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An Exploration of Factor Affecting Household's Travel Cost Budget Considering Household Life Stages Applying to Urban Bus Ridership

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Abstract – Urban bus reform so-called Trans Koetaradja (TK) is regarded as a potential urban transport policy aiming at alleviating autos traffic congestion and mitigating highly private mode dependency in Banda Aceh, Indonesia. The new bus system proposed by the Government has been operated since early 2018, and it remains free of fare services due to subsidy provide by the Government as the bus corridors have been expanded the budget getting escalating year by year. To reduce the burden of subsidies, the Government intends to drop monetary aid by applying full fare for the bus. However, declining the subsidy could affect bus ridership, especially low-income households whose captive riders may not afford the ticket. It hypothesizes that the travel cost budget (TCB) has significantly influenced the ability to pay for a particular household to afford the bus fare. The TCB for this study defines the maximum amount of money allocated by a specific family for their transportation within a month. Therefore, this study is aiming at exploring factors that effecting the households' transportation expenditures, taking into account household life stages (HLS) among TK' bus users. The use of revealed preference data obtained in 2019, the regression analysis of the ordinary least square (OLS) method, was used to calibrate and teste the exogenous variables across HLS. To simplify, the HLS in this study is segmented as early, middle, and established HLS. The distribution of TCB across HLS revealed that the share of transport expenditure on average to their monthly income had shared about 10-11 %. The finding from the OLS indicates that the variables of the female gender, monthly income, and the number of owned motorcycles have significant contributions to the TCB. The most significant finding is the impact of monthly income on the TCB across HLS. It exhibited early, and middle HLS has shown more spending share on income compared to the established HLS.

Keywords: Trans Koetaradja, fare, subsidy, travel cost budget, household life stages, OLS, Banda Aceh

Introduction

Urban bus reform so-called Trans Koetaradja (TK) is regarded as a potential urban transport policy aiming at alleviating autos traffic congestion and mitigating highly private mode dependency in Banda Aceh, Indonesia. Profound urbanization and motorization lead to uncontrolled personal mobility, such as preferring using a motorcycle or car for traveling. This private mode dependency has crucially affected the quality of life within the city centers as a consequence, severely autos traffic congestion (Saleh *et al.*, 2017). Several studies have alerted for this issue, for instance in Rumania (Tosa *et al.*, 2018), Ho Chi Minh City, Vietnam (Chu *et al.*, 2015; 2017) Jakarta (Sugiarto *et al.*, 2014; 2020), and Banda Aceh (Saleh *et al.*, 2017; Aggraini *et al.*, 2017). They notice that rising travel time, extra fuel consumption, and worsening of the city's environment are the main externalities manifested from urban traffic congestion.

To deal with auto traffic thoroughly, the demand-based oriented policy is considered as one promising transportation demand management—this TDM strategy aimed at lessening auto dependence while promoting public transportation usage. Research has approved that promoting public transport, particularly urban bus transit, could achieve the efficiency of road infrastructure used. The implementation of the urban bus policy can be viewed as the bus reform scheme (Saleh *et al.*, 2019; Sugiarto *et al.*, 2019) or bus rapid

transit policy (Nursyamsu., 2019; Joewono & Kubota., 2007). In the case of Banda Aceh city, The new bus system proposed by Government has been operated since early 2018, and it remains a free of fare services due to subsidy as the bus corridors have been expanded the subsidy getting escalating year by year. To reduce the burden of contributions, the Government intends to drop monetary aid by applying full fare for the bus.

