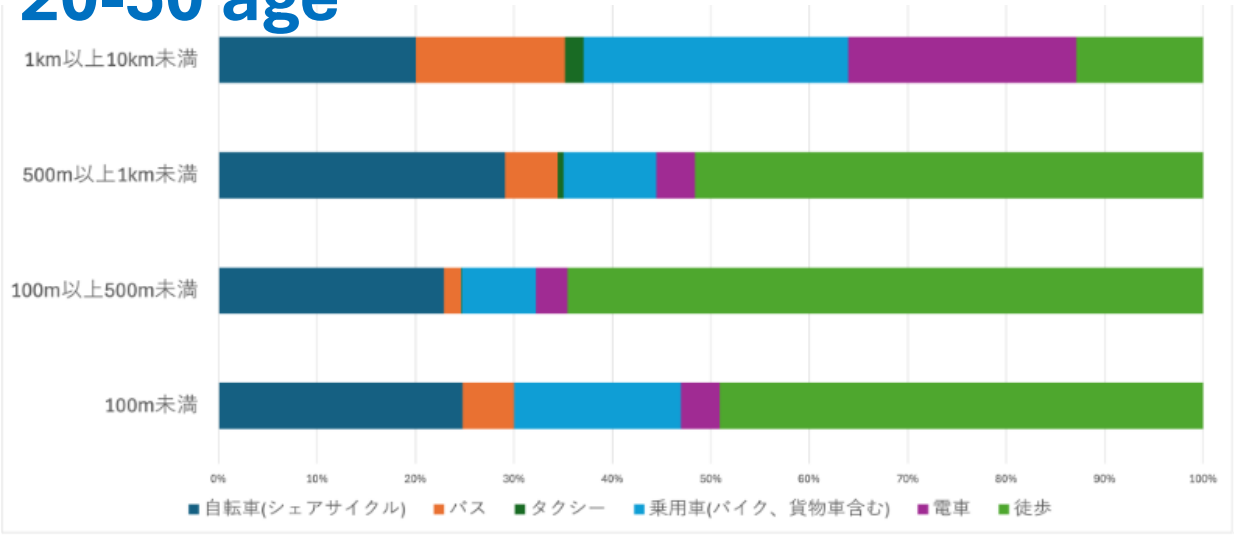
- Generally, the proportions of "**walk**" are high, indicating the characteristic of urban areas. (You can do most things without going further from your residence.)

- Senior citizens use **railways** less, **cars** and **buses** more than 20-50s.

