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INVESTIGATING TRAVELERS' STATED MODE CHOICE PREFERENCES UNDER THE INFLUENCES OF VARIOUS MODE AVAILABILITY OPTIONS IN BRT SYSTEM IN SURABAYA CITY

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1. INTRODUCTION

This study evaluates bus rapid transit (BRT) system in Surabaya, Indonesia considering various mode choice contexts based on choice context SP design. Mode choice models of multinomial logit type have widely been developed based on stated preference survey considering some future hypothetical scenario where access mode, main mode and egress mode availability differs from one trip makers to another. The developed models were then used to forecasting travel demand for new transport services by simulation analysis. Changes in mode choice probabilities in response to changes in travel fare and travel time under various mode choice contexts were determined in proposed BRT system. Finally, policy recommendations are made for effective use of existing transportation modes in Surabaya city for successful implementation of BRT.

In almost all the previous studies it has been assumed that all the alternatives (Including access and main modes) are available to all individuals which are an oversimplification of reality. In this paper it has been assumed that not all the modes are available to all the commuters which has been reflected in SP design as shown in **Table 1**.For Example, In Surabaya Becak is not allowable to operate on some certain roads results in its non-availability as an access mode to different users. Surabaya city is also experiencing Car Free day (Anwar et al, 2010) where neither car nor Motorcycle is allowed to operate in some major routes of the city in some specific days resulting non-availability of cars and Motorcycle. Even long distance to the nearest station or unavailability of some access mode makes it difficult to avail some certain main travel modes to some users. On the other hand choice of access mode is strongly dependent on the availability of main mode and egress mode. This is necessary to determine the most preferred combinations of access and egress mode with the main mode for efficiently manage the future Demand.

2. MODEL STRUCTURE

Choice probability of mode i for individual n in this paper has been written as

$$P_{ni} = \frac{\lambda_{ni} \exp(V_{ni})}{\sum \lambda_{ni} \exp(V_{ni})} \qquad (1a)$$

Where,λ_{ni}=1, if mode *i* is available in the choice set of individual *n*, =0, otherwise. In this paper, four competitive main modes (i.e. bus, BRT, angkot and

Table 1 The contexts of the universal choice set in SP

Con-text	Access Mode	Main Mode	Egress Mode	Trip Purpose	Trip Distance
1	Becak Walk	Car Bus BRT Angkot	Walk	Shopping	20 km
2	MC Angkot Walk	Car Bus BRT	Angkot Walk	Shopping	8 km
3	Angkot Walk	Car Bus BRT Angkot	Walk	Work School	8 km
4	Angkot Walk	Car Bus BRT Angkot	Angkot Walk	Work School	20 km
5	MC Angkot Walk	Car Bus BRT	Walk	Work School	8 km
6	MC Becak Walk	Car Bus BRT	Walk	Shopping	20 km
7	Angkot Becak Walk	Bus BRT	Angkot Walk	Work School	20 km
8	Becak Walk	Car Bus BRT Angkot	Angkot Walk	Work School	20 km
9	Angkot Becak Walk	Bus BRT	Walk	Work School	8 km
10	MC Angkot Becak Walk	Bus BRT Angkot	Angkot Walk	Shopping	8 km
11	MC Angkot Becak Walk	Bus BRT Angkot	Walk	Shopping	8 km
12	MC Becak Walk	Car Bus BRT	Angkot Walk	Shopping	8 km
13	Walk	Bus BRT	Angkot Walk	Work School	20 km
14	MC Walk	Bus BRT Angkot	Angkot Walk	Shopping	20 km
15	MC Walk	Bus BRT Angkot	Walk	Work School	8 km
16	Walk	Bus BRT	Walk	Shopping	20km

car) have been considered whether all the modes may or may not be available in the choice set for any individual *i*, Probability of access modes were also estimated based on the similar types of equation.

3. MODEL ESTIMATION /DISCUSSION

Here, two different mode choice models were developed; one for main mode choice and another for access mode choice based on the assumption that access mode choice strongly depends on main mode choice. The significant deterministic variables for main mode choice and access mode choice are shown in **Table 2** and **Table 3** respectively.Main mode choice was found to have profound effect on access mode choice. **Table 3** shows how utility of MC, Walking and Angkot depends on the mode choice of Bus and BRT as main mode.Although, bus has more average utility than Angkot, in all the contextt it has lower average choice probability than BRT. In all context bus was assumed to exist with the BRT with cheaper and slower attributes than BRT. It will be