It is argued that dropping the subsidy could affect bus ridership, especially low-income households whose captive riders may not be able to provide the bus's fare. It means that applying full fare strategy is challenging, especially to thoughtful barriers to pursuing full charge for the low-income bracket whose mainly captive riders. According to Maitra *et al*., (2014) captive and choice riders are considerably different among them, the captive is those who do not have a car, and choice riders are those who have a car. In this case, determining the affordable fare for low-income households is substantially necessary, and the subsidy may need to keep for them even if partially. It hypothesizes that the travel cost budget (TCB) has significantly influenced the ability to pay (ATP) for a particular household to afford the bus fare. The TCB in this study is defined as the maximum amount of money allocated by a specific family for their transportation for a month. Therefore, this study is aiming at exploring factors that effecting the households' transportation expenditures, taking into account household life stages (HLS) among TK' bus users. The HLS in this study is referred to as the definition of previous studies, for example, Zimmerman (1982), Sun (2009), and Sugiarto *et al.* (2014). The HLS was classified into (1) early HLS (single, married with no children, and family with pre-school children), (2) middle HLS (family with elementary school children), and (3) established HLS (family with college/university children and family with adult). This HLS segmentation is adopted from Sugiarto *et al*., (2014) with minor modification from their definition. Using revealed preference data obtained in 2019, the regression analysis of the ordinary least square (OLS) method was used to calibrate and teste the exogenous variables across HLS. The following section explains the materials and techniques used in this study. The results, discussions, and conclusions of the study are presented at the end of the paper.

Materials and Methods

Materials

This study focused on the Trans Koetaradja (TK) corridors/lines with three the targeted the busiest and dense of TK' lines are chosen for the study as reported by Aqlima (2019). They noted that the number of passengers about 2.4, 0.8, and 0.3 million passengers/year for lines 1, 2b, and 3, respectively. The selected target bus line for this study was line 1, line 2b, and line 3 which is connected the suburban area to the city center of Banda Aceh, as it is illustrated in Figure 1.

Table 1: Summary of the questionnaire survey.

Descriptions	Details
The time collected data	April 2019
The city of the collected data	Banda Aceh, Indonesia
Method of data collection	On-board survey with a paper-pencil direct interview and collected by the enumerator
Number of samples	450 samples
Socioeconomic attributes	Gender, age, education, occupation, household life stages, monthly income, monthly travel expenditure, housing owned status, household member, motorcycle ownership, car ownership.
Daily travel attributes	Mode use, public transportation use, frequency of public usage mode in daily life, willingness to use public transportation, travel destination, the reason to use modes of transportation, and purposes of traveling during received questionnaire survey.

The Reveal Preference (RP) survey method was implemented for constructing questionnaires. Target respondents were visitors to the city centers, business, and commercial areas or universities which are including commuters, shoppers, commercial visitors, and employees of business establishments. The questionnaire implemented from prior relevance studies (Sugiarto *et al*., 2014; Saleh *et al*., 2016). The target population used in this study was a total of number passengers within lines 1, 2b, and three which represents the TK' bus corridors with the highest number of passengers—using the Slovin formula (Ryan., 2013) with a margin of error 5% the total sample in this study is then determined. A total of 450 sample size is valid and used for the analysis. The on-board survey on the TK bus was performed in distributing questionnaires. The

targeted respondents were asked about their socioeconomic attributes such as age, gender, income, social status, monthly income, monthly travel cost budget, and vehicle ownership. Moreover, the daily travel attributes representative mode used, frequency of using the public mode, frequency of using the private mode, the purpose of the trip, and the reason to use TK on the day of receiving the questionnaire. The itemized questionnaire in the RP, including the dates of the surveys, target locations, distribution methods, number of samples, and features asked in the questionnaire, are described in Table 1.