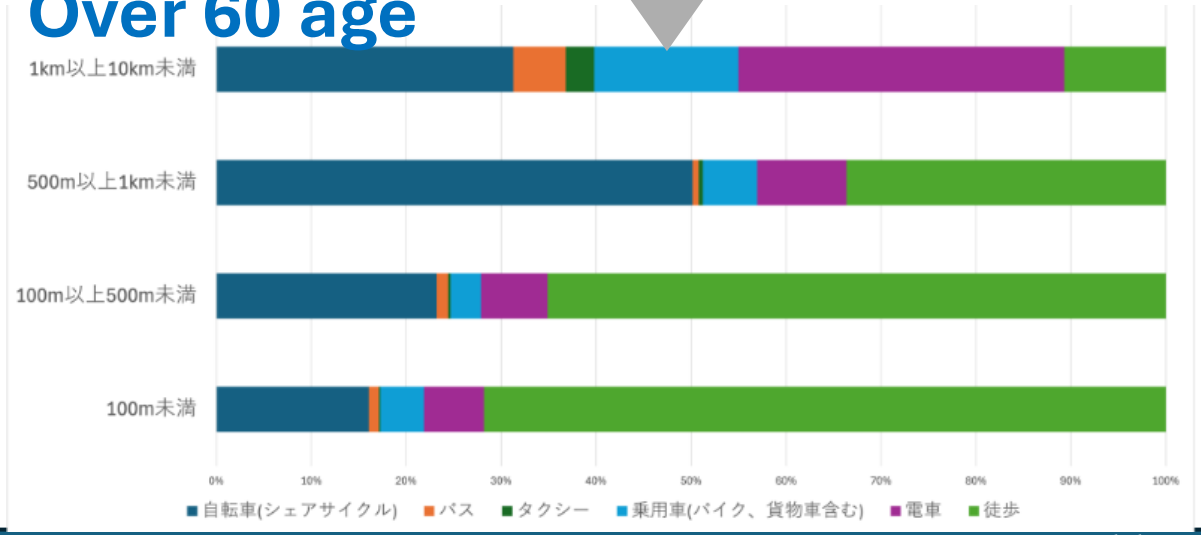
2.3 Basic analysis

The distribution of means of transportation by distances

20-50 age



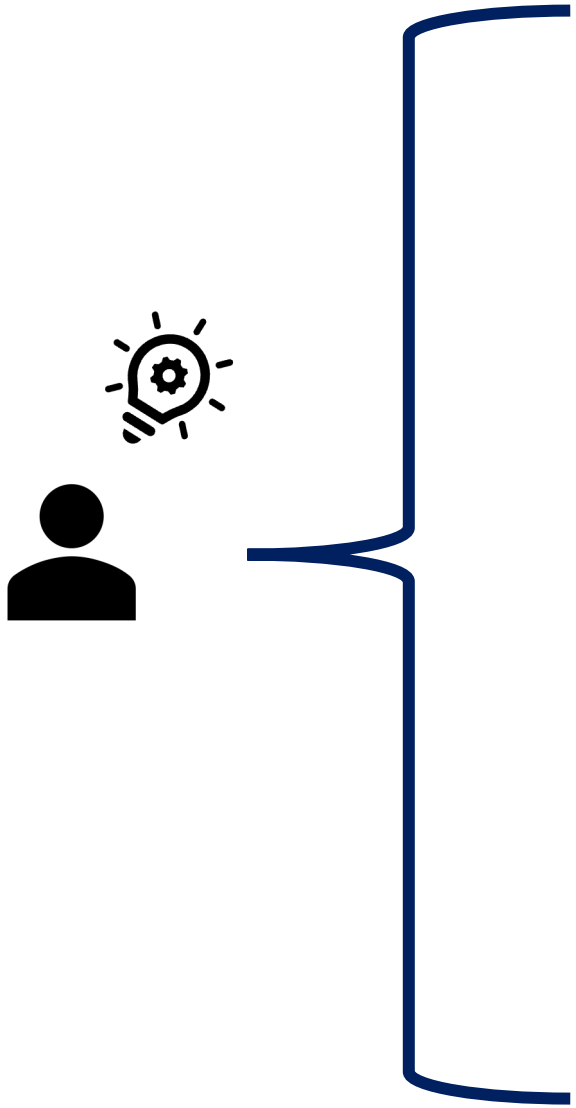
Over 60 age



- Senior citizens walk relatively less and the use of **cars** and buses compensates them.
- However, **buses** are used mainly in distances between 1km to 10km.

▶▷Senior citizens seems to be forced to **walk** **within 1km of movement**.

3.1 What is Multinomial Logit model?



Multinomial Logit model

It is a mathematical model aimed to explain **how much the mode of transportation is chosen**, by using fare, waiting time, etc and personal preferences as variables.

The model is determined by maximizing the utility function.

3.2.1 Utility function

$$U_{\text{train}} = \alpha_1 time + \alpha_2 cost + \alpha_3 access + \varepsilon$$

$$U_{\text{bus}} = \alpha_1 time + \alpha_2 cost + \alpha_4 o60age \times Cover + \varepsilon$$

$$U_{\text{car}} = \alpha_1 time + \alpha_2 cost + \alpha_5 h_{income} + \alpha_6 Owners + \varepsilon$$

$$U_{bike} = \alpha_1 time + \varepsilon$$

$$U_{\text{walk}} = \alpha_1 time + \varepsilon$$

$$U_{\text{taxi}} = \alpha_1 time + \alpha_2 cost + \varepsilon$$

3.2.2 Notational Glossary of Utility function

- Time = Total travel time
- Cost = Cost of destination
- Access = Access distance
- Owner = Car ownership
- **O60age × Cover = (Over 60 age dummy × Bus coverage)**
- High income = Over six million yen dummy
- ε= Constant

