論文 / 著書情報
Article / Book Information

論題(和文)	
Title(English)	Stated preference analysis for new public transport in a medium-sized asian city: A case study in Malang, Indonesia
著者(和文)	坂東 徹, 福田 大輔, Achmad WICAKSONO, Lila Kurnia WARDANI
Authors(English)	Tetsu BANDO, Daisuke FUKUDA, Achmad WICAKSONO, Lila Kurnia WARDANI
出典(和文)	, Vol. 11, , pp. 1451-1466
Citation(English)	Journal of the Eastern Asia Society for Transportation Studies, Vol. 11, , pp. 1451-1466
発行日 / Pub. date	2015, 12

Stated Preference Analysis for New Public Transport in a Medium-sized Asian City: A Case Study in Malang, Indonesia

Tetsu BANDO [a], Daisuke FUKUDA [b], Achmad WICAKSONO [c], Lila Kurnia WARDANI [d]

[a] *The Tokyo Metropolitan Government Office, Tokyo, 163-8081, Japan;*
E-mail: akatsuki2580@gmail.com
[b] *Department of Civil Engineering, Tokyo Institute of Technology, Tokyo, 152-8552, Japan;*
E-mail: fukuda@plan.cv.titech.ac.jp
[c,d] *Department of Civil Engineering, University Brawijaya, Malang, Jawa Timur 65145, Indonesia*
[c] *E-mail: wicaksono1968@yahoo.com*
[d] *E-mail: liladisini@gmail.com*

Abstract: This study analyzes citizens' travel choice behavior in a medium-sized Southeast Asian city to observe their intention to use new public transport. We selected Malang in Indonesia as a case study. A travel behavior and intention survey including stated preference questions was conducted with university students. The results of the latent-class model of commute mode choices show that respondents could be divided into "cost and delay time" and "travel and access time" oriented classes. Respondents who were likely to convert to new public transport modes were male, had a higher income, and were interested in new public transport. The estimation results of the scheduling choices model confirm the significant difference in the sensitivity to recreation time between recreational activities.

Keywords: Stated Preference, Public Transport, Class Heterogeneity, Medium-sized City, Southeast Asia, Malang

1. INTRODUCTION

1.1 General Background

The emission of greenhouse gases such as carbon dioxide (CO_2) and air pollution by nitrogen oxide and particulate matter in automobile exhaust gas are currently one of the most important environmental problems. Though there are some international agreements such as the Kyoto Protocol for CO_2 emission, many of them oblige developing countries to the least amount of responsibility or none at all.

In this study, we focus on traffic problems in the developing countries of Southeast Asia because any discussion of the problem of global warming and air pollution cannot ignore this issue. Traffic problems are characterized by the following four elements: (1) population increase, (2) proliferation of motorcycles (MC) and road traffic saturation, (3) progress of motorization, and (4) road capacity problems (Hanaoka and Acharya, 2008). Constructing new public transport is one of the possible countermeasures for these problems. Jakarta and Bangkok provide some examples of providing new public transport in Asian megacities. When considering the introduction of new public transport, it is necessary to identify the characteristics of passengers who might potentially convert to the new public transport service. Especially in medium-sized cities (population of 0.6–1.0 million) in Southeast Asia, the new public transport's relationship with the existing paratransit should be considered because the main traffic modes in the cities are MC and paratransit and they are deeply rooted in the society (Joewono and Kubota, 2005; Joewono, 2009).

Henceforth, this study focuses on medium-sized cities in Southeast Asia for the following reasons. First is the number of cities and their population ratio. There are few megacities with populations over a million people, and the population ratio for the total population of these countries cannot be said to be large. The second reason is the lack of countermeasures for global warming and air pollution. In the transportation field, countermeasures for global warming and air pollution are mainly carried out in megacities (e.g., bus rapid transit in Jakarta). However, there are insufficient examples of countermeasures and studies in the medium-sized cities of Southeast Asia. The research motivation for this study comes from these current transportation situations in the medium-sized cities of Southeast Asia. When considering the planning or installation of new public transport (e.g., light rail transit [LRT]) expected to contribute to the mitigation of environmental problems in medium-sized cities, its relationship with paratransit should also be considered.

1.2 Research Objective

The general objective of this study was to explore citizens' intention to use new public transport in a medium-sized Southeast Asian city. We assumed LRT as the specific new public transport and a travel behavior and intention survey including stated preference (SP) questions was carried out. The designed SP questions mainly asked respondents about their choice behavior for their daily commute mode and on their scheduling (i.e., trip timing) choices under the hypothetical situation of LRT installation.

In particular, this paper focuses on the following specific points:

1) To verify the passenger characteristics of those who are more likely to convert to LRT from their current choices, we classify respondents by their response tendency and introduce these classifications into the choice model.
2) LRT–paratransit cooperation in terms of transfer discount was incorporated into the SP questionnaire and discussed by verifying the effect of fare discounts.
3) The introduction of LRT would affect scheduling choices as well as travel mode choices. Travel-timing choices during the survey day were also examined by the SP questions.

Figure 1 illustrates the overall research flow of this study.

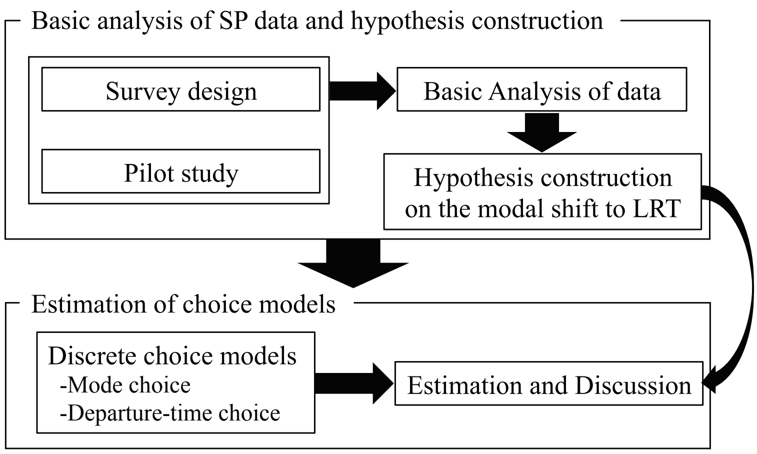


Figure 1. Overall research flow

2. SURVEY OUTLINE

2.1 Overview

The travel behavior survey was conducted in Malang, Indonesia, which is located in the east side of Java (Figure 2), and 90 km south of Surabaya (the capital of East Java Province). The area is nearly 145 km^2, and the population was nearly 820,000 in 2010 (Statistics Jawa Timur, 2015). One of the characteristics of Malang is that it is positioned as both a tourist city and an academic city because of the many famous tourism areas around the city and over 15 universities with approximately 150,000 students.