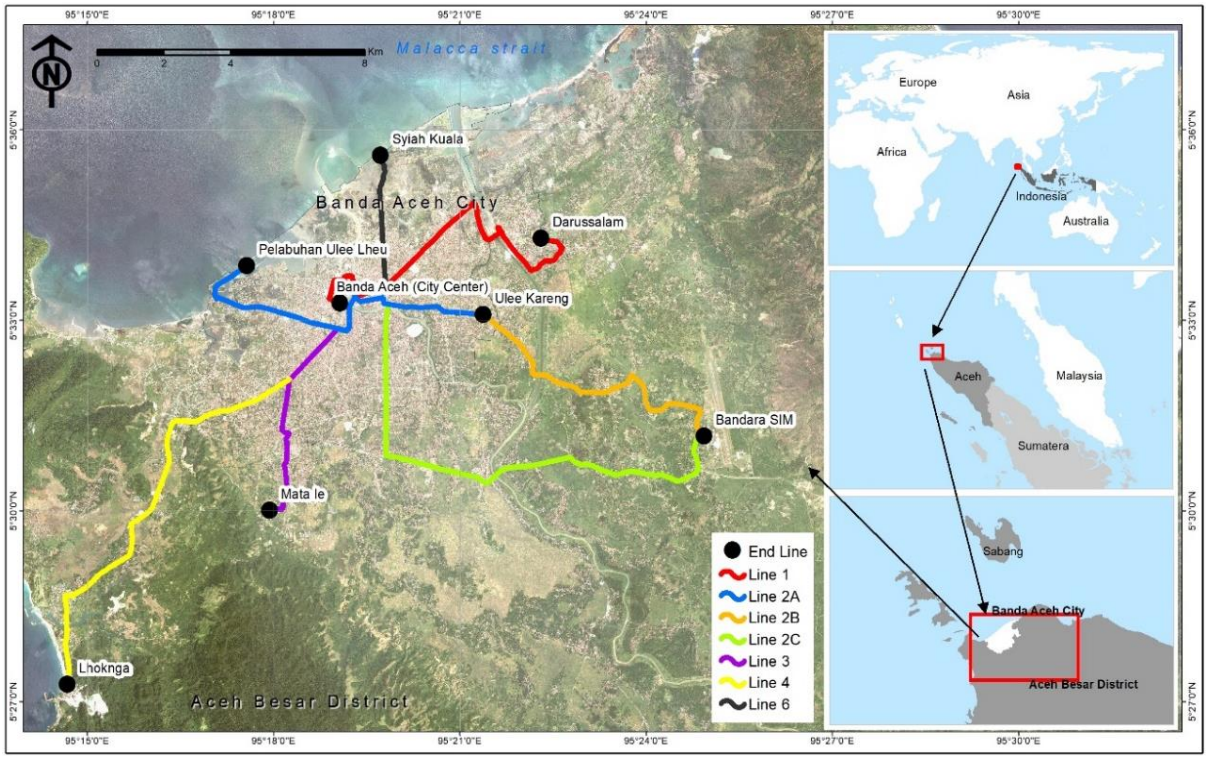

Figure 1. Banda Aceh City, and targeted TK bus line for the study (line 1, 2b and 3)

Methods

Travel Cost Budget (TCB) defines as the maximum observed amount of money that households willing to allocate for their transportation within a month, mostly the unit is a Rupiah/month (Sugiarto *et al.*, 2014; Putri *et al.*, 2020). The exogenous variable consists of socioeconomic, and daily travel attributes are regressed to the endogenous variable. The observed TCB is then treated as an exogenous variable. The regressor and their variable setting cosist of:

1) Female dummy 1, otherwise 0;
2) Income (million IDR/month);
3) Housing owned dummy, Otherwise 0;
4) Number of an owned car (unit);
5) Number of an owned motorcycle (unit);
6) Frequency of using TK bus (days/week);
7) Working dummy 1, otherwise 0;
8) Affordable fare dummy 1, otherwise 0.

In this study, the linear regression analysis is adopted to model the TCB. Previous studies have been demonstrated that the linear model is an appropriated and has better fitted to the normally distributed observed data of TCB, see for example studies by Sugiarto *et al.*, (2014), Saleh *et al.*, (2016a), and Putri *et al.*, (2020). The TCB modeling using the OLS has comprised numerous steps as well as data preparation, calibration, testing the Goodness of Fit (GoF) indices, establishing the final model, and revealing statistical inference of the final model, as this procedure illustrated in Figure 2. The TCB is formulated using multiple linear regression. Suppose that considering an experiment consisting of observing the exogenous variable,

that particular variable as such $\mathbf{Y} = \{Y_i\}$ takes for different values of independence variable **X**. If the experiment is a stochastic nature, it would observe different values of Y_i for the same amount of X_i (see for more detail in Ortuzar&Willumsen, 2014). Let's call for $f_i(Y|X)$ is the probability distribution of Y_i for a given value X_i. Thus, it could have a different function fi for each value of **X.**

By assuming the probability distributions $f_i(Y|X)$, it has the same variance σ^2 for all values of **X**. The means value of $\mu i = E(Yi)$ forms a straight line known as the *true regression line* and specified in equation (1). Where the population parameters α and β, defining the line, must be estimated from the observed data set.