3. Logit model

3.3 Result

	t value	Estimated coefficient
Constant(train)	** 17.82	1.86
Constant(bus)	** -3.83	-0.53
Constant(car)	** -9.32	-1.24
Constant(bike)	** 23.39	1.82
Constant(walk)	** 40.56	3.10
Time	** -36.11	-5.40
Cost	** -6.62	-0.04
Access distance	** -12.86	-1.14
High income	** 9.64	1.12
O60age × Cover	** 9.72	1.76
Owner	** 20.71	1.61
sample		13585
Initial likehood		−18390.91
Final likehood		-11753.22
Coefficient of determination		0.361
Adjusted coefficient of determination		0.360

Forecasting Methodology: Reflecting the 2030 Population Structure

Objective

This analysis evaluates transportation policies from a future perspective by forecasting the 2030 demand, accounting for the projected aging of the population.

Method: Sample Re-weighting

We replicated the projected 2030 population structure by re-weighting our 2021 survey data. Based on official estimates, the elderly (60+) population ratio is expected to increase from **22.0%** (2021) to **24.2%** (2030).

This yields the following weights:

Weight for Elderly Sample: 1.1 (= 24.2% / 22.0%)

Weight for Non-elderly Sample: 0.972 (= 75.8% / 78.0%)

The future mode shares are then simulated by calculating a weighted average of the choice probabilities.

Policy Scenario 1: Fare Discount for the Elderly

Hypothesis

By directly reducing the financial burden on the elderly, this policy is expected to encourage them to go out more and promote a modal shift towards public transportation.

Content

- Implement a uniform discount on bus and rail fares for elderly individuals aged 60 and over.

4. Policy evaluation

Policy Scenario 1: Fare Discount for the Elderly

discount(%)	train	bus	car	bike	walk	taxi
10	0.127994	0.013319	0.075955	0.272043	0.478812	0.031876
20	0.128051	0.013359	0.075935	0.271982	0.478804	0.03187
30	0.128108	0.013398	0.075915	0.271921	0.478795	0.031864
40	0.128164	0.013438	0.075895	0.27186	0.478786	0.031858
50	0.12822	0.013477	0.075875	0.271799	0.478777	0.031852

4. Policy evaluation

Policy Scenario 1: Fare Discount for the Elderly

50	0.12822	0.013477	0.075875	0.271799	0.478777	0.031852

An increase in the choice probability was observed as a result of offering public transportation discounts.

4. Policy evaluation

Policy Scenario 2: Fare Discount for Transportation Disadvantaged Areas

Hypothesis

By geographically targeting the policy, we can more efficiently support the transportation vulnerable and promote the use of public transport.

Content

This policy discounts bus and rail fares for residents in areas with low bus coverage (50% or less).

4. Policy evaluation

- In the case of providing public transportation discounts for transportation disadvantaged areas.

Discount(%)	Train	Bus	Car	Bike	Walk	Taxi
10	12.79528	1.328211	7.596945	27.20941	47.88198	3.188177
20	12.7968	1.328393	7.596428	27.20842	47.88186	3.188096
30	12.79831	1.328576	7.595918	27.20744	47.88174	3.188015
40	12.79981	1.328759	7.595414	27.20646	47.88163	3.187934
50	12.8013	1.328943	7.594917	27.20548	47.88151	3.187853

4. Policy evaluation

- In the case of providing public transportation discounts for transportation disadvantaged areas.

