LPEM-FEBUI Working Paper - 066
November 2021

ISSN 2356-4008

TRAVEL DEMAND OF DENPASAR GREATER AREA

Dhaniel Ilyas

LPEM-FEB UI Working Paper 066

Chief Editor : Riatu M. Qibthiyyah
Editors : Kiki Verico
Setting : Rini Budiastuti

Institute for Economic and Social Research
Faculty of Economics and Business
Universitas Indonesia (LPEM-FEB UI)

Salemba Raya 4, Salemba UI Campus Jakarta, Indonesia 10430
Phone : +62-21-3143177
Fax : +62-21-31934310
Email : lpem@lpem-feui.org
Web : www.lpem.org

LPEM-FEB UI Working Paper 066, November 2021
ISSN 2356-4008

Travel Demand of Denpasar Greater Area

Dhaniel Ilyas[1,★]

Executive Summary
Using micro commuting data in 2015, I estimate travel demand of Denpasar greater area. Motorcycle and car are still more preferred greatly compare to public transport. Faster travel time are the most important factor that drive the use of motorcycle and car in Denpasar greater area. Younger people seems to use the public transport more, including the *Trans Sarbagita* BRT. An incentive in pricing for older group of people and improving the bus scheduling might help increase the use of public transport.

JEL Classification: R22; R41

Keywords
Denpasar — Indonesia — travel demand — transportation

[1] *Institute for Economic and Social Research, Faculty of Economics and Business, Universitas Indonesia (LPEM FEB UI)*
★**Corresponding address**: Institute for Economic and Social Research (LPEM), Universitas Indonesia Building. Campus UI Salemba Raya St., No. 4, Jakarta, 10430, Indonesia. Email: dhaniel@ui.ac.id.

1. Introduction

There is an abundance of travel demand studies using aggregated and disaggregated data. Aggregated data measures travel attributes over a set of individual entities (e.g. person, firms, or households). For example, a model might use the number of round trips between districts within a city by travel purpose and mode to estimate the travel demand structure. If we have access to a micro data, we can build a disaggregate or behavioral travel demand modelling. This kind of model have an advantage in aligning our explanation with standard demand of theory in microeconomics. For a thorough explanation of its modelling ideas, we can refer to Small et al. (2007).

Indonesia bureau statistics (BPS) in the past does not have a particular micro survey data related to commuting behavior of a certain city area. Arifin & Ananta (2017) mention that since 2011, National Labor Survey (SAKERNAS) recorded non-permanent (worker) population mobility focusing also on commuters behavior. This information along with individual characteristics information might also explain to some extents travel or mobility demand among cities or districts within a city. Although this might be interesting to look at, it lacks a more detailed information usually available in travel demand study (e.g. transport mode and purpose, travel time and cost, etc.)

BPS conducted its first commuting survey in 2014 of Jakarta Greater Area and in 2015 of Medan and Denpasar Greater Area. The survey's city choices are reasonable for Jakarta and Medan since they are the first and third biggest metropolitan city in Indonesia but not so much on Denpasar. It might be because Denpasar is located in the island of Bali, one of Indonesia most visited tourist locations. In term of city size, Denpasar greater area is relatively small with 2.39 million inhabitants in 2016 compare with 31.6 million inhabitants of Jakarta Greater Area in 2015 and 4.6 million inhabitants of Medan Greater Area in 2015. Another reason might be because of the operation of Bus Rapid Transit (BRT) system in all three cities. Whatever the reasons are, we have available data for those three cities. A new commuting surveys are available in 2019 for Jakarta and Medan Greater Area but no follow-up survey for Denpasar Greater Area. It might be interesting to explore the travel demand of Denpasar greater area due to its city size and tourism-city characteristic. This paper attempt to present travel demand study of Denpasar greater area using (limited) micro data of commuting survey.

