Mode Choice of Transit System in Denpasar Greater Area (SARBAGITA)

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Abstract: In this paper, we examined mode choices of bus rapid transit (Trans Sarbagita) and other alternatives such as car, motorcycle, and feeder in Denpasar Greater Area, Bali (Sarbagita Area). The data used for this research are 526 respondents from Sarbagita Area. There are 30 stated preference scenarios for each person obtaining14,055 observations. We estimate multinomial logit (MNL) model with attributes such as travel time, travel cost, waiting time, walking distance, parking cost, and easiness. We found that travel cost, travel distance, and walking distance to the shelter are important factors to increase load factor of Trans Sarbagita. We also found some strange case where the value of travel time savings of car is lower compare to the Trans Sarbagita and Feeder. Some policies might be needed in order to shift the private vehicle users to Trans Sarbagita.

Keywords: Sarbagita, Mode Choice, Multinomial Logit, Value of Travel Time Savings

1. INTRODUCTION

The government of Indonesia, in Medium Term National Planning (RPJMN) (Government of Indonesia, 2014), has stated that there are six agglomeration cities that become prioritize of development. Those six agglomerations are Jabodetabek (Jakarta Metropolitan Area), Mebidangro (North Sumatera), Gerbang Kertosusila (East Java), Metro Bandung Raya (West Java), Mamminasata (South Sulawesi) and Sarbagita (Bali). Sarbagita or Denpasar Greater Area has a population of approximately 2,428,000 habitants with a population density reaches 10,229 population/km (Statistics Indonesia, 2015). In addition, Sarbagita is also well known as tourist destinations both domestic and international. The potential of the tourism sector induces massive traffic and commuting activities in Sarbagita causing traffic congestion. This congestion might bring bad image for tourism in Bali, and it could decrease the number of tourist in the next following years. Hence, improvement of public transportation in Sarbagita is crucial to support tourism activities and increase the economy.

In RPJMN, the government has declared to develop Bus Rapid Transit (BRT) system in 34 cities in Indonesia to improve the current public transportation system. This policy is important to support public transportation in the cities and increase mode share of public transportation from 23% to become 34% in 2019 (Government of Indonesia, 2014). Those cities have received buses from the national government and operated by local government.

Trans Sarbagita[1] is part of those BRT planning.

Currently, provision of Trans Sarbagita is one of the approaches to reduce private vehicle users in Sarbagita. Trans Sarbagita has been operated in four corridors out of 17 corridors planned (Governor of Bali regulation, 2010). There are two corridors that have been operated since 2011, while other two corridors have been operated since 2015. The routes are Denpasar – GWK, which pass through Udayana University, (corridor 1). Batu Bulan - Nusa Dua (corridor 2), Tabanan – Ngurah Rai Airport (corridor 3), and Lebih – Mahendradata (corridor 4). Those four corridors do not serve the entire region of Sarbagita yet. However, the load factor of Trans Sarbagita is still low that is around 20% – 30% in 2012 (Bali Transportation Agency, 2012). The are a few studies have been conducted about Sarbagita. Among these, Surung and Arka (2014), using binary logistic regression, study the intention of students for using Trans Sarbagita. They found that Income and accessibility of shelter are factors that significantly influence students' decision to use Trans Sarbagita. It is necessary to understand what factors influence not only the student but also general population to use Trans Sarbagita in order to make improvement and development of the remaining corridors.

This research investigates choices of BRT (Trans Sarbagita) and other mode choice options (such as cars, motorcycle, and feeder), with variables that might influence mode choice decision in Sarbagita such as travel distance, travel cost, travel time, and income. This paper is structured as follows. Section 2 provides a brief discussion of the data collection and continued with description statistic of the sample. Section 3 describes the methodology of this research. Section 4 discusses model simulation using Multinomial Logit (MNL) model. The following section, Section 5, conclusion and recommendation are given.

2. DATA COLLECTION AND DESCRIPTION

2.1 Questionnaire Distribution

The data was collected on 22nd – 25th of January 2016 in Sarbagita area by SUTIP (Sustainable Urban Transportation Improvement Project) which is part of GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) project in Indonesia (Prayudyanto et al, 2016). The targets of this survey are 620 respondents which distributed proportionally based on population in each region (Denpasar, Badung, Gianyar, and Tabanan). The method for the survey was an interview survey. Seventeen surveyors from Bali Province transportation agency and Udayana University conducted the survey, some of the surveyors are students. The respondents are a user of the motorcycle, car, feeder, and Trans Sarbagita.