Figure 2. Location of Malang, Java

The main travel mode in Malang is MC, while the main public transport for inner-city travel is a carpool-type paratransit called an *Angkutan Kota* (or, *Angkot*) (Figure 3). Individual-type paratransit such as the *Ojek* (MC taxis) are also available. A single Angkot ride costs Rp. 4000 (approximately 38 JPY on the survey day).

Figure 3. Typical Angkot (Angkutan Kota) in Malang

The paper-based face-to-face interview survey was performed between November 19 and 21, 2014. The respondents were selected from those enrolled at Malang universities whose commuting distance to their university was more than 500 meters. The number of respondents was 501 (167 men and 334 women) from nine universities. The main reason for limiting respondents to university students is that there is an advantage for simplifying the whole-day activity choice into “mode and departure time choice in commuting time” and “recreational choice after class” in the case of students.

2.2 Survey Questionnaire Design

The survey questionnaire consists of four main parts as follows: daily transportation intention, daily stop pattern, SP questions, and individual intentions and attributes.

2.2.1 Part 1: Daily transportation intention

Respondents' intentions towards the importance and performance of some transport service elements (e.g., punctuality, fare, travel time, waiting time, comfort, travel safety, passenger security) for their weekday transport were explored. Respondents evaluated their importance and performance for each item on a 5-point Likert scale with 1 (not important) to 5 (very important) for importance and 1 (very unsatisfied) to 5 (very satisfied) for performance.

2.2.2 Part 2: Daily stop pattern

We asked how respondents performed some activities during a normal weekday, the travel modes they normally used, and the contents of their usual recreational activity.

2.2.3 Part 3: SP questions

This part will be discussed in detail in Section 3.3.

2.2.4 Part 4: Individual intentions and attributes

General intentions for transportation and environment (e.g., interest level in new public transport services, environment protection, air pollution) and individual attributes (e.g., age, gender, income) were examined. Respondents evaluated their interest levels on a 5-point Likert scale with 1 (not interested in it) to 5 (very interested in it).

3.3 SP Questions

The SP Questions portion of the questionnaire comprises two main sections: commute mode choices assuming LRT is introduced, and scheduling choices after class.

3.3.1 Section A: Commute mode choices assuming LRT are introduced

We explored the possibility of converting current travel modes to LRT. Commute mode alternatives were "MC," "Angkot," and "LRT." Angkot may be used to access LRT rides, and a fare discount on LRT is available when commuters use both Angkot and LRT. The attributes shown in the survey sheets are: "total cost," "normal travel time," "maximum delay time," "frequency," "walking access time (only for Angkot and LRT)," "frequency (only for Angkot and LRT)," and "LRT–Angkot discount rate (only for LRT)." Figure 4 shows the answer sheet for mode choices.

3.3.2 Section B: Scheduling choices after class

We explored the "tradeoff between free time and travel cost after university and use of free time." There were three schedule alternatives: Choice 1 (cheaper but no free time), Choice 2 (more expensive but more free time available for recreation), and Choice 3 (more expensive but more free time available to relax at home). The attributes shown in the survey sheet are "travel cost," "transfer discount (only for Choice 2)," "recreation time (only for Choice 2)," and "relaxation time at home (only for Choice 3)." In this study, the recreation cost is not focused on in Choice 2. Choice types were ranked (1–3). This question is shown in Figure 5.

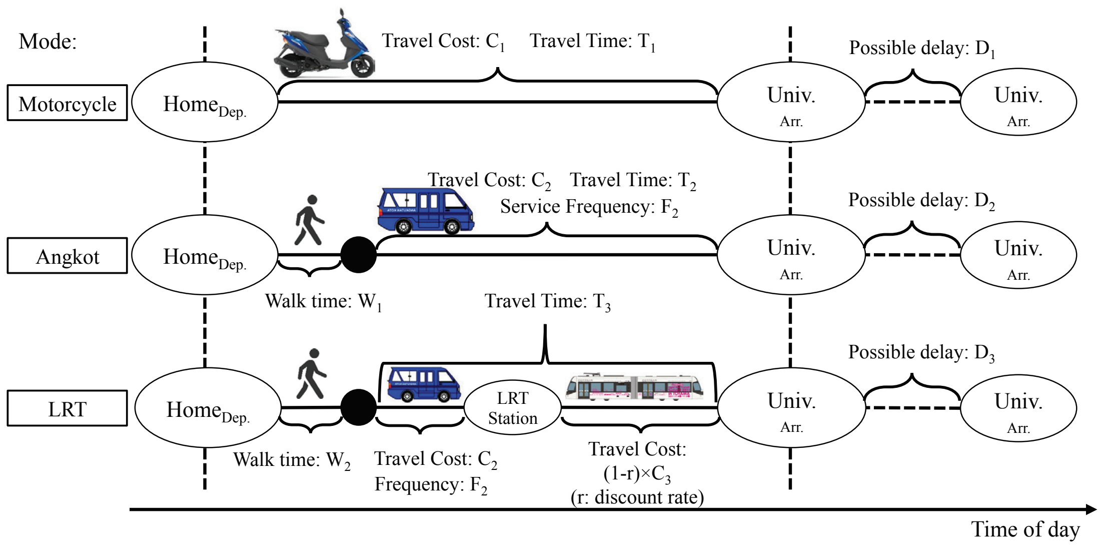
Table 1 shows the attribute levels for these three SP questions. The SP questions were constructed based on the following steps.