2. Literature review

Disaggregate travel demand models in the form of discrete-choice model studies are in abundant. Refer to Small & Winston (1998) and McCarthy (2001) for a thorough review. Train (1978,1980) use survey data collected in San Fransisco to analyze automobile ownership and commuting mode travel demand pre- and post- implementation of the Bay Area Rapid Transit (BART) system. McFadden et al. (1977) use simple modeling of mode choices explained by three independent variables and three alternative specific constants from a sample of 771 commuters to Oakland or San Fransisco before the BART system is open to public. These kind of models are still quite popular until today and often also used in other engineering studies. Some of them also sometimes have been linked into a large simultaneous system to answer certain research questions.

Surprisingly, there are no Sabargita travel demand studies attempted using 2015 commuting data of Denpasar greater area in the literature. Many studies prefer to use primary data to estimate travel demand in certain locations of Bali province. Widiarta (2010) analyzes mode of transport choice for work trips using primary data surveyed in Dalung village and found that lowering the price of public transport will decrease the use of private vehicles. Some authors interested in knowing the mode choices used by international and domestic tourists since Bali is a famous tourist destination and rely heavily in tourism economy. Dewi & Dewi (2017) study transport mode choice of international tourists coming to Kuta Beach of Denpasar using primary data and found that their choices are mainly influence by comfortability, transport cost, alternative route availability and parking supply at place of destination. Hermawati et al. (2017) also use primary data to analyze the attribute mode of rental