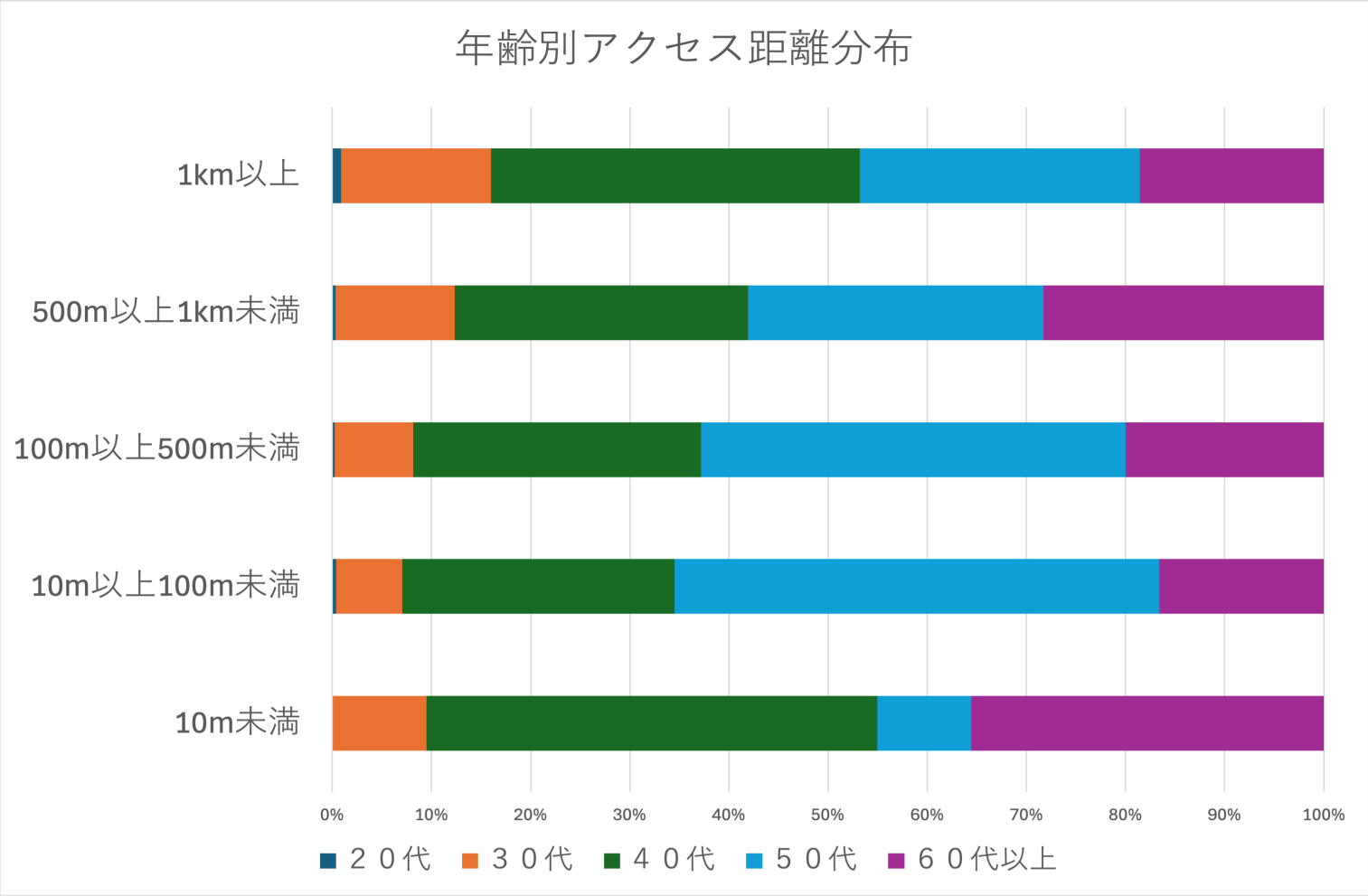
50	12.8013	1.328943	7.594917	27.20548	47.88151	3.187853

The fare discount policy for poorly served areas yielded only a marginal increase in public transport choice probability.