1) Decision of attributes and levels

To represent the choice alternatives reasonably, the attribute levels of "travel time" and "travel cost" were set based on another survey by the authors. Each attribute has 2–4 levels (mainly 3) as shown in Table 1.

2) Decision of scenario groups with orthogonality

In the full factorial design with all possible combinations of attribute levels, the number of scenarios is extremely huge. Therefore, 36 scenarios for each SP section were subtracted using orthogonality to estimate the main effects correctly.

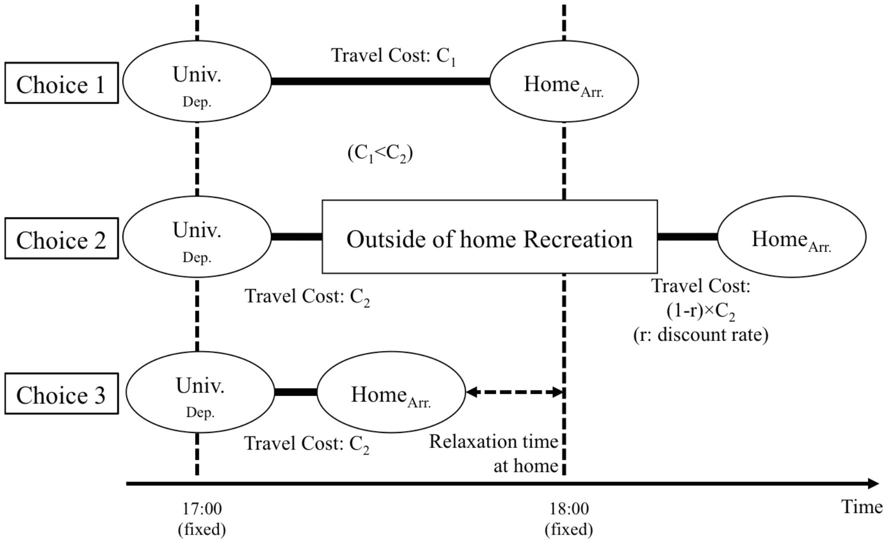


Question

Which mode would you like to use if the attributes are given as below? *Please rank from 1 to 3 (1: Most likely to use; 3: Least likely to use)*

Example of the Scenario			
Alternative	Motorcycle	Angkot	LRT & Angkot
Time (min.)			
Normal Travel	25	17	10
Maximum delay	15	7	2
Access by walk	-	5	8
Total possible time	40	29	20
Total cost (Rp.)	2500	3500	3500+6000 ↓(−50%) 6500
Frequency (/hour)	-	15	12
Which mode would you like to use?			

Figure 4. Answer sheet for mode choice (Originally written in Indonesian)



Question

Which mode would you like to use, if the attributes are given as below?
Please rank from 1 to 3 (1: Most likely to use; 3: Least likely to use)

Example of the Scenario			
Alternative	Choice 1	Choice 2	Choice 3
Total cost (Rp.)	2500	6000 (−50%)	4000
Recreation time (min.)	-	15	-
Relaxation time at home (min.)	-	-	40
Which mode would you like to use?			

Figure 5. Answer sheet for schedule choice (Originally written in Indonesian)

3) Distributing scenarios into blocks
The 36 constructed scenarios from the previous step were divided into six blocks. This means that each respondent answers six different SP questions for each section.
4) Maintenance of attribute levels
After blocking, each attribute level was determined so that the choice scenarios would be more realistic.

3. BASIC ANALYSIS OF SURVEY DATA AND HYPOTHESIS CONSTRUCTION

3.1 Basic Analysis of Survey Data

Figure 6 shows the distribution of respondents by their current commute travel mode. In the current situation, respondents were mainly using MC. While most male respondents chose MC, female respondents selected walking at a similar rate to MC. Female respondents also used Angkot much more often than male respondents. Figure 7 represents the distribution of respondents by their usual recreational activity. Over half of the respondents selected “talking with friends/hanging out.” Following reasons were “sports” for men and shopping for women, respectively.

Table 2 shows the distribution of respondents by current stop pattern and current main

Table 1. Attribute levels in SP questions

Section	Alternatives	Attributes (unit)	Attribute levels
A	Motorcycle	Travel time (min)	20, 25, 30
		Maximum delay time (min)	10, 15, 20
		Total cost (Rp.)	2500, 3000, 3500
	Angkot	Travel time (min)	15, 17, 20
		Possible delay time (min)	7, 10, 13
		Walking access time (min)	5, 7
		Total cost (Rp.)	3500, 4000, 5000
		Frequency (units/h)	10, 12, 15
	LRT	Travel time (min)	10, 12, 15
		Possible delay time (min)	0, 2, 5
		Walking access time (min)	4, 8
		Total cost (Rp.)	6000 (fixed)
		LRT discount rate (%)	0, 20, 30, 50
		Frequency (units/h)	8, 10, 12
B	Choice 1	Total cost (Rp.)	2500, 3000, 3500
	Choice 2	Total cost (regular) (Rp.) (Double choice 3's cost)	8000, 10,000, 12,000
		Transfer discount rate (%)	25, 50
		Recreation time (min)	60, 90, 120
	Choice 3	Total cost (Rp.)	4000, 5000, 6000
		Relaxation time at home (min)	20, 25, 30