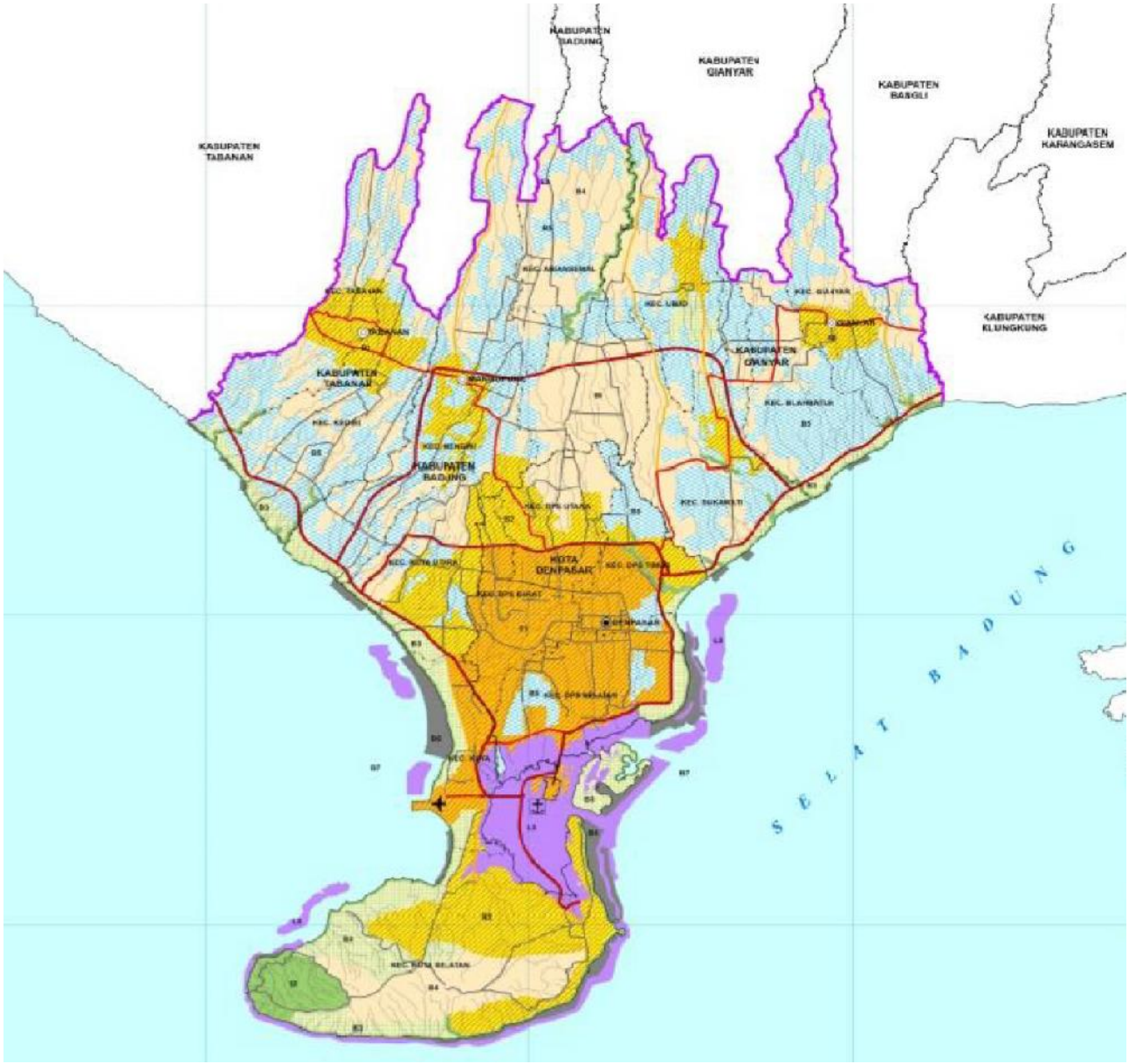

Figure 1. Denpasar Greater Area

vehicle used by international tourists in Bali. They conclude that tourist are more inclined to minimize their cost of trip compare to travel time in using rental car services. In contrast, Wiradnyana et al. (2021) study the travel behavior of domestic tourist in Denpasar Greater Area. They conducted survey to 300 individuals across several famous tourist attraction and found that trip frequency, household income and travel companions influences greatly their choice of transport mode. Other authors interested in the effectiveness of public transport infrastructure in Denpasar Greater Area. Wulandari & Sudiana (2018) assess Denpasar Greater Area's BRT (Bus Rapid Transit) service and found that it is satisfactory in term of accessibility, capacity and ticket price but not sufficient in term of trip frequency and bus scheduling. Sukadana et al. (2014) use multinomial logit model estimation to infer trip pattern of students and employee of Udayana University in Denpasar. They found that most of the travelers still prefer to use their own motor-vehicles, especially motorcycle. According to them, BRT of Denpasar Greater Area on average tend to fail in attracting passengers that use private vehicles. Faster travel time in using private vehicle is the main reason of the low substitution to public transport. Both studies again use primary survey data.

3. Data and Descriptive Analysis

Most travel demand study in Denpasar Greater Area use primary survey data. In contrast, this study attempts to explore and use the secondary data collected by BPS in 2015. There are 10600 individuals in 2760 households that are surveyed. Unfortunately, there are only 838 individuals answer their trip information in details. Around 92 percent of the sample record missing information or not answered. Although it is most likely that a portion of the sample will be individuals that rarely made a work or school-related trip (such as kids under 5 years of age, pregnant woman, old-unproductive individuals, etc.), the number of missing information is considerably large. This is a concern that need to be improved by BPS in the future to support better research and analyses. This study will explore and optimize the available

Table 1. Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Mode of choice (1=motorcycle, 2=car, 3=bus)	1.088	0.310	1	3
Sex (1=male, 0=female)	0.684	0.465	0	1
Age (in years)	35.11	10.81	16	67
Monthly income (in Rupiah)	3162479	2550971	400000	30000000
Formal education duration (in years)	14.87	3.105	0	22
Basic education (1=finished bas. education, 0=others)	0.096	0.295	0	1
Intermediate education (1=finished int. education, 0=others)	0.577	0.494	0	1
Advanced education (1=finished adv. education, 0=others)	0.310	0.463	0	1
Travel time (in minutes)	42.88	26.25	4.187	211.5
Travel cost (in Rupiah)	18917.75	19527.01	906.667	174091.2
Number of observation (**N**)		645		

information to estimate travel demand of Denpasar Greater Area. From the descriptive statistics, the standard deviation still show quite significant variation in the data. This will support to some degree, the validity of our estimation.