The questionnaire contains socio-demography profile, preferences of facilities and infrastructures of Trans Sarbagita, preferences of activities, preferences of mode transportation. Each of the respondents is given sets of scenarios where they need to choose between four alternatives modes: Trans Sarbagita (TS), feeder, car, and motorcycle. Each of the alternatives is given some attributes. For Trans Sarbagita and Feeder, the attributes are travel time (in minute), travel cost (in IDR 1K), waiting time (in minute), and walking distance to the shelter (in meter). While for car and motorcycle the attributes are travel time (in minute), travel cost (in IDR 1K), parking cost (in IDR 1K), and the ease of parking (binary response; 1=easy, 0=otherwise). Each scenario has different attribute characteristics which can be seen in Figure 1.

[1] BRT Trans Sarbagita is not operated with dedicated bus line

Scenario 1

Attributes	TS	Feeder	Car	MC
Travel Time (min)	30	60	60	60
Travel Cost (IDR)	5,000	9,000	15,000	3,000
Waiting Time (min)	10	15	-	-
Walking Distance to Shelter (meter)	100	150	-	-
Parking Cost (IDR)	-	-	2,000	8,000
Easiness of Parking	-	-	Easy	Easy
My Mode Choice	☐	☐	☐	☐

Scenario 2

Attributes	TS	Feeder	Car	MC
Travel Time (min)	30	45	45	45
Travel Cost (IDR)	9,000	7,000	10,000	3,000
Waiting Time (min)	20	10	-	-
Walking Distance to Shelter (meter)	100	150	-	-
Parking Cost (IDR)	-	-	5,000	6,000
Easiness of Parking	-	-	Easy	Easy
My Mode Choice	☐	☐	☐	☐

Scenario 3

Attributes	TS	Feeder	Car	MC
Travel Time (min)	75	30	60	60
Travel Cost (IDR)	5,000	3,000	10,000	9,000
Waiting Time (min)	5	10	-	-
Walking Distance to Shelter (meter)	150	200	-	-
Parking Cost (IDR)	-	-	5,000	6,000
Easiness of Parking	-	-	NotEasy	Easy
My Mode Choice	☐	☐	☐	☐

Scenario 4

Attributes	TS	Feeder	Car	MC
Travel Time (min)	60	60	60	60
Travel Cost (IDR)	7,000	3,000	20,000	12,000
Waiting Time (min)	15	15	-	-
Walking Distance to Shelter (meter)	100	50	-	-
Parking Cost (IDR)	-	-	2,000	6,000
Easiness of Parking	-	-	NotEasy	Easy
My Mode Choice	☐	☐	☐	☐

Figure 1. Examples of scenarios for stated mode choice experiments

There are four mode choice options (Trans Sarbagita, feeder, car, and motorcycle). This survey consists six blocks which designed using orthogonal fractional factorial (Hensher et. al., 2005). In total, each respondent faces 30 SP experiments and for all blocks. Therefore we have180 combination of different attributes. Detailed attributes and values in each choice are shown in Table 1.

Once the data that have been collected, data sorting is performed to omit irrelevance data. Sorting the data is conducted with checking incomplete data and conformity of the data answers (Hair et. al., 2002; Hensher et. al., 2005). As a result, we obtained 526 respondents and 14,055 observations from the data cleaning process that we use for analysis.

Table 1. Attribute and values of the alternatives in stated choice survey

Alternatives	Attribute	values
Trans Sarbagita	Travel time (minutes)	5, 10, 15, 30, 45, 60, 75, 105
	Travel cost (IDR 000)	2, 3, 5,7,9
	Waiting time (minutes)	5, 10, 15, 20
	Walking distance to shelter (meter)	50, 100, 150, 200
Feeder	Travel time (minutes)	5, 10, 15, 30, 45, 60, 75, 90 105
	Travel cost (IDR 000)	2, 3, 5, 6, 7, 9, 12
	Waiting time (minutes)	5, 10, 15, 20
	Walking distance to shelter (meter)	50, 100, 150, 200
Car	Travel time (minutes)	5, 10, 15, 20, 30, 45, 60, 75, 90, 105
	Travel cost (IDR 000)	2, 4, 5, 6, 8, 10, 15, 20, 25
	Parking Cost (IDR 000)	2, 4, 5, 8 ,10
	The ease of parking	0 1 (easy)
Motorcycle	Travel time (minutes)	5, 10, 15, 30, 45, 60, 75
	Travel cost (IDR 000)	1, 2, 3, 4, 6, 9, 12, 15
	Parking Cost (IDR 000)	2, 4, 6, 8
	The ease of parking	0 1 (easy)

2.2 Socio-Economic Characteristics

Table 2 presents descriptive statistics of the sample. We found that the number of male and female respondent is equal about 50%. The majority of respondent are between 18 – 23 years old about 42.51% which most of them are students 52.43% and private employee about 15.59%.