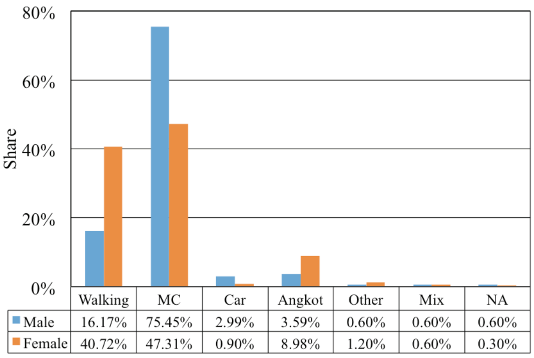


Figure 6. Respondent share by current commute mode

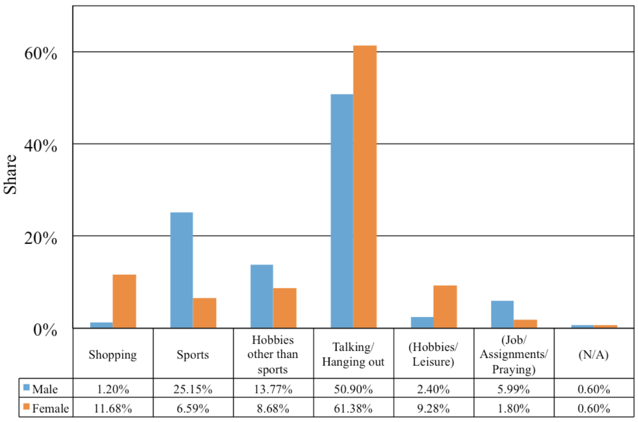


Figure 7. Respondent share by usual recreation activity

commute modes. On the one hand, more than half of the respondents selected stop patterns with fewer stops such as "home–university–recreation–home" and "home–school–home." On the other hand, some MC users chose stop patterns with side trips before university such as "home–others–university–others–home" and "home–others–university–recreation–home." Therefore, this tendency in MC users differs from the other modes. We presume that journeys indicated by "others" for MC users would be mostly to deliver companions to other places because MC riding pillion or more is also common in Malang.

Table 3 shows the sample mean of interest levels in general topics, such as transportation and environment by current major commute mode. Although there is no clear difference between commute modes, respondents have higher interests or concerns about air pollution and environmental protection overall. Therefore, they might be more likely to convert to a transport service with high environmental protection, which does not conflict with their high interest in new public transport.

Table 2. Current stop pattern by main commute modes

Stop pattern	MC	Angkot	Walking	Others	Total	Share
H–U–R–H	98	16	53	7	174	34.73%
H–U–H	52	13	48	1	114	22.75%
H–O–U–O–H	26	2	8	3	39	7.78%
H–U–O–H	20	2	14	0	36	7.19%
H–U–O–R–H	22	3	10	1	36	7.19%
H–O–U–R–H	25	0	5	3	33	6.59%
H–U–R–O–H	14	0	13	0	27	5.39%
Others	27	0	12	3	42	8.38%
Total	284	36	163	18	501	100%

(H: home, U: university, R: recreation: O: others)

Table 3. Interest levels by main commute modes

Transportation importance	Walking	MC	Angkot
New public transportation	4.00	4.16	4.28
New goods or services	3.58	3.76	3.39
Air pollution	4.72	4.76	4.64
Environmental protection	4.78	4.80	4.67
Own health	4.50	4.44	4.36
Angkot traffic safety issues	4.29	4.18	4.25
Angkot passenger security issues	4.45	4.27	4.53

Table 4 exhibits the sample mean of respondents' anticipated importance levels for transport elements by current major commute modes. Regarding the importance levels, e.g.. while walking commuters expressed high importance for punctuality, travel time, travel safety, and passenger security, they put relatively low importance on fare and waiting time. MC users expressed high importance on punctuality, travel time, travel safety, and passenger security as well as walking commuters, but they also gave clearly higher importance to fare than walking commuters. Angkot users gave higher importance to waiting time than other users, probably because this is a particular characteristic of public transportation.

3.2 Importance–Performance Analysis

Table 5 summarizes the sample mean of respondents' anticipated performance levels for transport elements by current major commute modes. Much clearer differences are discernable for performance evaluation than those for importance. Notably and unexpectedly, Angkot users expressed low satisfaction levels in all items. This result suggests that introducing new public transport could improve performance. Conversely, there was no clear difference between MC and walking commuters. However, when these two were compared, higher importance was placed on fare and travel safety for walking commuters and the other items became of higher importance for MC users.

Based on the above comprehensive discussion of the importance and performance analysis, we derive the following two implications: (1) Differences in the evaluation of importance and performance are distinct across the respondents' chosen commute modes. Though some of these choices can be described as characteristics of travel modes, their performance difference cannot be explained fully. (2) There are clear differences in importance and performance between individuals because the standard deviations are high enough that they cannot be ignored.

Following these points, it would be better to construct an integrated value of importance and performance. From the hypothesis that "tendency of evaluation on each traffic element affects commute mode choices," the evaluation score is constructed as:

$$S_j = \frac{I_j}{\Sigma_k I_k} \times P_j, \quad (1)$$

where S_{ij} is the evaluation score of transport element j (e.g., punctuality), I_j is its important score, and P_j is its performance score. This score is computed for each individual.

Table 4. Transportation importance levels by current commute modes

Transportation importance	Walking	MC	Angkot
Punctuality	4.49	4.46	4.39
Transportation fare	3.80	4.20	4.14
Travel time	4.47	4.40	4.31
Waiting time	3.74	3.87	4.19
Comfort	4.33	4.34	4.31
Travel safety	4.54	4.58	4.47
Passenger security	4.53	4.53	4.50

Table 5. Transportation performance levels by current commute modes

Transportation importance	Walking	MC	Angkot
Punctuality	3.35	3.82	2.58
Transportation fare	3.75	3.25	2.44
Travel time	3.31	3.74	2.36
Waiting time	3.41	3.50	2.20
Comfort	3.34	3.59	2.42
Travel safety	3.62	3.53	2.67
Passenger security	3.42	3.52	2.58

Table 6. Result of exploratory factor analysis

Score of each element	Factor 1	Factor 2	Factor 3
$S_{punctuality}$	0.14	0.681	
S_{fare}		0.147	0.986
$S_{traveltime}$	0.121	0.783	
$S_{waitingtime}$		0.347	0.174
$S_{comfort}$	0.588	0.348	
S_{safety}	0.912		
$S_{seculity}$	0.788		
Factor loadings	1.829	1.38	0.983
Cumulative variance	0.229	0.401	0.524