After cleaning the data, there are 645 individuals that are available for analysis (see Table 1).

Sex and age variables are quite self-explanatory. I create two-type of variables regarding individual education level. The first one is by translating their formal education length (in years) from their education attainment information assuming that they go to kindergarten. The second one is by grouping the education level group into individuals with no-education, basic education (up until junior high school), intermediate education (high school up until 1-2 years diploma school), and advanced education (three-years diploma school up until PhD school level). I create dummy variable for basic, intermediate and advanced education with no-education individuals as the reference group.

There are three type of transport mode that is chosen by the traveler: motorcycle, car and bus. Motorcycle and car are considered to be private transport while bus is one of the public transports used in Denpasar greater area. I can safely assume that the choice between the three modes is fairly *independent* to ensure the validity of our econometrics specification. From the survey, I construct trip characteristics of each individual by using the information of their commuting distance and the average cost of each respective mode. Al-Salih & Esztergár-Kiss (2021) also use average cost of travel time and cost in their study. In this way, I can have information of travel time and cost that are choice specific. Monthly income, travel time and cost usually have skewed distribution. A specification using logarithm transformation might be desirable.

4. Econometric Specifications

The theoretical foundation of the estimation is the standard additive random-utility model of McFadden (1974). A traveler i have to choose and decide among j mode choice alternatives that maximizes utility as given by

$$U_{ij} = V(Z_{ij}, S_j; \beta) + \varepsilon_{ij} \tag{1}$$

where $V(\cdot)$ is called the systematic utility, in which Z_{ij} represent a vector of attributes related to the mode choice alternatives chosen by the traveler, S_j is a vector of characteristics of each individual travelers and β is a vector of unknown parameters that will be estimated later on. $V(Z_{ij}, S_j)$ is the utility that usually measurable and observed, such as age, income, travel time, travel cost, etc. The component of ε_{ij} is an unobserved part of utility that captures idiosyncratic preferences. It can be said also that ε_{ij} is the unpredicted part of the utility, and it is assumed to be independent from the unknown part of other mode choice alternative and sometimes specified to follow the Gumbel distribution. The construction process of such model is basically a trade-off of variables in the utility function of different modes.

The constructed data have both individual and choice-specific data. Individual-specific data are individual-characteristic variables such as age, sex, income, and so on. Choice-specific variable are trip characteristics such as travel time and cost. Since some of the regressors are alternative specific, the conditional logit model is used. Following Cameron & Trivedi (2010) notation, the conditional logit model can be written as follows

$$p_{ij} = \frac{exp(x'_{ij}\beta + z'_i\gamma_j)}{\sum_{l=1}^{m} exp(x'_{il}\beta + z'_i\gamma_l)}, \quad j = 1, \cdots, m \tag{2}$$

where x_{ij} are mode choice alternative-specific regressors and z_i are case-specific or individual-specific regressors. In the model the alternative-specific regressors are travel time and cost while the individual-specific regressors are sex, age, income and a set of education variables. As a requirement to be able to identify the model, one of the γ_j need to be set as zero. From the data, we have three mode of choice (motorcycle, car and bus). I set the mode of bus as the reference choice (this is the same as setting $\gamma_{bus} = 0$). Some papers sometimes called the model a *mixed logit model*. The term of *'conditional'* in the preferred name refer to a more restrictive model compare to the one that has only alternative-specific or choice-specific regressors.

5. Empirical Results

The estimation have two specifications. The first one use length of formal education (in years) while the second one use dummy variable of intermediate and advanced education. Basic education variable is omitted to avoid multicollinearity problem and hence will be captured by the constant. Although most of the variable is not significant, the sign are conforming to expectation. Travel time and cost parameters have negative values, indicating that as travel time and cost increases, the demand of that mode decreases while demand for all other modes increases.