$$E(Y_i) = \alpha + \beta X_i \quad (1)$$

The random variables **Y** are statistically independent. It is sometimes convenient to describe the deviation of Y_i from its expected value as the error term ε_i. Thus, equation (1) can be rewritten as:

$$Y_i = \alpha + \beta X_i + \varepsilon_i \quad (2)$$

For multiple linear forms can be written as:

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon_i \quad (3)$$

The parameters of α and β_1, β_1, and β_n can be calibrated using observed data set obtained from the survey. One standard method to calibrate the parameter is the ordinary least square (OLS) method. In this study, the calibration model was performed using STATA statistical software.

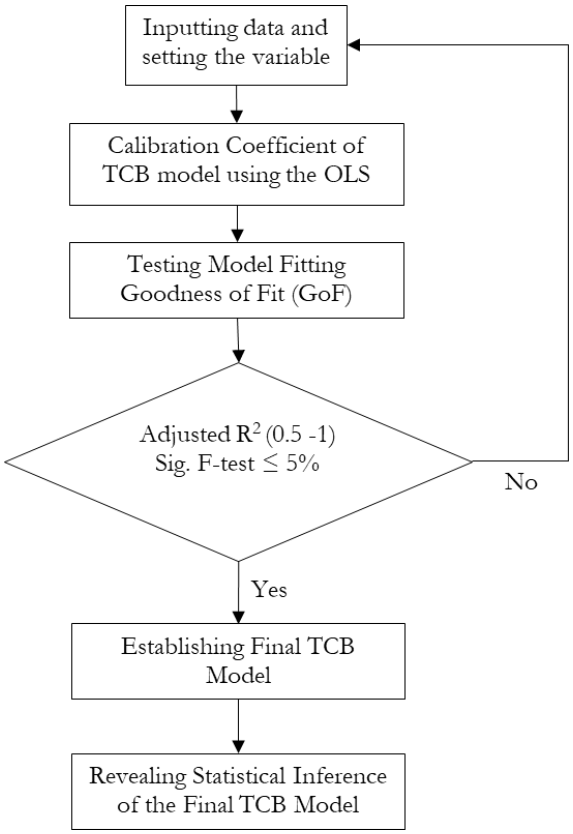

Figure 2. Procedures to model the TCBs

Several Goodness of Fit test (GoF) indices were calculated to clarify the fit of the TCB models. The GoF indices used, including the coefficient of determination (adjusted R^2). This coefficient of determination is defined as the ratio of explained to total variation, and it has to limit values of 1 (perfect explanation) and 0 (no explanation at all). Intermediate values may be interpreted as the percentage of the total variation explained by the regression (Ortuzar & Willumsen, 2014; Washington *et al.*, 2020). The model hypothesis testing F-test is used to test the hypothesis that involves a linear restriction between several estimators with the significant level at 5%. As for testing a hypothesis regarding a specific estimator (parameters coefficient), the t-test is applied with suggested significant error at 10% or lower.

Results

Socioeconomic attributes distributions

Table 2 labels the distribution of the socioeconomic attribute. As regards gender variables, it uncovers that the distribution is somewhat skewed on the female as much as 312 samples (69%) suggest to the female gender. This meaning that the females are more likely to use the bus in the dataset. Looking at the age attributes, adult people with age ranges at 30 to 49 years are predominant (55%) compared to young (10%) and the older one (35%). The variable of income, Table 2, further explores that the low-medium monthly income (less than 5 M.Rp) has steered the dataset, accounting for 411 samples (91%). Only a few the household has high a monthly income in our data set (9%).

Seeing the variable of education, most of the respondents have a final education (on the day of the distributed questionnaire) elementary school about 55% of the sample size and followed by a university's degree for 127 respondents (28%). As regards to social status attribute, it is surprising that the housewives are dominated the dataset as much as 211 samples (47%) compared to the employee, such as Government (12%) and private employees (21%). Lastly, looking at housing status and family size, most of the households have their own house (62%), with a total of 295 households (66%) has 3 to 5 family members.