Table 2. Sample Descriptive Analysis

Variable	Value	Proportion (%)
Gender	Male	50.00
	Female	50.00
Marital status	No Answer	3.24
	Single	62.15
	Married	34.62
Age	9-17	15.18
	18-23	42.51
	24-35	18.42
	36-50	16.60
	51-65	6.07
	>65	1.21
Income (in IDR per month*)	Less than IDR 1,000 K	34.62
	IDR 1,000 K - 2,000 K	28.54
	IDR 2,000 K - 6,000 K	30.16
	IDR 6,000 K - 10,000 K	5.87
	More than IDR 10,000 K	0.81
Education level	No Answer	1.21
	Elementary School	6.07
	Junior High School	13.77
	High School/Vocational School	47.77
	Bachelor	25.51
	Master	4.86
	Doctoral	0.81
Employment	Civil Servant	7.69
	Retired Civil Servant	2.23
	Private Employee	15.59
	Private Employer	12.35
	Student	52.43
	Housewife	2.02
	Teacher/Lecturer	4.45
	Others	3.24
Travel Distance	0-5 km	19.03
	5-10 km	24.90
	10-15 km	21.66
	15-20 km	17.41
	20-25 km	8.30
	> 25 km	8.70
Vehicle Ownership	No Vehicle	15.59
	At least has Car or Motorcycle	41.50
	Has both car and motorcycle	42.91

*At time the survey was conducted, 13,600; IDR was equivalent to about 1 US Dollars

The interesting fact that the income of respondent tends to be equally distributed: The respondents with the monthly income less than IDR 1,000 K are 34.62%, the respondents with the monthly income between 1,000 K and 2,000 K are 28.54%. The respondents with the monthly income between 2,000 K and 6,000 K are 30.16%. It appears that the majority part of

our respondents travels below 15 km.

3. METHODOLOGY

There are four alternative modes in this study. Therefore, there are four utility (V_i) functions in total. The four alternatives are Sarbagita (i=1), feeder (i=2), car (i=3), motorcycle (i=4). The general utility function of the base model is as follows:

$$V_i = \alpha_i + \beta_{TT_i} \cdot TT_i + \beta_{TC} \cdot TC_i + \beta_{WT_i} \cdot WT_i + \beta_{WD_i} \cdot WD_i + \beta_{PC_i} \cdot PC_i + \beta_{PE_i} \cdot PE_i \quad (1)$$

where, V_i : utility for Trans Sarbagita (i=1), feeder (i=2), car (i=3), motorcycle (i=4)
α_i : alternative specific constant (ASC) associated with i (fixed at 0 for i=1)
β_{mi} : estimable parameter associated with attribute m for alternative i
TT_i : travel time for alternative i
TC_i : travel cost for alternative i
WT_i : waiting time for alternative i, WT_i =0 for i=3 and i=4
WD_i : walking distance to shelter for alternative i, WD_i =0 for i=3 and i=4
PC_i : parking cost for alternative i, PC_i =0 for i=1 and i=2
PE_i : the ease of parking for alternative i, PE_i =0 for i=1 and i=2

Our models are multinomial logit models (MNL), estimated with maximum likelihood estimation using PythonBiogeme for the discrete choice model (Bierlaire, 2016). PythinBiogeme is a software package designed to estimate the parameters of various models using maximum likelihood estimation which particularly designed for discrete choice models. Maximum likelihood estimates parameters value which maximizes the likelihood function. For all attributes, we estimate those attributes with respect to the alternative, except for travel cost.

We also perform a model comparison of random utility maximization and random regret minimization using the same data set in our other work (Belgiawan et al., 2017).

4. MODEL ESTIMATION

This section describes the results obtained from the estimation described in the previous section. We found interesting results from the survey that contrary with current condition load factor of Trans Sarbagita. The result found that 34.29 respondents prefer Trans Sarbagita, and 31.98% respondents prefer to take the motorcycle. The respondents who chose feeder are about 20.73%, and car are about 13 % respondents. The detail can be seen in Table 3.