Table 2. Conditional Logit Estimation Results

	Model (1)	Model (2)
Mode alternative specific constant		
Travel time	-0.0391***	-0.0387***
	(-4.34)	(-4.31)
Travel cost	-0.000021	-0.000019
	(-1.71)	(-1.53)
Motorcycle		
Sex	16.09	15.70
	(0.02)	(0.02)
Age	-0.094*	-0.089
	(-1.99)	(-1.79)
Monthly income	3.27e-08	-2.00e-08
	(0.12)	(-0.08)
Education	-0.130	
	(-0.81)	
Intermediate education dummy		0.247
		(0.14)
Advanced education dummy		-0.623
		(-0.38)
Constant	9.417**	7.590**
	(3.02)	(2.87)
Car		
Sex	16.21	15.92
	(0.02)	(0.02)
Age	-0.024*	-0.021
	(-0.48)	(-0.41)
Monthly income	3.44e-07	2.89e-07
	(1.27)	(1.18)
Education	-0.051	
	(-0.30)	
Intermediate education dummy		-0.104
		(-0.06)
Advanced education dummy		-0.155
		(-0.09)
Constant	1.960	1.321
	(0.60)	(0.47)
Observations	645	645

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

I choose the specifications without using logarithm transformation of variable travel time, income and travel cost since the estimation result is more suitable and make more sense. The result also show that the decrease of travel cost is relatively more inelastic compare to travel time. Therefore people in Denpasar greater area are more sensitive to change in travel time compare to travel cost. The value of travel time parameter is also highly significant, implying the time they spend in making the trip is an important factor in their mode of transport decision making.

The only significant parameter in each case-specific alternatives (when someone choose to ride motorcycle or car) is the age variable. It seems that as people get older, the probability for them to use the bus compare to motorcycle or car is lower. Since the bus choice in our model include the *trans sarbagita* BRT, it can be inferred that younger individuals relatively use it more often compare to older people. These knowledge of demand characteristics might be useful for local government of Denpasar greater area to improve the use of public transport. Overall, the empirical result show that motorcycle and car are still the dominant mode of choices since it has relatively faster travel time compare to using bus.

6. Conclusion

Local government of Denpasar Greater Area (Denpasar, badung, Gianyar and Tabanan) have always been involved in establishing coordinated transport infrastructure investment in cooperation with Ministry of Public Works and Public Housing and Ministry of Transportation. In 2011, *trans sarbagita* BRT is launched to reduce congestion. During the first five years of its operation, the demand for the BRT are always considerable low. Some routes are even closed since it cannot generated enough revenue for the operator. This study reflect the aforementioned condition showing that the demand for motorcycle and car in Denpasar greater area in 2015 still far outstripped the demand for public transport.

The most important aspects for these demand pattern is travel time. People consider the choice of using car and motorcycle are more superior since it can get them faster to their destination. Although local government often mention that the BRT construction is meant to combat congestion, it seems that the congestion problem in Denpasar greater area not at a level that can create enough demand such as in Jakarta. Also, it seems that younger people use the *trans sarbagita* more often compare to older people. This is in line with the pricing scheme of BRT operator that charge higher price to adults compare to teen/young passangers. For comparison, Jakarta greater area have a flat price for all passanger and even subsidized their BRT services for older seniors (by giving free pass to use the BRT for free).

This hindrance in making people substitute from using private vehicles to public transport has been made even worse by regular incidence of *trans sarbagita* late bus schedule. Local government of Denpasar greater area need to take into account all of these characteristics in the future that has been shown from the result of the travel demand estimation in this study. Careless planning of local government in developing a BRT transport system in a city would end up like the case of Denpasar greater area. A thorough transport demand study using proper executed commuting survey need to be carried out before deciding on building a public transport system. Not all city have enough demand capacity to at least cover the operational cost of certain public transport. Also, the readiness for high quality services of the public transport needs to be ensured when the project are finally greenlit (in order to ensure that the public transport travel time can compete with the use of private vehicles). Therefore in the case of Denpasar greater area, policy such as widening the road might be more effective compare building a BRT transport system.