Appendix

A1. The distribution of access distances by ages

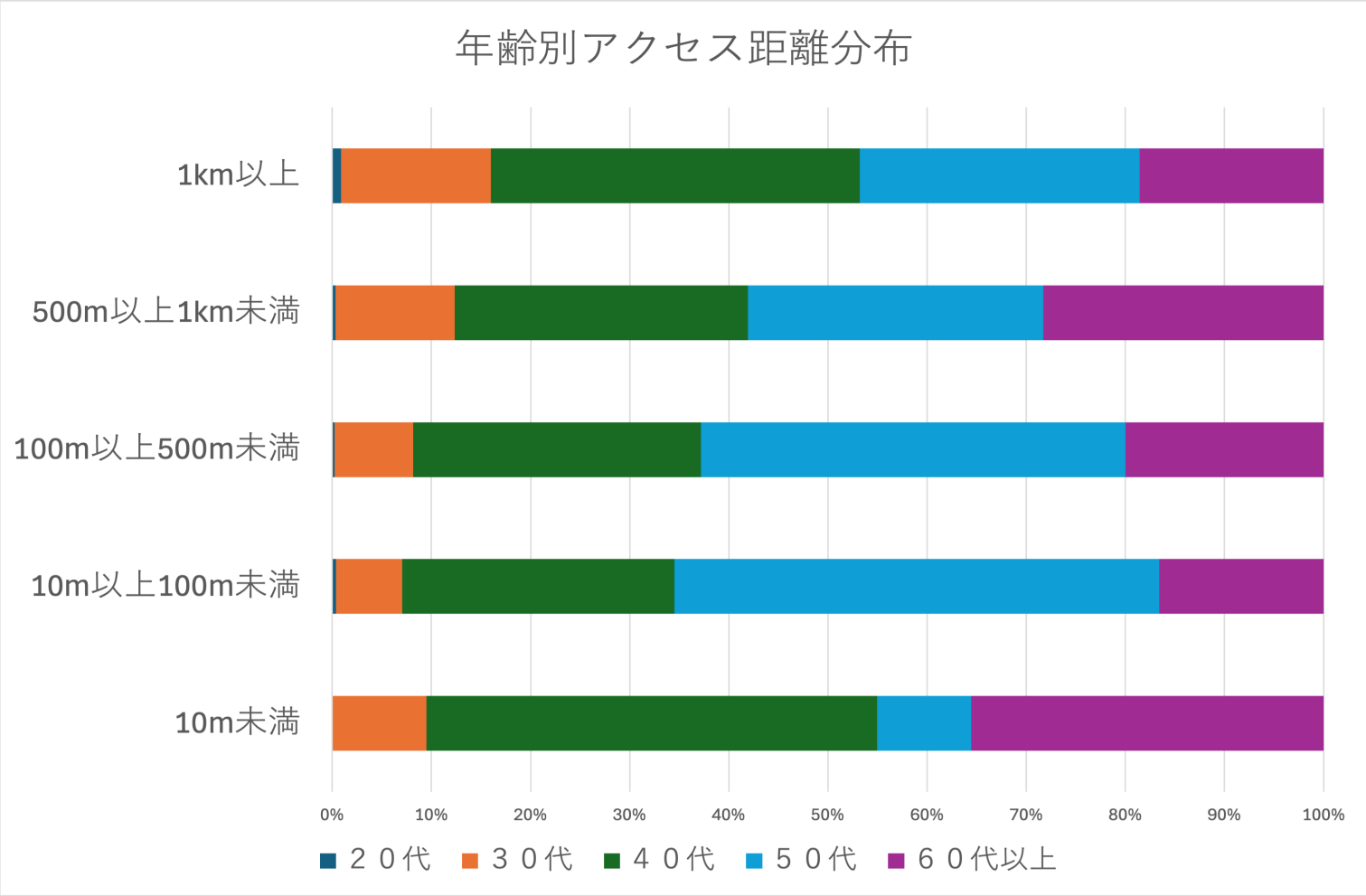
- Senior citizens generally use means of transportation near their home.