Table 3. Chosen alternative in the observations

Alternative (N=14,055)	Number of observations who chose the particular alternatives	Proportion (%)
Transarbagita	4.819	34.29
Feeder	2.914	20.73
Car	1.827	13.00
Motorcycle	4.495	31.98

The MNL result is shown in Table 4. Most of the parameter are significant at the 5 percent level, Trans Sarbagita waiting time and feeder walking distance to shelter are not significant. One parameter, feeder waiting time is significant at 10 percent.

Table 4. Model estimation results

Variables	Parameter	t score	p value
ASC Feeder	-0.582**	-5.81	0.00
ASC Car	-1.340**	-13.17	0.00
ASC Motorcycle	-0.334**	-4.09	0.00
Travel Cost	-0.085**	-22.50	0.00
Trans Sarbagita travel time	-0.020**	-25.41	0.00
Trans Sarbagita waiting time	0.004	1.17	0.24
Trans Sarbagita walking distance to shelter	-0.001**	-3.85	0.00
Feeder travel time	-0.018**	-20.11	0.00
Feeder waiting time	-0.006	-1.73	0.08
Feeder walking distance to shelter	0.000	-1.23	0.22
Car travel time	-0.010**	-9.59	0.00
Car park cost	-0.019*	-2.28	0.02
Car park easiness	0.540**	10.09	0.00
Motorcycle travel time	-0.023**	-20.07	0.00
Motorcycle park cost	-0.058**	-7.65	0.00
Motorcycle park easiness	0.626**	16.56	0.00
Model Fit			
Observations	14055		
Initial log-likelihood	-19484.367		
Final log-likelihood	-17691.211		
McFadden's	0.092		
AIC	2.52		
BIC	2.53		

* Significant at 10% level; ** Significant at 5% level.

Alternative-specific constants (ASCs) were estimated with Trans Sarbagita (δ_{Ts}), as the basis alternative, among other alternatives Feeder (δ_{feeder}), Car (δ_{Car}), and Motorcycle (δ_{Mc}). We found consistent results with table 3 that the respondents have higher preferences to choose Trans Sarbagita as a mode of transportation.

Reducing travel cost, and walkable walking distance to the shelter have a positive influence for respondent using Trans Sarbagita, these results are similar with Surung and Arka (2014). Increasing park easiness and VTTS of the private vehicle will not affect respondent using Trans Sarbagita. In addition, increasing and park cost will shift respondent from use private vehicle (Car, and Motorcycle) to use Trans Sarbagita,

The result of this model can be used to measure the value of travel time savings (VTTS). VTTS) measures how much money (e.g. IDR) a person is willing to pay for a reduction of travel time unit (e.g. hour). To measure the VTTS for MNL model we just need to divide travel time parameter of each mode with travel cost parameter. The result of the VTTS can be seen in Table 5. It is interesting that the VTTS of car is lower than the VTTS of both public transport (Trans Sarbagita and feeder). The VTTS results obtained for these modeling approaches can be used for policy makers to do cost benefit analysis for the transportation related project.

Table 5. Value of Travel Time Savings

Alternatives	VTTS
Trans Sarbagita	14,040
Feeder	12,369
Car	6,843
Motorcycle	16,269

5. CONCLUSION

We found that travel cost, travel distance, and walking distance to the shelter are important factors to increase load factor of Trans Sarbagita. The travel cost could be reduced by implement integrated ticketing system, which means that people do not need to pay more money if they want to change to another mode of transportation. The travel distance of Trans Sarbagita network in four corridors are relatively long (more or less than 25 km) and limited connection (see, Governor of Bali regulation, 2010). Accelerating development of the rest of planned Trans Sarbagita corridors and feeder systems will reduce the travel distance. The number of shelters is also still limited. Therefore, people tend to walk more than walkable distance. It will be more convenient for the passenger if the number of shelters is increased.

Based on our model, we found that the respondents tend to use Trans Sarbagita comparing other modes of transport. However, the quality of services is very crucial to attract people to use public transportation, and the government should pay attention that respondent rate in high standard. We also suggested several policies, which could reduce the number of the private vehicle user, by increasing private vehicle travel cost. It could be by implementing road pricing (see, for example, Agarwal and Koo, 2015; Elliassom and Mattsson, 2006; Rotaris et. al, 2010; Santos, 2005) and increasing car parking cost (see, Litman, 2010). However, it should be proofed by future research.

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