Table 2. Distribution of socioeconomic attributes

Attributes Description	Detail of Attributes	samples (Share of Sample Size) (N=450)
Gender	Male	138 (31%)
	Female	312 (69%)
Age	17-29 years	44 (10%)
	30-39 years	123 (27%)
	40-49 years	124 (28%)
	50-59 years	95 (21%)
	60 years or more	64 (14%)
Monthly Income (million Rp/M.Rp)	Less than 1 M.Rp	41 (9%)
	M.Rp 1 – 2.9	139 (31%)
	M.Rp 3 – 4.9	231 (51%)
	M.Rp 5 – 6.9	34 (8%)
	More than M.Rp 7	5 (1%)
Education Level	Elementary School	249 (55%)
	College	74 (16%)
	University / Bachelor	127 (28%)
Social Status	Government Employee	52 (12%)
	Private Employee	94 (21%)
	Retired	27 (6%)
	Trader/enterprenuer	66 (15%)
	Housewife and others	211 (47%)
Housing Status	Owned house	280 (62%)
	Family-owned house	66 (15%)
	Renting house	104 (23%)
Family Size	Less than two members	122 (27%)
	3 -5 members	295 (66%)
	More than five members	33 (7%)

Daily mobility attributes distributions

Table 3 illustrates the distribution of dataset concerning daily mobility attributed to the respondents. The dataset collected revealed that up to 394 respondents (88%) and 208 samples (46%) of the households do not have a car and motorcycle, respectively. The likelihood is that most of the respondents in this study are the captive rider. That is a people or person who regularly commutes using public transport (i.e., bus, online PT) because they have no other choice. This statement can be proved by investigating the variable of the representative daily mode used by the households. It can be witnessed in Table 3 that about 341 of respondents (76%) choose the bus and online PT for their necessary daily travel. These findings are similarly consistent with the distribution of the frequency of using the TK bus and the attribute of the frequency of using a car or motorcycle for their regular travel.

Table 3 further exposes that the attribute of the frequency of using the TK bus most the respondents have used the TK bus for 341 samples (76%) they frequently used such a bus for at least three days per week. Additional investigation is revealed that as much as 337 respondents (75%) have not used the car or motorcycle for their commuting within a week. Again this finding is in line with the previous result with stated that most of the respondents are the captive rider. Lastly, investigating the variable of purposes traveling on the day of the distributed questionnaire, the dataset has shown up to 313 samples (70%) they travel for working and shopping. It is reasonable that 70% of the respondent were female gender. The variable of a driver's license has indicated that 399 of the respondents (89%) have no driver's license. The result is also consistent with the distribution of car or motorcycle owned by the households, as shown in Table 3.

Table 3. Daily mobility attributes distributions

Attributes Description	Detail of Attributes	Sample Size (Share of Sample Size) (N=450)
Cars owned within the household	None	394 (88%)
	1-2 cars	56 (12%)
	More than two cars	0
Motorcycle owned within the household	None	208 (46%)
	1-2 cars	231 (51%)
	More than two cars	11 (3%)
The representative daily mode used within the household	Motorcycle	66 (15%)
	Car	15 (3%)
	Bus & online Public Transport (PT)	341 (76%)
	Both private mode and PT	28 (1%)
Frequency of using TK bus for daily travel	None	82 (18%)
	1-2 days a week	27 (6%)
	3-4 days a week	129 (29%)
	Five days a week or more	212 (47%)
Frequency of using a car or motorcycle for daily travel	None	337 (75%)
	1-2 days a week	5 (1%)
	3-4 days a week	18 (4%)
	Five days a week or more	90 (20%)
Purposes of traveling	Work	151 (34%)
	Shopping	162 (36%)
	Pick up & drop to school	3 (1%)
	Social activity	47 (10%)
	Entertainment and others	87 (19%)
Driver's license	Has a driver's license	51 (11%)
	Has no driver's license	399 (89%)

