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Mode Choice Model of Intercity Traveling in the Provinces (AKDP)

(Case Study: AKDP Route Makassar-Parepare, South Sulawesi)

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Abstract: *Intercity transportation (AKDP) is transportation that connects the city with other cities both located within the administrative area of the province or between cities in the province, as well as those located in the other province. AKDP services, performed in a route network and infrastructure of the road as set out in a predetermined route permit. There are various types of transportation modes that serve the route Makassar-Parepare, namely Damri Bus , Mini Bus , BMA and transport MPU (Panther, Kijang, Avanza, etc.). These modes each have advantages and disadvantages, so a lot of alternatives to choice the mode that will be used in a traveler, by looking at all the attributes in the mode. The objectives of the study are to modelling mode choice model AKDP Makassar-Parepare and the probability that influence mode choice. The method of analysis used multinomial logit model with conditional logit form (clogit), using Stata software which is one of the statistical data analysis program. Prediction probability analysis results for the mode choice of Provincial Intercity traveling, with Multinomial Logit (Conditional Logit form), from maximum-likelihood postemated, based on factors that influence the mode choice AKDP was, DAMRI=31.552 %, Mini Bus=18.454 %, BMA=0.144 %, and MPU=49.850 %, respectively.*

Keywords: *Multinomial Logit Model, Clogit, AKDP and Mode Choice*

1. INTRODUCTION

Makassar is the capital of South Sulawesi province, and one of the major cities in Indonesia which continues to experience rapid growth from year to year and triggered by the increasing number of residents in the city of Makassar. Makassar position as the center of economic development and as a City Education Center for Eastern Indonesia, being a pull factor for urbanization processes that have an impact on the increase of population and of course impact the increased travel of goods and people, both between cities in the province (AKDP), and inter-city inter-province (AKAP).

Intercity transport is transportation that connects of the city to other cities both located within the administrative area of the city in a province or between provinces (AKDP), as well as those located in other provinces. AKDP services, performed in a route network and hosted by service characteristics, among others, the availability of the passenger terminal type B at least at the beginning of departure, transit, and destination terminals, as well as the infrastructure of the road as set out in a predetermined route permit. Makassar apart, Parepare city is one of the largest cities in South Sulawesi, and is one of the public purpose of public transport users AKDP. Distance between cities of Makassar and Parepare

±155 km and passes through several districts of the city to Parepare, such as Maros, Pangkep, and Barru.

Daya' regional terminal is the largest terminal in the city of Makassar and including A-type terminal, in operation since 2003, located in the Biringkanaya District or ±15 km from the center of Makassar, and within ± 300 meters from the Perintis-Kemerdekaan street. Inside the terminal is set circulation route public transportation in the city (Angkot), Intercity in the Province (AKDP) and Intercity Inter Province (AKAP). Based on data from the Regional Company (PD) as a manager, that Daya' regional terminal serving 20 route travel between cities, with details of 7 AKAP routes and 13 AKDP routes, including Makassar-Parepare route.

The problem that arises is the lack of proper functioning of the terminal's role as a place to pick and drop goods or passengers and the arrival and departure arrangements AU (public transport). Because of the level of service terminals that are not optimally utilized properly, provoke others took the opportunity to make the other-terminal (wild terminals) around Daya' regional-terminal. Impact, many were reluctant public transportation into the terminal to pick-up and drop-off passengers, finally AKDP-transport especially Public Passenger Cars (MPU) took charge outside the terminal which resulted AKDP-transport passenger chose to wait at the curb than must be entered into terminal.

While the number of operators or AKDP transport company, which makes the base and do the departure of each in the cities of Makassar as Damri-Bus vehicle located in Toddopuli street and road bases BMA-Bus in Gn.Bawakaraeng street. They pay a levy on vehicle terminal but not through the terminal, make a lot of people in Makassar AKDP transport users no longer have to enter the terminal to await transport departure.

In an intercity movement, modal choice factor plays a fairly important, someone who will move from one city to another would have to consider a lot of things: whether the movement is doing will use private vehicles or to use public transport, many alternative modes of transportation can be used [14].

The concept is based on the absence of movement of transport trip between the place of origin and destination. In a way, there is a movement journey that begins from home (home-based trip) and there are also trips the origin and the destination is not from home (non-home based-trip), for example, trips from the workplace to the marketplace, trips from the bus station to the campus, and so forth [17].

Modal choice is strongly influenced by the demand variable is related to socio-economic conditions of the traveler and supply variables associated with the level of service provided by the transport modes [15].

2. OBJECTIVES

Analysing the utility and probability of mode choice between DAMRI Bus, Mini Bus, BMA Bus and Public Passenger Car (MPU) with a multinomial logit model (clogit), it is important to know both utility and probability of traveler in AKDP Makassar-Parepare, to improvement the public transport mode and the Terminal used, especially for Intercity Travelling in the Provinces.