Figure 8. Cluster distribution by current commute modes

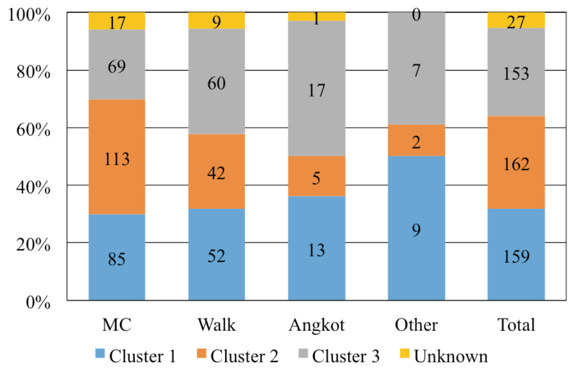


Table 6 shows the result of the explanatory factor analysis of the constructed evaluation scores. From this, it is possible to aggregate the evaluation of seven elements into three factors that would possibly be interpreted as: Factor 1: safety, security, comfort (Comfort cluster); Factor 2: travel time, punctuality (Time cluster); Factor 3: fare (Fare cluster).

The score of these three factors were calculated in this analysis and they are the score for "evaluation of individual respondents on each factor." These scores will be used for analyzing commute mode choices in the next chapter.

Figure 8 shows the distribution of each cluster on which respondents scored the highest by current major commute modes. Travel time and punctuality were found to be high among MC users. One reason could be that MC drivers could slip through congestion during the morning peak period. Walking commuters evaluated fare highly, which is consistent with the characteristic of walking. Many Angkot users evaluated fare highly, but the number of those who evaluated travel time and punctuality highly was small. One reason for this could be that, unlike MC users, Angkot cannot slip through the congestion.

3.2 Hypothesis Construction

Using the results of the basic analysis, the performance–importance analysis, and general perceptions, some hypotheses were constructed for commute mode and schedule choices of Malang university students.

3.2.1 Commute mode choices after introducing LRT

- *Gender*: Male respondents have more possibility for converting to LRT than female respondents.
- *Income/Expenditure*: Respondents with high household income and personal expenditure have more possibility for converting to LRT because they are less sensitive to fares.

- *Current commute mode*: MC users are unlikely to select LRT, but walking commuters and Angkot users are likely to convert to LRT.
- *Evaluation on traffic elements*: Respondents who have evaluated fares highly and comfort low would have more possibility for converting to LRT.
- *Interest level in new transportation services*: Respondents who have high interest in new public transportation services are more likely to convert to LRT.
- *Interest level for environment protection*: Respondents who have high interest for air pollution and environment protection are more likely to converting to LRT.
- *Angkot concerns*: Respondents who are concerned about traffic safety and passenger security issues in the use of Angkot are more likely to convert to LRT.

3.2.2 Scheduling choices after class

- *Income/Expenditure*: Respondents who have high household income and personal expenditure might select recreation or leisure activity because they may be less sensitive to fare or cost.
- *Usual recreation activity*: Recreation time-length sensitivity may be different between usual recreation activities.
- *Importance on travel time*: Respondents who place low importance on travel time select recreational activities. However, respondents who place high importance on travel time may select going home quickly more often.
- *Interest level in new transportation services*: Respondents with high interest in new public transportation services are less concerned with costly activities.
- *Angkot users*: Angkot users are likely to avoid selecting activities with expensive travel costs.

These hypotheses will be considered directly or indirectly when building discrete choice models for analyzing SP data in the next chapter.

4. ESTIMATION OF DISCRETE CHOICE MODELS

This chapter introduces the results of discrete choice analysis with the SP data obtained through a survey. We focus on the results of commute mode and scheduling choices after class by which we can empirically examine the possibility of students' using LRT.

4.1 Discrete Choice Models

In the analysis with SP data, latent class choice (LCC) and rank logit (RL) models are used.

In the LCC model, respondents belong to the "classes," which are given stochastically. The heterogeneity across classes for choice behavior is considered, whereas the normal multinomial logit (MNL) model has the implicit assumption that the effects of SP attributes and individual attributes for choice behavior are common for the entire population. In the LCC model, there are some ways to calculate the class probability such as logit form (Greene and Hensher, 2003). In this study, the "cutoff LCC" model (Fukuda *et al.*, 2004) is adopted.

In the normal MNL model, the choice probability is given as in Eq. (2) (McFadden, 1973):

$$P_{in} = \frac{\exp(V_{in})}{\sum_m \exp(V_{mn})} \tag{2}$$

$$V_{in} = \sum_j \beta_{ij} x_{ij}$$

where, i: choice alternative, n: individual, V_{in}: deterministic term of utility function, x_{ij}: the jth explanatory variable of Alternative i, and β_{ij}: an associated parameter.

In the LCC model, the choice probability is given as in Eq. (3):

$$P_{in} = \sum_{c=1}^{C} \left(K_{nc} \times \frac{\exp(V_{inc})}{\sum_{n \in N} \exp(V_{inc})} \right)$$
$$V_{inc} = \sum_j \beta_{icj} x_{inj} \tag{3}$$

where, V_{inc}: fixed term of utility function of class c, β_{ic}: unknown parameters of class c, and K_{nc}: class membership probability of class c.