Table 2 Estimation results of the models for main mode

Variables	Specific mode	Parameter	t-statistics
Education*gender (=1, if higher education and male)	Angkot	-0.423	-2.48**
Student	Car	-1.958	-4.763**
Employment (=1, if employed in service) Employed as Company Service (=1, if company service)	BRT Bus	0.571 0.649	2.813** 2.957**
Age Age Age*gender (=1,if,male) Age * occupation (=1,if employed as company service)	Car BRT Bus Angkot	-0.020 0.037 0.012 0.045	-1.799* 5.901** 1.965* 4.172**
Household income (Rp) Household income (Rp) Household income (Rp) Household income (Rp) Household income (Rp)*occupation*education(=1,if employed as company service and higher education)	Car Angkot BRT Bus BRT	0.171E-06 -0.224E-06 0.120E-06 -0.770E-06 -0.144E-06	2.50** -2.46** 2.204** -1.15 -3.193**
Car Ownership Car Ownership * Gender (=1,if male)	To Car To BRT	0.671 -0.324	4.046** -1.999*
Total Travel Cost (Rp)	All mode	-0.508E-06	-9.102**
Total Travel Time (min.)	All mode	-0.303E-03	-1.11
Travel Distance (km) Travel Distance*Occupation (=1 if employed as Govt Service) Travel Distance* Occupation (=1 If Student) Travel Distance* Occupation*Gender (=1 If male Student)	Car BRT Bus Angkot	0.377 0.020 -0.082 0.039	8.863** 1.692* -5.12** 1.6205
Log likelihood at Zero Log-Likelihood at convergence McFadden's Rho Square Adjusted Mcfadden's Rho Square No of cases		-1153.234 -788.764 0.31603 0.29728 1080	

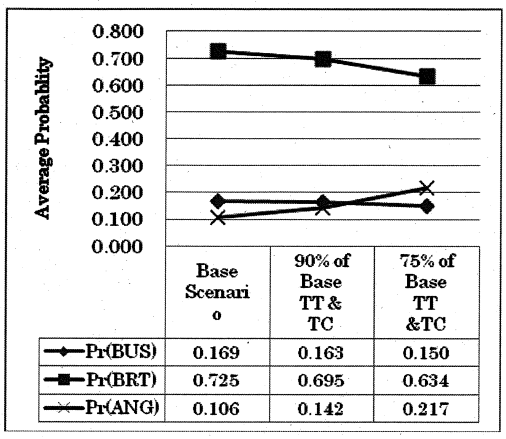

Fig.1 Sensitivity of change in Angkot Travel Time and Travel cost to main mode choice Probablity (Context 14)

Table 3 Estimation result for Access Mode Choice

Variables	Specific Mode	Parameter	t- statistics
Alternative Specific Constant	Car	1.679	3.595**
Student (=1if Student, 0 otherwise)	Walk	-0.574	-2.846**
Age	Becak	0.059	7.022**
	Motorcycle	-0.037	-3.484**
Household Income (HIC) (Rp)	Becak	0.112E-06	1.657*
	Car	0.269E-06	2.271**
Car Ownership	Car	0.356	1.639*
Motorcycle Ownership	Motorcycle	0.232	2.004**
Gender (=1 if Male, 0 otherwise)	Angkot	0.813	2.452**
	Motorcycle	0.732	2.190**
	Walk	0.519	1.987*
Trip Distance (km)	Motorcycle	0.072	3.015**
	Walk	0.055	2.996**
BRT as Main Mode (=1, If main mode choice is BRT, 0 otherwise)	Angkot	3.360	9.314**
	Motorcycle	3.778	8.684**
	Walk	4.256	12.074**
BUS as Main Mode (=1, If main mode choice is BUS, 0 otherwise)	Angkot	2.462	3.878**
	Motorcycle	2.773	4.258**
	Walk	4.383	8.672**
Log likelihood at Zero		-1153.234	
Log-Likelihood at convergence		-662.73	
McFadden's Rho Square		0.42533	
Adjusted Mcfadden's Rho Square		0.40799	
No of cases		1080	

highly infeasible for buses to operate on the routes where BRT exists unless there are reduction of travel time and cost. On the other hand, bus has higher average utility than angkot at any level of household income and it can compete with angkot to get the more modal share. So, unavailability of BRT on any particular route can draw major trips in to bus over angkot.It has been found that, access mode choice is strongly dependent on main mode choice as shown in the **Table 3**. In this sense, successful implementation of BRT requires attention to accessibility policies. Under BRT system access mode choice will be dependent on main mode choice and unless good walking facilities are provided there can be major shift in motorized access mode in future. Walking Facilities should be improved in the Surabaya City which can reduce the use of private motorized vehicles in Surabaya city as an access mode and can also stimulate public transit use.

Becak can still be very effective for elderly people for access mode choice and sufficient road safety and security measure should be provided for its effective use. With a high motorcycle ownership in Surabaya, it can be used as an access mode under BRT system; especially, it has high preference among younger people. **Fig 1** shows how travel time and travel cost reduction of angkot increase its choice probability as main mode. The same is true for bus

4. CONCLUSION

This paper explores the factors which can affect the utility of BRT in future. Mode availability contexts can be properly tested through this model and outcome of the study can be used in demand predictions as for changes in the variables both for access mode and main mode; for instance travel time and various scenarios of mode availability. The proposed model can be used in Surabaya metropolitan region to design and implement more effective and appropriate transportation solutions for an environment friendly and sustainable transportation horizon.

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