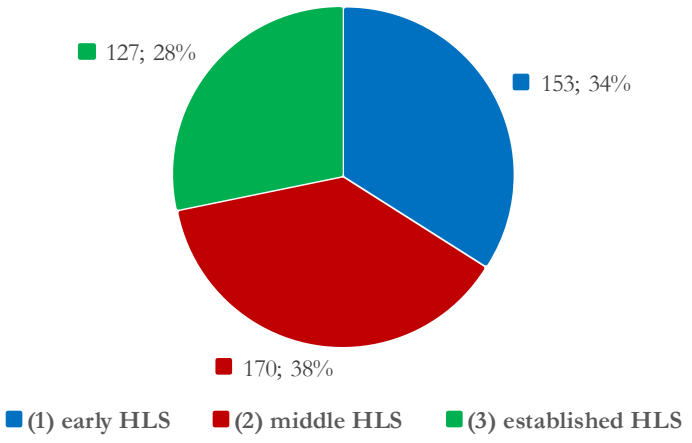

Figure 3. The distribution of the household life stages (HLS)

Travel cost budged (TCB), and household life staged (HLS) distributions

Figure 3 depicts the HLS distribution consists of (1) early HLS (single, married with no children, and family with pre-school children), (2) middle HLS (family with elementary school children), and (3) established HLS (family with college/university children and family with adult). The HLS distribution shown in Figure 3 is based on the aggregation data set according to each establishment of the household life stages in the data set. From Figure 3, it can be seen that family with elementary school, family with college/university children, and family with an adult has substantially dominated the dataset as much as 72%. Furthermore, the HLS distribution in datasets is distributed evenly throughout the HLS. The early HLS, including single, married with no children, and family with pre-school children, also have contributed nearly one-third of the samples. As the primary focus of this study is to explore the TCB based on the HLS, the segmentation of HLS is a prerequisite before the TCB analysis.