In the cutoff the LCC model, the class probability is calculated as in Eq. (4):

$$Class_n = \begin{cases} 1 & \text{if} \quad Y_n \leq \tau_1 \\ 2 & \text{if} \quad \tau_1 \leq Y_n \leq \tau_2 \\ & \vdots \\ C & \text{if} \quad \tau_{C-1} \leq Y_n \end{cases}$$
$$K_{nc} = \text{Prob}(Class_n = c) = \begin{cases} G(\tau_1 - \overline{Y_n}) & \text{if} \quad c = 1 \\ G(\tau_2 - \overline{Y_n}) - G(\tau_1 - \overline{Y_n}) & \text{if} \quad c = 2 \\ \vdots & \\ 1 - G(\tau_{C-1} - \overline{Y_n}) & \text{if} \quad c = C \end{cases} \tag{4}$$
$$G(\nu_n) = [1 + \exp(-\nu_n)]^{-1}$$

where, $Y_n, \overline{Y_n}$: the value of class membership function and its fixed term, and τ: cutoff parameter (threshold value of membership function for grouping).

Next, the choice probability of the RL model is given as in Eq. (5):

$$\text{Prob}(ranking\ 1,2,\ldots,R) = \prod_{k=1}^{R-1} \frac{\exp(V_{kn})}{\sum_{r=k}^{R} \exp(V_{rn})}$$
$$V_{in} = \sum_j \beta_{ij} x_{inj} \tag{5}$$

where ("$ranking\ 1,2,\ldots,R$" means that the response is given as "Rank 1 is alternative 1," "Rank 2 is alternative 2," and "Rank R is alternative R").

The advantage of the RL model is that there is an opportunity of more precise model representation because the model considers the preference superiority for all choices the respondents are given.

4.3 Commute Mode Choices

4.3.1 Estimation results

Table 7 shows the estimation results of commute mode choices with the initial MNL model (which includes SP attributes only and no classification) and the proposed LCC–MNL model (relatively high significant factors only for membership function, and two classes). The LCC–

Table 7. Estimation results of commute mode choices (MNL and LCC models)

Explanatory variables	Initial model (SP attributes only)			LCC model				
				Class 1		Class 2		
	Parameter	*t*-value		Parameter	*t*-value	Parameter	*t*-value	
Utility function								
ASC (Angkot)	4.68×10^{-2}	0.18		-1.63×10^{-1}	-0.68	-1.54×10^{-1}	-0.42	
ASC (LRT)	1.06×10^{-1}	0.41		8.90×10^{-3}	0.00	1.23	2.70	**
Total cost (100 Rp.)	1.13×10^{-5}	1.00		-6.80×10^{-1}	-1.34	-2.41×10^{-2}	-5.57	**
Normal travel time (min)	-3.47×10^{-2}	-4.25	**	-4.40×10^{-3}	-0.04	-4.72×10^{-2}	-3.59	**
Delay time (min)	-3.70×10^{-2}	-4.75	**	-4.99×10^{-1}	-1.19	-5.32×10^{-2}	-4.38	**
Walking access time (min)	-9.04×10^{-2}	-4.77	**	6.11	1.17	-9.02×10^{-2}	-3.57	**
Frequency (/h)	-1.03×10^{-1}	-5.62	**	-3.09	-1.45	-1.48×10^{-2}	-0.65	
Class membership function				Parameter		*t*-value		
Male				3.94×10^{-1}		2.32		**
Household income				1.59×10^{-1}		4.48		**
Personal expenditure				-1.33×10^{-1}		-2.67		**
Interest level for new stuff				2.46×10^{-1}		4.63		**
Interest level for Angkot issues				-7.86×10^{-2}		-1.45		
Commute mode = Angkot				1.08		3.15		**
Commute mode = walking				1.69		5.33		**
Factor score 1 (comfort)				-1.68×10^{-1}		-2.24		**
Factor score 2 (time)				1.20×10^{-1}		1.86		*
Cutoff parameter τ				1.63		3.03		**
Observations	2827			2827				
Initial log likelihood	-3105.8			-3105.8				
Final log likelihood	-2732.7			-2613.1				
Adjusted likelihood ratio	0.118			0.151				

(**: 5% significant, *: 10% significant, ASC: alternative specific constant)

RL model was also tested, but the likelihood ratio was much lower than that of the MNL model. Therefore, many respondents may have answered the second rank choice randomly. This is probably because the change of SP attributes could not pull out respondents' tradeoff in choice decisions and the SP configuration might have been complicated. In fact, some respondents answered in the same way in all six scenarios, as if they did not consider their tradeoff of the variables.

In the initial MNL model, respondents mainly considered time elements (travel time, delay time, and walking access time). However, the estimation of frequency was opposite to our expectation. Therefore, we suggest that respondents did not consider frequency.

In the estimation of the LCC–MNL model, it is necessary to determine the number of classes in advance. We use Akaike's information criterion (AIC) and consistent Akaike's information criterion (CAIC) to select the optimal number of classes, with the variables shown in Table 7. Both AIC and CAIC are based on the log likelihood at convergence and the calculation equations are shown in Eqs. (6) and (7) (Fukuda *et al.* 2004):

$$AIC_S = -2(LL_S - P_S) \tag{6}$$

$$CAIC_S = -2LL_S + (4S - 1)\{\ln(2N) - 1\} \tag{7}$$

where, LL_S: log likelihood at convergence for a model with S classes, P_S: number of unknown parameters for a model with S classes, S: number of classes and N: number of observations.

The calculation results of AIC and CAIC are illustrated in Figure 9. The results show that both AIC and CAIC reach minimum when the number of latent classes is two. This suggests that the two-classification model is the best model to express the taste heterogeneity

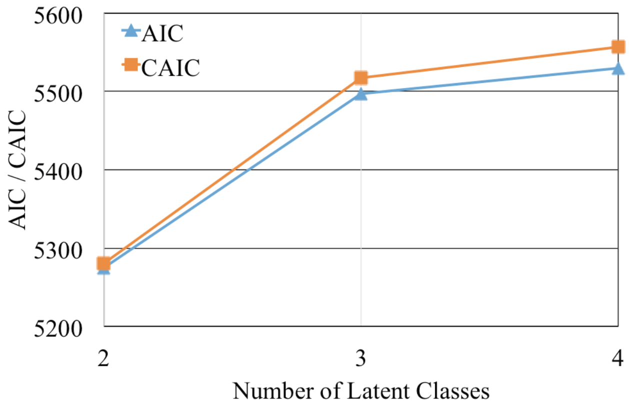


Figure 9. Calculation results of AIC and CAIC in LCC models

between respondent classes.