3. METHODS

3.1 Data Collection

In Makassar city area, only there are three path of departure to go out from the area with the road transportation, one of them is path which is becoming focus of this research. The second path is also passed by AKDP mode, but do not as much destination area of path in research focus. Third is Toll street, which not passed by AKDP public transport.

Implementation of the research conducted on public transport trip route Makassar-Parepare, where Makassar as the center of the movement. The data collection method that is placed in the location of passenger departure, Daya' regional terminal, wild terminals at some point of passenger departure along the Perintis-Kemerdekaan street up to the Makassar border, and on public transit base in Makassar. Data collected use a questionnaire form, as according to what is on characteristic of AKDP transportation, and characteristic of AKDP consumer. Based on survey results, the type of transport mode in the study area of Makassar - Parepare divided into 4 type vehicle, as show in Figure.1.

1. Damri Bus Vehicle, capacity 49 seats
2. Mini Bus Vehicle, capacity 28 seats
3. BMA Bus, capacity 9 seats
4. Public Passenger Car (MPU), namely Panther, Kijang, Avanza , etc, with capacity 8 seats.

Figure1. *Vehicle types of AKDP-transport, DAMRI, Mini Bus, BMA and MPU (top to bottom)*

3.2 Sampling

Population is all user transport modes Makassar-Parepare by counting the number of passengers per day each mode rider where the observations were made during once week. From observations obtained 1064 responder. The sample is part of the number and characteristics possessed by the population. Mathematically, the sample size of a small population of 10,000 or less can be formulated as follows:

$$n = \frac{N}{1 + Nd^2} \quad (1)$$

where: n (number of samples required), N (number of population), and d (deviation of the population or the degree of accuracy /degree of reability). The degree of accuracy is taken at 5 % (0,05), or 95 % of the total population respectively. Based on calculations using the above formula, the obtained results where as many as 624 samples for each type of vehicle that Damri Bus 174 passengers (28%), Mini Bus 163 passengers (26%), BMA-bus 104 passenger (17%), and the Public Passenger Cars (MPU) 183 passengers (29 %). More detail can be seen in the Table 1. as follow :

Table 1. *Number of Samples each AKDP mode type*

Type of Mode	Total Population	Total Sample (%)
DAMRI	308	28
Mini Bus	276	26
BMA	142	17
MPU	338	29
Total	1064	100

3.3 Data Analysis

The multinomial logit uses only variables that describe characteristics of the individuals and not of the alternatives. This limits the usefulness of the model for counterfactual predictions. Some examples: Travellers choose among a set of travel modes: “Damri”, “Mini Bus”, ”BMA”, “MPU”. There are variables that describe the traveller, such as her income. There is no information on the travel modes.

The conditional logit model requires variables that vary across alternatives and possibly across the individuals as well. Some examples: Travellers choose among a set of travel modes: "Damri", "Mini-Bus", "BMA", "MPU". There may be a variable "travel time" which is alternative specific and a variable “travel costs” that depends on the travel mode and individual income through opportunity costs. In the conditional logit model, individuals only care about utility differences across alternatives. Factors that influence the level of utility for all alternatives in the same way can therefore not explain the individual’s decision.

Mode choice model analysis, namely data analysis using Stata software which is one of the statistical data processing program is relatively complete. AKDP mode choice model analysis with multinomial logit model, for the calculation of the probability of alternative modes of transport to the type of modes: DAMRI Bus, Mini Bus, BMA Bus and MPU vehicle. AKDP Makassar-Pare-pare mode choice model, analyzed with Multinomial - logit models (Conditional) or so-called Conditional Logit (CL), CL models can be estimated by using Maximum Likelihood (ML) . It is a little different is that in the CL (-clogit- in Stata) should be used long-format of the data, which means the data will increase by the amount of data multiply by the number of AKDP modes. Variables to the model used in the mode choice

modeling AKDP (DAMRI, MiniBus, BMA, MPU), this is:

1. Respond variables, such as AKDP modes, where the modes are taken as the base category (base-outcome) called pilihan (MPU mode=mpu), and three dummy variables that are named apart from the modes set as a base-category, such as dmr, mib, and bma variables.
2. Explanatory variables, such as distance traveled (jap), travel time (wap), travel cost (bip), and income (phsl). And three variables: distance (jtmp), travel time (wtmp), and cost (bypkl) to AKDP-base-placed, respectively, combined to get the total distance, time (5)' cost. Other explanatory variabel was, g (jkel), age (umur), level of education (pddt), employment (pkrj), and purpose of travel (mkpr)

In conditional-logit, some dummy variables need to be generated (make interaction) if the data did not vary in any alternate mode choice.