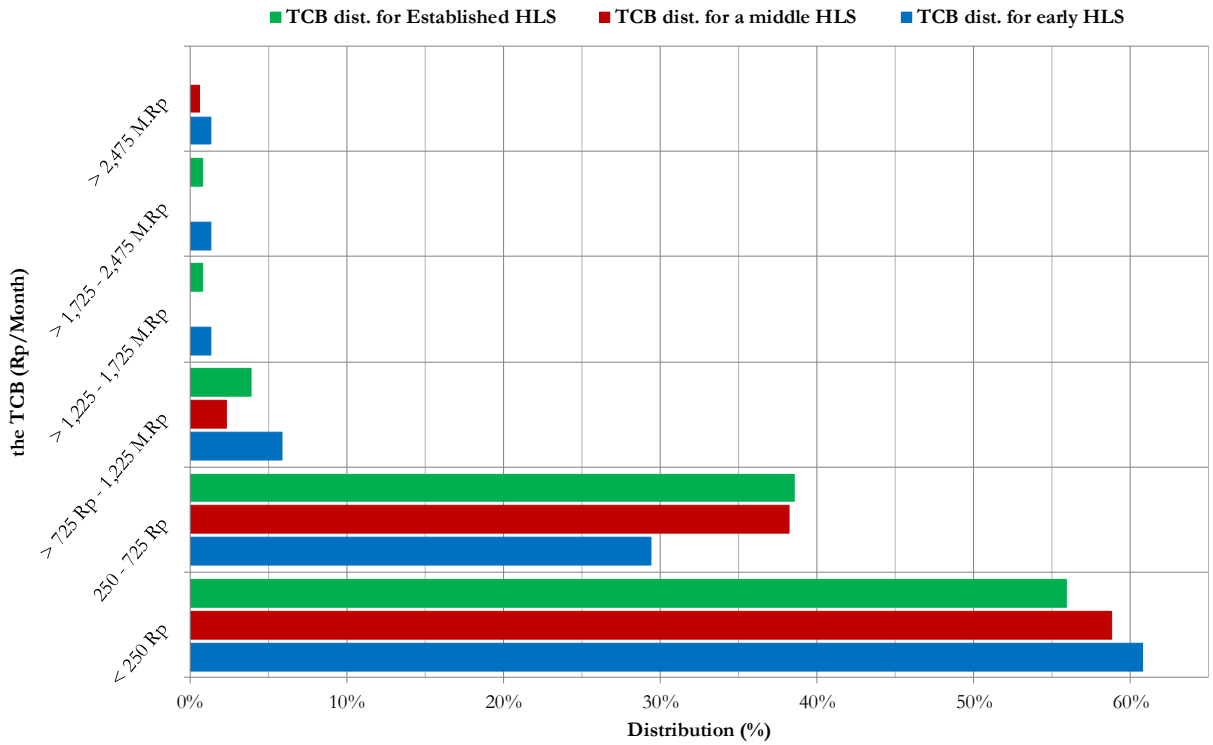

Figure 4. The distribution of the TCB across HLS

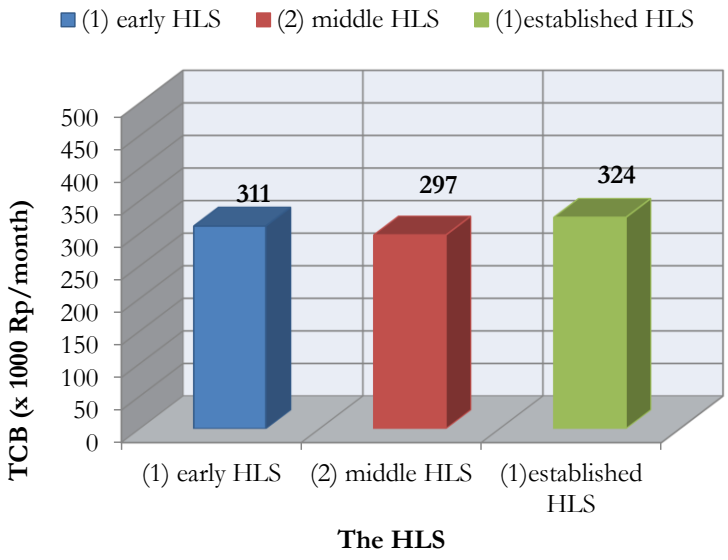

Figure 5. Average of the TCB across HLS

Figure 4 illustrates the distribution of TCB across HLS segmentation. According to Figure 3, all of the HLS groups have spent TCB less than Rp. 250 per month with a share of the proportion of about 55%, followed by expenditure on the money about Rp. 250-750 per month accounting share nearly 35% across the HLS. Furthermore, Figure 5 discloses that, on average, HLS has disbursed approximately Rp. 311,010, Rp. 297,240 and Rp. 324,000 per month for early, middle, and established HLS, respectively. This distribution concludes that the share of transport expenditure on average to their monthly income has shared about 10-11 %. It means that they were spending money on their transportation about 10 to 11% from monthly income. Paying 10-11% of income on the ride is quite reasonable compared with the previous study conducted in Jakarta by Sugiarto *et al.*, 2014. They revealed that people in Jakarta had allocated about 20% of the income for daily travel. This significant difference may partially due to the dominant respondents in the data set were low-medium income households (see distribution income in Table 2) who used the bus because they are a captive rider.

Table 4. Model for TCB across HLS segmentation.

Exogenous Variable	Model Coefficients			
	All Data	Early HLS	Middle HLS	Established HLS
Female dummy 1, otherwise 0	-0,112***	N/A	-0.092***	N/A
Income (million IDR/month)	0,078***	0.094***	0.042***	0.039***
Housing owned dummy, Otherwise 0	N/A	N/A	N/A	-0.128**
Number of an owned car (unit)	N/A	0.155***	N/A	N/A
Number of an owned motorcycle (unit)	0,142***	N/A	0.155**	0.170**
Frequency of using TK bus (days/week)	0,142***	N/A	0.155**	0.170**
Working dummy 1, otherwise 0	N/A	-0,037***	N/A	N/A
Affordable fare dummy 1, otherwise 0	-0,091***	N/A	N/A	N/A
Number of Samples (N)	450	153	170	127
Adj. R square	0,64	0,72	0,69	0,69
F test	201,443***	104.231***	92.515***	73.074***

Note: ***significant at 1%, **significant at 5% level, and *significant at 10% level.

Discussions

Table 4 shows the result of regression analysis calibrated using the OLS. As mentioned in section "methods" the endogenous variable in the regression is an observed monthly TCB that particular household within the HLS willing to allocate their money for transportation. The explanatory variables used and their setting can be seen in Table 4.

