# Preferences of urban rail users for first- and last-mile autonomous vehicles: Price and service elasticities of demand in a multimodal environment

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### INTRODUCTION

- Integrating autonomous/automated vehicles (AVs) in transit networks is a critical problem in metropolitan areas (MAs) worldwide.
- In large/medium-sized MAs, first- and last-mile AVs to rapid transit are expected to contribute to ulletimprovements in transit accessibility, particularly in suburban areas, among other benefits.
- Preferences of urban rail users for these services are not well understood and are investigated in the Tokyo MA that has diverse conditions in access to rail stations.

# **ACCESS MODE CHOICE**

### First- and last-mile transportation market <sup>1</sup>

The majority of daily transit users walk/cycle to and from transit stations.

#### **Figure 1 Places of respondents**



- Current practice uses 800 m (1/2 mile) walking access to train stations and 400 m (1/4 mile) to bus stops as the rule of thumb to define the transit catchment areas.
- Longer distance is strongly correlated with a lower probability of walking to transit.

#### **Behavioral assumption of urban rail users**

- In the Tokyo MA, 80% of rail users walk/cycle to and from stations if they started/ended a trip within a 1-km radius of stations, and motorized modes might not be competitive here.
- Rail users who begin a trip far from stations are assumed to have a sequential decision process. They first choose a station to depart and second an access mode.<sup>2</sup>
- Access mode choice model is then estimated for those rail users given their predetermined departure stations. Home-end access is investigated in this study.

# DATA

- A web-based survey was conducted for 2300 residents, aged 20 to 74 years, who lived within 1–5 km from their nearest stations in the Tokyo MA. [Figure 1]
- Among all respondents, 35% take three or more rail trips per week and 80% (regarded as rail users) take at least a rail trip per year. [Table 1]

#### **Stated choice**

#### Table 1 Current access mode use of rail-using respondents (n=1834)

Alternative	Modal share	Distance (average)	Travel time (average)
Bus	19.2%	2.4 km	21 min
Car driver	4.0%	2.9 km	19 min
Car passenger (drop-off)	6.5%	2.5 km	13 min
Bike	20.0%	1.8 km	15 min
Walk only	50.0%	1.3 km	16 min

- Stated choice tasks were pivoted around rail-users' recent access to the station; each respondent was asked to choose a preferred mode given attributes of the current access mode and AV service.<sup>3</sup> [Table 2]
- Before choice tasks, Information on AVs was presented with text, illustrations, and photos, including a summary of the latest safety guidelines for AVs.
- Each respondent conducted six repeated choices with varied AV service levels. In total, 10,800 choice observations are used for the analysis.
- With these choice data, multinomial logit models (with an error correlation between AVs and buses) are estimated for leisure and work trips.

# RESULTS

21% of choice observations prefer AV service over the current access mode.

- 1. Negative effects of non-family members in a vehicle on AV use are stronger if they were strangers and/or in leisure trips; individuals who have physical difficulties in traveling are more likely to use AVs. [Appendix in next page]
- 2. For leisure trips, individuals traveling with others prefer AV use; individuals living with small children or living alone and/or younger individuals prefer AV use.
- 3. AV service is more sensitive to its price in leisure trips. **[Table 3]**

#### Table 2 Design of stated choice experiment for access mode

Attribute	Current access mode	AV service
Travel cost	XXX [JPY]	Cost per capita: 30%   50%   70% × taxi fare per capita
Wait time	_	After hailing AV service: 3   5   10 min or 6   10   15 min (for suburbs)
Frequency for buses	XXX	
Travel X time	XXX [min]	In-vehicle time: 70%   100%   130% × car travel time (seven categories by place of the trip and peak/off-perk)
		Walk time to reach the ticket gate: 1 min
Ride sharing	_	none/family members only   acquaintances   strangers

#### Table 3 Elasticities of demand for access modes WRT AV cost

4. AV service is a substitute for driving a car and bus use in leisure trips, and it is so for bus use but less likely for cycling and walking in work trips. **[Table 3]** 

## **CONCLUSIONS**

- 1. AV access could be a substitute for slower transit in work trips, while it has diverse substitution patterns in leisure trips.
- 2. On-demand and affordable transit access enabled by AVs may particularly benefit those who may currently have restrictions in accessing transit.
- 3. Transit users' strong resistance to introducing first- and last-mile AVs was not observed from the results of the overall acceptability. [Appendix]

In future research, these preferences serve as fundamental knowledge for estimating demand for the service and the impacts on transit/rail demand.

#### and wait time (based on estimated models)

	Alternative								
	AV service	Bus	Car driver	Car passenger	Bike	Walk			
eisure trips									
AV cost	-0.57	0.31	0.36	0.18	0.13	0.11			
AV wait time	-0.15	0.06	0.07	0.05	0.04	0.04			
Vork trips									
AV cost	-0.27	0.35	-	-	0.08	0.04			
AV wait time	-0.05	0.06	-	_	0.02	0.01			

Note: Mode choice elasticity approximates the ordinary elasticity in work trips, and underestimates it in leisure trips as trip generation effects are not incorporated (Wardman, 2014)

<sup>1</sup> e.g., Chalermpong and Wibowo (2007); Chia et al. (2016); Durand et al. (2016); Rastogi and Rao (2003); Martens (2004); Wang and Liu (2013); <sup>2</sup> Chakour and Eluru (2016); <sup>3</sup> Abe et al. (2020) for a review of SC studies for AVs