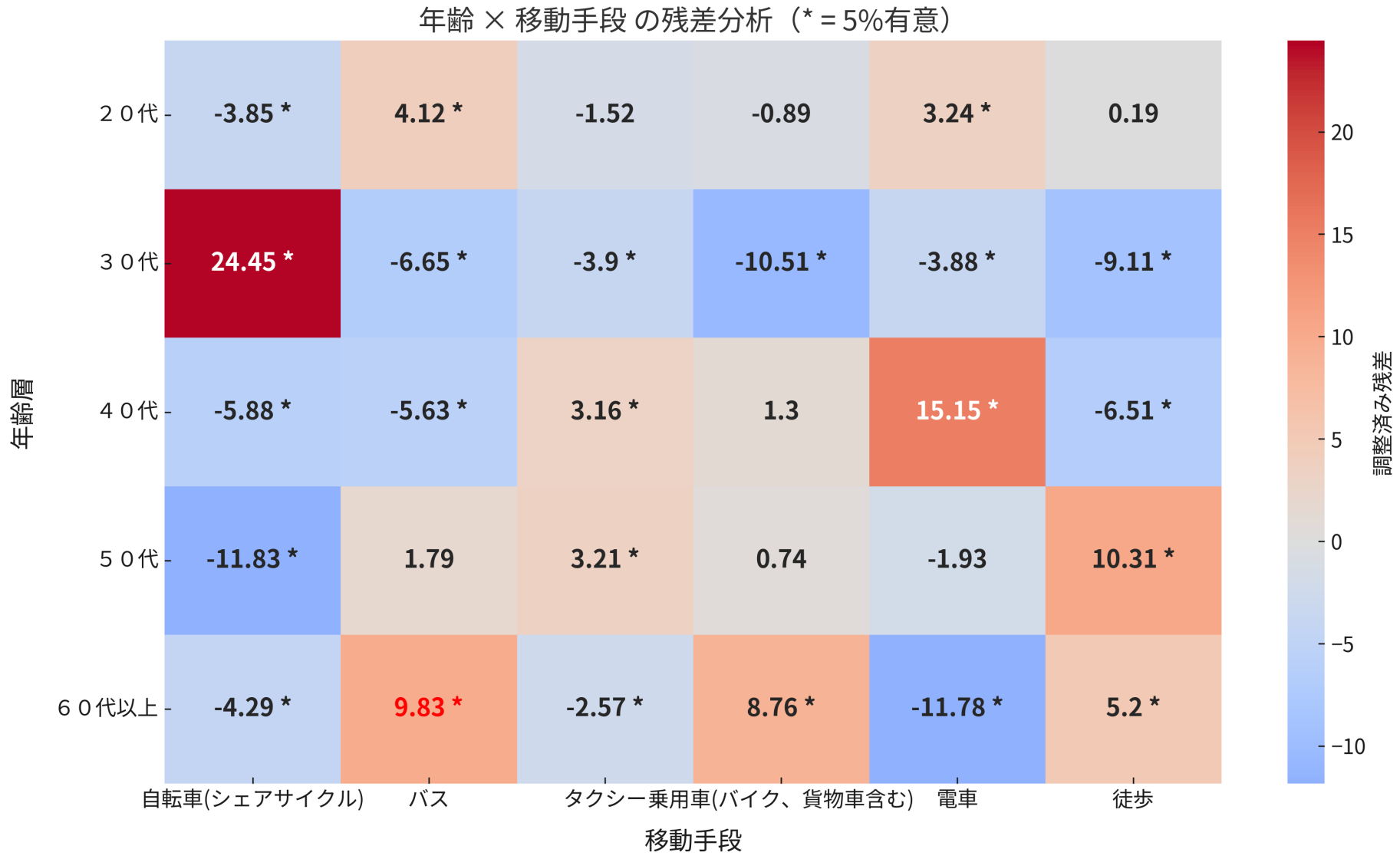
Appendix

A2. The distribution of egress distances by ages

- Senior citizens generally use means of transportation near their destination.



A3. Residual analysis for age/mode of transportation cross tabular



A4. Residual analysis for income/mode of transportation cross tabular