The final estimation results of LCC–MNL in Table 7 implies that Class 1 respondents consider total cost and delay time most for mode choice, and that Class 2 respondents incur all of the items other than frequency for mode choice. However, the total cost and delay time sensitivity that can be inferred from the estimated values of parameters are much higher in Class 1 than those in Class 2. Therefore, it is implied that Class 1 people would be a "cost and delay time-oriented class," and those in Class 2 would be a "travel time and access time-oriented class." When considering the LRT characteristic, we might guess that passenger groups "more likely to convert to LRT" should be those belonging to Class 2 (travel time and access time-oriented class). We also see that the respondents who have higher value on class membership function have more probability for belonging to Class 2. The results show that respondents who are likely to belong to Class 2 would be those who are "male," with "high household income," "low personal expenditure," "high interest in new public transport service," "Angkot commuters," "walking commuters" and "low evaluation for comfort and high evaluation for travel time on current commute mode." However, Class 1 respondents might use LRT more if the LRT fare is cheaper because they are much more cost-sensitive than Class 2 respondents. Therefore, a transfer discount fare between LRT and Angkot would be more effective for Class 1 respondents.

From these interpretations of the estimation results, the hypotheses about *gender*, *income*, *current commute mode*, *evaluation on traffic elements*, and *interest in new transportation service* might be accepted, but the hypothesis about *expenditure* was opposite to our expectations. All other hypotheses could not be verified because of their low significance level.

4.3.2 Market segmentation

With the estimated parameters in the LCC–MNL model and respondents' choice results, the prior and posterior probabilities that each respondent belong to, classes can be calculated. To calculate posterior belonging probability, prior belonging probability and the joint probability are needed (Greene and Hensher, 2003). First, the prior belonging probability is calculated as in Eq. (8) based on Eq. (4):

$$K_{nc} = \begin{cases} G(\hat{\tau} - \widehat{Y_n}) = \left[1 + \exp(\widehat{Y_n} - \hat{\tau})\right]^{-1} & \text{if } c = 1 \\ 1 - K_{n1} & \text{if } c = 2 \end{cases} \tag{8}$$

where, $\widehat{Y_n}$: calculated values of class membership function of each respondent from estimation result, and $\hat{\tau}$: estimated cutoff parameter. The hat represents the estimated parameters.

Then, the joint prior probability is calculated as in Eq. (9):

$$\widehat{P_{n|c}} = \prod_{t=1}^{T_n} \widehat{P_{nt|c}} \tag{9}$$

where, $\widehat{P_{nt|c}}$: estimated choice probability for scenario t in class c and T_n: Number of answers for each respondent.

By using Bayes' theorem, the posterior belonging probability can be finally calculated as in Eq. (10):

$$H_{c|n} = \frac{\widehat{P_{n|c}} K_{nc}}{\sum_{c=1}^{2} \widehat{P_{n|c}} K_{nc}} \tag{10}$$

Figures 10 and 11 represent the distributions of the prior and posterior probabilities in Class 2, respectively. On the one hand, in terms of prior probabilities, respondents were sparsely and somewhat widely distributed. That means that it may be difficult to judge which respondents are more likely to be a Class 2-type person or not. On the other hand, in terms of posterior probabilities, the respondent groups were almost clearly defined, such as "almost Class 1 group," "almost Class 2 group" and "fifty–fifty group," which the posterior probability is nearly equal to 0.5 for both classes. The respondent share of the "almost Class 2 group" can be approximately 65%.

4.3 Scheduling Choices after Class

The RL model is adopted in estimating scheduling choices after class. The utility functions are specified to verify the hypotheses that were explained in Section 3.3.

Table 8 shows the estimation results of the RL model. The results suggest that some monetary individual attributes such as income and expenditure affect choice behavior directly, but not through cost sensitivity. Although the estimated parameter for personal expenditure was opposite to the hypothesis, it can be interpreted that "people who usually spend a lot of

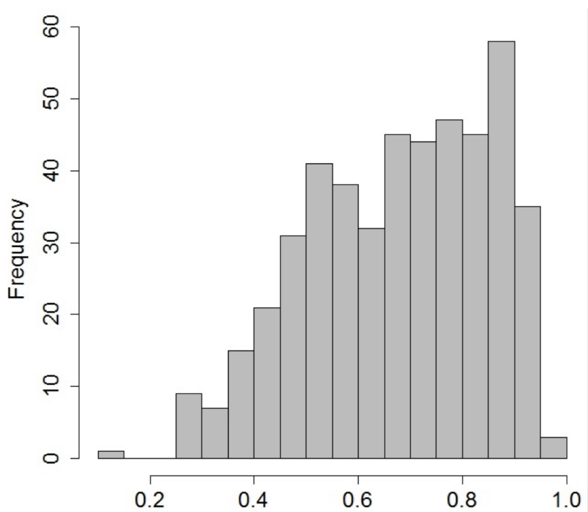


Figure 10. Histogram of prior probability to belong Class 2

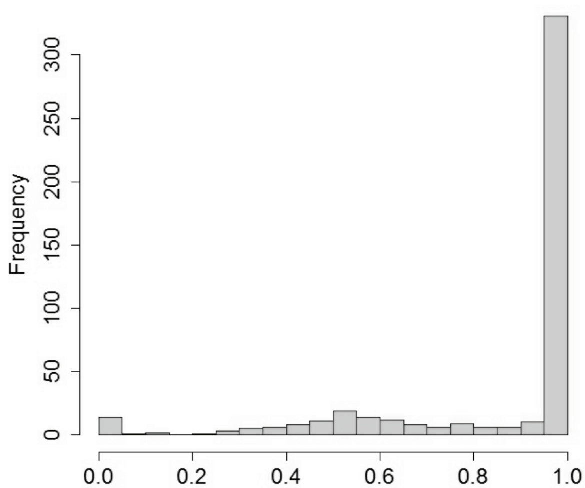


Figure 11. Histogram of posterior possibility to belong to Class 2

Table 8. Estimation result of schedule choice after university (RL model)