The goodness of fit model (GoF) model and statistical significance for the TCB of a low-income household can be seen in Table 4. The GoF shows us medium fit with adjusted R^2 0.60-0.70 and a significant F test at a 1% level of error across the models. It should be noted that we keep the variables with a statistically significant till 10% level of error because the calibrated model has only used to investigate factors that contribute to the TCB rather than for the prediction model. Moreover, the sign (+) represents explanatory variables that have a significant positive t-statistics. In Table 4, N/A represents the variable whose statistics are grossly insignificant (larger than 10% error).

As regards to Early HLS model, Table 4 reveals that the variables of the female gender, monthly income, number of owned motorcycle, and affordable fare have significant contributions to the TCB. The female gender dummy has a negative sign on the model, which means that the male gender has more allocated money to spending on travel compared to the female. By referring to the monthly income and the number of cars owned by the family, these variables have a significant positive correlation to the TCB. The likelihood is that an increase in income and vehicle ownership could lead to a rise in allocated money for transportation expenditure. These results are in line with a study conducted by Saleh *et al.* (2016) in Jakarta. They concluded that monthly household income and vehicle ownership are significantly correlated with total transportation expenditure, especially for early and middle HLS. Lastly, the negative sign of affordable fare could be

explained because, during this year, it is free of charge (subsidy by the Government). Thus, the fare could not have positively signed to the expenditure on money for travel across the HLS.

The middle and established HLS seems to have shown the same tendencies of the explanatory power of the TCB models, particularly investigating at the variable of income, owning a vehicle, and frequency in using the TK bus. Regarding the female dummy variable at the middle HLS model, the female gender dummy has a depressing mark on the model. The implication that the male gender has more allocated money to spending on travel compared to the female. In addition to this, examining income and owning vehicle variables, both variables have a favorable implication to the TCB across middle and established HLS. That is, the more income they are, the more money they spend on travel, the same pattern applies to own a vehicle variable. The last, the frequency of using the TK bus variable, has warned a positive correlation on the TCB for both middle and established HLS. It looks like the more they are using the TK bus, the more likely they will spend money on travel.

The result of this study has explored that it seems that people in Banda Aceh are more likely to spend a higher percentage of TCB in particular in this study dominated by low to medium-income households. The HLS in this study has demonstrated that significantly correlated with the TCB. The most significant finding contribution of monthly income to the TCB across HLS is that the early and middle HLS have shown more spending share on income compared to the established HLS. This finding is substantially the same as a condition in Jakarta that investigated by Sugiarto *et al*., 2014. Consequently, implementing full charge and reducing the subsidy may significantly affect both HLS. Therefore, understanding the income capacity and its share for transportation expenditure before the implementation of full fare/charge is a crucial issue in fare implementation. The authors expect that this study could be served as relevant knowledge that explains the effects and obstacles on planning affordable bus fare.

Conclusions

This work mainly aims to investigate and identify contributing factors to the amount of TCB considering the HLS. The distribution of TCB across HLS has revealed that, on average, HLS has disbursed approximately Rp. 311,010, Rp. 297,240 and Rp. 324,000 per month for early, middle, and established HLS, respectively. It means that they spent money on their transportation about 10 to 11% from monthly income. This result concluded that people in Banda Aceh (the TK bus users) are more likely to spend a higher percentage of TCB in particular in this study dominated by low to medium-income households.

The regression analysis performed in this work further shows that the variables of the female gender, monthly income, number of owned motorcycle, and affordable fare have significant contributions to the TCB on the early HLS. While the variable of income, owning a vehicle, and frequency in using the TK bus significantly correlation to the middle and established HLS. The regression model has also clarified that the TCB influenced considerably by the HLS. The most significant finding is the impact of monthly income on the TCB across HLS. It exhibited early, and middle HLS has shown more spending share on income compared to the established HLS. Thus, the implementation of the full charge and reducing the subsidy may significantly affect. In this case, understanding the income capacity and its share for transportation expenditure before the implementation of full fare/charge is a crucial issue in fare implementation. The authors expect that this study could be served as relevant knowledge that explains the effects and obstacles on planning affordable bus fare. Moreover, a better understanding of travel attribute characteristics is vital for successful transport-related policy implementation for a better society.

Acknowledgment

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