The Log Likelihood function of Maximum-Likelihood estimation, is

$$\log \mathcal{L} = \sum_{n=1}^{N} \sum_{j=1}^{J} d_{nj} \log(P_{nj}), \tag{2}$$

where *dnj* = 1 if individual *n* chooses alternative *j* and *dnj* = 0 otherwise. The maximum likelihood estimator β is consistent, asymptotically, efficient and normally distributed. All that matters is utility of one choice relative to utility of another choice, i.e. relative utility. To estimate the model, we need to choose a basecategory choice, and compare results to that category. Suppose choice 4 is a basecategory from four mode to choice. Then:

$$\Pr[Y_i = j] = \frac{\exp(\beta_j X_i)}{1 + \sum_{k=1}^{m-1} \exp(\beta_k X_i)}, \quad j = 1, \ldots, m-1 \tag{3}$$

For basecategory:

$$\Pr[Y_i = j | Y_i = j \text{ or } 4] = \frac{\exp(\beta_j X_i)}{1 + \exp(\beta_j X_i)} \tag{4}$$

Test of entire model is used to test multiple hypotheses simultaneously. This test statistic can then be used for any case when one or more restrictions are imposed on a model to obtain another model. If all the restrictions that distinguish between the restricted and unrestricted models are valid, one would expect the difference in log-likelihood values (at convergence) of the restricted and unrestricted models to be small. If some or all the restrictions are invalid, the difference in log-likelihood values of the restricted and unrestricted models will be "sufficiently" large to reject the hypotheses.

This underlying logic is the basis for the likelihood ratio test [8]. The test statistic is:

$$LR\,\chi^2 = -2\,(LL_R - LL_U) \tag{5}$$

where LR = likelihood ratio

LL_R = log-likelihood restricted model

LL_U = log-likelihood unrestricted model

4. Results and Discussions

4.1. Model Estimation

Maximum Likelihood estimation results, for the conditioned logit models (-clogit-), are presented in the Table 2, as follow:

Generally, utility model of Table 2, are:

$$U_{ij} = \alpha + \beta_i X_{ij} \tag{6}$$

where i = 1 ··· Total Observation (2496)
j = 1 ··· Total Mode (J=4 | 0 to 3)

Interpretation of the model according to the coefficients of model, can be said that users AKDP Makassar-Pare-Pare, tend to prefer the MPU mode, compared to the three other modes (DAMRI, Mini Bus, and BMA), are more likely to choose the Mini-Bus than DAMRI, and more likely to choose DAMRI than BMA.

Based on the odds-ratio, the interpretation of the utility model is obtained for each dummy variable influence of modes, and the explanatory variables in the form; income (phsl), gender (jkel), age (umur), level of education (pddt), employment (pkrj), trip purpose (mkpr), the reason for using the mode (alsn), and travel frequency (frek).

The odds ratios for the alternative-specific constants dmr, mib, and bma, indicate the relative likelihood of choosing these options versus travelling by mpu (the base category), assuming that distance (jtot), time (wtot), and cost (btot) variables are the same for all options.

Table 2 . *Results of ML estimation, postemation and Test of Model*

Utilities Model			Base category (MPU)			Predicted Probability Model (percent)
			Coef.	Odds Ratio	Variables Code	
dmr (α_0)			–5,06159	0,0063		31,552
mib (α_1)			–3,30491	0,0367		18,454
bma (α_2)			–9,98370	0,0000		0,144
mpu (α_3)						49,850
dmrXjkel		(β_0)	0,39095	1,4784	X1	
mibXjkel		(β_1)	0,43588	1,5463	X1	
bmaXjkel		(β_2)	0,41446	1,5136	X1	
dmrXumur		(β_0)	0,50696	1,6602	X2	
mibXumur		(β_1)	0,41829	1,5194	X2	
bmaXumur		(β_2)	–0,07185	0,9307	X2	
dmrXpddt		(β_0)	0,49619	1,6425	X3	
mibXpddt		(β_1)	0,30856	1,3615	X3	
bmaXpddt		(β_2)	0,36348	1,4383	X3	
dmrXpkrj		(β_0)	0,01487	1,0150	X4	
mibXpkrj		(β_1)	–0,04706	0,9540	X4	
bmaXpkrj		(β_2)	0,05679	1,0584	X4	
dmrXmkpr		(β_0)	–0,01345	0,9866	X5	
mibXmkpr		(β_1)	0,11914	1,1265	X5	
bmaXmkpr		(β_2)	0,17376	1,1898	X5	
dmrXalsn		(β_0)	0,33360	1,3960	X6	
mibXalsn		(β_1)	–0,01867	0,9815	X6	
bmaXalsn		(β_2)	0,30390	1,3551	X6	
dmrXfrek		(β_0)	0,10957	1,1158	X7	
mibXfrek		(β_1)	0,12196	1,1297	X7	
bmaXfrek		(β_2)	0,13191	1,1410	X7	
dmrXphsl		(β_0)	–0,03547	0,9652	X8	
mibXphsl		(β_1)	–0,04864	0,9525	X8	
bmaXphsl		(β_2)	0,01646	1,0166	X8	
jtot	(β_{0123})		–0,30836	0,7347	X9	
wtot	(β_{0123})		0,00923	1,0093	X10	
btot	(β_{0123})		0,13220	1,1413	X11	
					Total	100
$LR\ \chi^2$					327,02	
prob > χ^2					0,0000	
LL_R					–865,04768	
LL_U					–701,53627	
pseudo-ρ^2					0,1890	