Explanatory variables	Parameter	*t*-value	
ASC (Choice 2)	6.80×10^{-3}	0.02	
ASC (Choice 3)	-3.82×10^{-2}	-0.11	
Total cost (100 Rp.)	-1.50×10^{-2}	-2.87	**
Total cost -HH income (100 Rp.)	1.87×10^{-4}	0.19	
Total cost -per. expense (100 Rp.)	-9.58×10^{-4}	-0.61	
Total cost -trans. expense (100,000 Rp.)	-1.50×10^{-4}	-0.85	
Recreation time (shopping) (min)	1.11×10^{-2}	6.38	**
Recreation time (sports) (min)	4.83×10^{-3}	3.04	**
Recreation time (hobby) (min)	-3.56×10^{-4}	-0.20	
Recreation time (hanging out) (min)	7.72×10^{-3}	5.69	**
Recreation time (others) (min)	1.38×10^{-4}	0.08	
Relaxation time at home (min)	2.02×10^{-2}	2.67	**
Household income (Choice 2)	7.88×10^{-2}	1.51	
Household income (Choice 3)	9.92×10^{-2}	3.93	**
Per. expense (Choice 2)	1.50×10^{-2}	0.18	
Per. expense (Choice 3)	-8.55×10^{-2}	-2.12	**
Trans. expense (Choice 2) (1000 Rp.)	-3.28×10^{-3}	-0.40	
Trans. expense (Choice 3) (1000 Rp.)	-1.46×10^{-2}	-3.20	**
Interest in new activities (Choice 2)	6.08×10^{-2}	2.34	**
Interest in new activities (Choice 3)	8.12×10^{-2}	3.23	**
Travel time importance (Choice 2)	-4.13×10^{-2}	-0.85	
Travel time importance (Choice 3)	7.33×10^{-2}	1.62	
Current commute mode = Angkot	-2.21×10^{-2}	-0.16	
Observations	2981		
Initial log likelihood	-5341.2		
Final log likelihood	-4591.5		
Adjusted likelihood ratio	0.136		
Time values for recreation (Rp./h)	4440 (shopping) (≒43.2 JPY/h) 1930 (sports) (≒18.8 JPY/h) 3090 (hanging out) (≒30.1 JPY/h) 55.3 (others) (≒0.538 JPY/h)		
Time value for leisure (Rp./h)	8070 (≒78.5 JPY/h)		

(**: 5% significant, *: 10% significant, ASC: alternative specific constant)

money are likely to try to save by using cheap transport.” The other hypotheses were almost verified. In particular, the sensitivity to recreational time for some activities was very significantly different. Notable activities were shopping, sports, and hanging out. The most sensitive activity was shopping and its impact was estimated to be approximately 2.3 times that of sports. This implies that university students might use LRT more if it operates near shopping malls or entertainment facilities than near sports facilities.

5. CONCLUSIONS AND FUTURE WORKS

In this study, travel behavior data, particularly SP data was fully examined to reveal intention of use for the assumed introduction of new public transport (specifically LRT) in a medium-sized Asian city. Malang in Indonesia was used in our case study. The following findings were derived from discrete choice analysis.

5.1 Commute Mode Choices

In commute mode choices, respondents can be briefly divided into “cost and delay time-oriented people (Class 1)" and "travel and access time-oriented people (Class 2)." Passengers who were likely to convert to LRT include those with "high household income and low personal expense" and "currently walking commuters."

The posterior probabilities that belong to the two classes were calculated from the estimation results of the LCC–MNL model. It was possible to classify respondents into the derived two classes. When assuming that passenger groups who are more likely to convert to LRT would be Class 2, the share of those respondents was about 65%. This distribution may not be negligible.

5.2 Scheduling Choices

In scheduling choices, the difference of recreation time values between the usual recreation activities was found. LRT should be ideally located near markets and entertainment venues.

Higher income and lower expenditure respondents are more likely to select going home quickly with expensive transportation (i.e., Choice 3). Respondents with high interest in new public transportation services are likely to select an expensive transportation schedule (Choices 2 and 3). However, we were unable to fully determine respondents' intended use of LRT because the configuration of the SP questionnaire was complicated for some respondents. Including this issue, conceivable future works include: implementing a wider-ranging survey with higher representativeness; simplification of assumptions in SP questions; and acquisition of more extensive individual attribute information to identify the respondents who would convert to LRT in more detail.

ACKNOWLEDGEMENTS

Toshiba Corporation and a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (A) #15H02632 supported this study. The authors thank Professor Tetsuo Yai and Dr. Yasunori Muromachi for their valuable comments.

REFERENCES

Fukuda, D., Opachavalit, N., Yai, T. (2004). Use of stated choice analysis to determine ETC in-vehicle transmitter purchasing behavior. *Journal of Japan Society of Civil Engineers*, (772), 227–238.

Greene, W.H., Hensher, D.A. (2003). A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research Part B*, 37(8), 681–698.

Hanaoka, S., Acharya, S.R. (2008). Characteristics and issues of transport policy in East Asian megacities. *Transportation and Economy*, 68(11), 14–20. (in Japanese)

Joewono, T.B. (2009). Exploring the willingness and ability to pay for paratransit in Bandung, Indonesia. *Journal of Public Transportation*, 12(2), 85–103.

Joewono, T.B., Kubota, H. (2005). The characteristics of paratransit and non-motorized transport in Bandung, Indonesia. *Journal of the Eastern Asia Society for Transportation Studies*, 6, 262–277.

McFadden, D. (1973). Conditional logit analysis in qualitative choice behavior. In P. Zarembka (ed.), *Frontiers in Econometrics*. Academic Press: New York, 105–142.

Statistics Jawa Timur (2015) [Online] Available from: http://jatim.bps.go.id/?cat=62. [Accessed: 25th February 2015]