E.g.: If distance, time, and cost were equal, individuals would be (1–0.0063=0.9937) times more likely to travel by MPU than by DAMRI, (1–0.0367=0.9633) times more likely to travel by MPU than by MiniBus, and they would be 1 times (100%) more likely to travel by MPU than by BMA.

Explanatory variables jtot, wtot, and btot, represent the variable from other variable quantifying result, that is jtot=jrk+jtmp, wtot=wap+wtmp, and btot=bip+bypkl respectively. Explanatory variable with 'X' character represent the variabel owning same value for the mode alternative, so that conducted by a interaction, that is by multiplying the variable by dummy moda alternative, such as dmrXjkel=dmr*jkel, that is the same away for other variables with 'X' character.

Utility models from mode choice AKDP Makassar-Parepare (basecategory MPU), can be generated from Table 2. By example for DAMRI AKDP-mode, the utility model, can be write, as follow:

$$U_{i0|dmr} = -5{,}06159_{(0)} + 0{,}39095\ X_{i1(0)} + 0{,}50696\ X_{i2(0)} + 0{,}49619\ X_{i3(0)} + 0{,}01487 X_{i4(0)} - 0{,}01345\ X_{i5(0)} + 0{,}33360\ X_{i6(0)} + 0{,}10597\ X_{i7(0)} - 0{,}03547\ X_{i8(0)} - 0{,}30836\ X_{i9(0)} + 0{,}00923\ X_{i10(0)} + 0{,}13220\ X_{i11(0)}$$

In the same way can be written for Mini-Bus, BMA, and MPU. For MPU-mode because the mode as base-category thereis no explanatory variabel, except X9, X10, and X11 only.

4.2. Predicted Probability

The results of predicted probability for entire model with 2496 observation, with the maximum-likelihood (conditional-logit) postemated, gives the probability for DAMRI, Mini Bus, BMA, and MPU, respectively. Show in Figure.2 below.

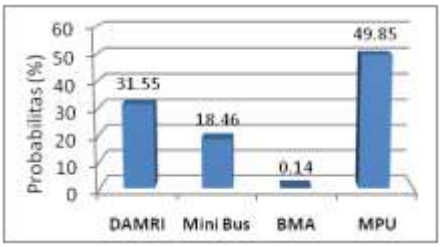

Figure 2. *Predicted probability for entire model*

Individual predicted probability also obtained from clogit postemation, (by example predicted probability for one responder), summary in the Table 3 below.

Table 3. *Example of Individual Predicted Probability*

id	altmo	pilihan	phsl	jtot	wtot	btot	pAKDP
1	0	1	14	160.1	317	47	0,1066839
1	1	0	14	163.3	336	50	0,1001016
1	2	0	14	160.1	240	92	0,2617961
1	3	0	14	164.9	288	52	0,5314184

Result of individual probabilities (pAKDP) obtained from utility function which mode choice apropriate, with relevant data input from observation data to utility model equations. Then calculate the utility function by using equations (3) and (4) to determine individual predicted probability.

5. Conclusion

The probability of mode-choice of intercity traveling in the Provinces (AKDP) with Multinomial Logit (clogit), based on factors that influence the AKDP mode choice was: DAMRI=31.552%, Mini Bus=18.454%, BMA = 0.144%, and MPU = 49.850%. respectively. Utility model presented that total of distance of intercity travelling route Makassar-Parepare, not influence in chosening mode, and total of cost more influence than total travel time.

The BMA bus generally choose by executive or by those who high income, with the tariff BMA which mean twice compared to other tariff AKDP mode, this make the BMA non favorite choice for the public in chosening AKDP mode. The three explanatory variables above (distance, travel time, and travel cost), which can be made cosideration by policy maker, in innovating regulation of AKDP and Terminal which not yet functioned properly.

In clogit needed correctness in dissociating variables in result of estimated, to form the utility models from each mode, because given estimation result, one for all mode.

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