7. Study Limitation

The most obvious limitation of our study is the quality of the data. I only manage to use a small portion of individual trip information from a large pool of possible response from the respondent. Hopefully, future commuting survey of BPS can improve the survey response significantly in order to have more sample and variation in the data. Also, this study can be seen as a preliminary exploration of travel

demand pattern of Denpasar greater area using the available secondary data from BPS with hope of further improvement from possible newer data in the future. Furthermore, travel demand study utilizing BPS commuting data of other region can also be performed. Hopefully the data of these regions are richer and can be used to answer a more detail question concerning travel demand characteristics. A study that can also answer the demand characteristic of online taxi transport services (such as Gojek, Gocar, GrabBike, GrabCar, etc.) will be an interesting topic to be pursued. Unfortunately, commuting data of Denpasar greater area does not have enough information to carry out such study.

References

Al-Salih, W. Q., & Esztergár-Kiss, D. (2021). Linking mode choice with travel behavior by using logit model based on utility function. *Sustainability, 13*(8), 4332. (cit. on p. 5). doi: https://doi.org/10.3390/su13084332.

Arifin, E., & Ananta, A. (2017, October). Toward rising non-permanent population mobility: A case of commuters in Indonesia. In *2017 International Population Conference*. International Union for the Scientific Study of Population. (cit. on p. 2). https://iussp.confex.com/iussp/ipc2017/mediafile/Presentation/Paper3388/IUSSP%202017%20paper%20sent.pdf.

Cameron, A. C., & Trivedi, P. K. (2010). *Microeconometrics using Stata* (Vol. 2). College Station, TX: Stata Press. (cit. on p. 6).

Dewi, N. G. A. S., & Dewi, L. G. L. K. Motivasi pemilihan moda transportasi wisatawan mancanegara ke daya tarik wisata Pantai Kuta Bali. *Jurnal Kepariwisataan dan Hospitalitas, 1*(2), 281-288. (cit. on p. 3).

Hermawati, P., Adisasmita, S. A., Ramli, M. I., & Hamid, S. (2017). Analisis atribut moda perjalanan wisatawan mancanegara berbasis kendaraan sewa di Bali. *Seminar Nasional Sains dan Teknologi IV 2017*, Kuta, 15-16 Desember 2017 (pp. 58-65). (cit. on p. 4). http://digilib.mercubuana.ac.id/manager/t!@file_artikel_abstrak/Isi_Artikel_136958138727.pdf.

McCarthy, P. S. (2001). *Transportation economics: Theory and practice: A case study approach*. Wiley-Blackwell. (cit. on p. 2).

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In P. Zarembka (ed.), *Frontiers in Econometrics*, New York, Academic Press (pp. 105-142). (cit. on p. 5).

McFadden, D., Talvitie, A., Cosslett, S., Hasan, I., ..., Train, K. (1977). Demand Model Estimation and Validation. Urban Travel Demand Forecasting Project Phase 1 Final Report Series, Vol. V. *Special Report UCB-ITS-SR-77-9*. The Institute of Transportation Studies University of California - Berkeley and Irvine. (cit. on p. 2). https://eml.berkeley.edu/wp/utdfp/vol5/front.pdf.

Small, K., & Winston, C. (1998). The demand for transportation: Models and applications. *Papers 98-99-6*. California Irvine - School of Social Sciences. (cit. on p. 2).

Small, K. A., Verhoef, E. T., & Lindsey, R. (2007). *The economics of urban transportation* (2nd edition). Routledge. (cit. on p. 2).

Sukadana, I. W., Saraswaty, A. N., & Indraswari, I. G. A. P. A. (2014). Top gear race: The estimation of society's choice on transportation mode using a multinomial logit model". *Jurnal Perspektif Ekonomi, 7*(2). (cit. on p. 4).

Train, K. (1978). A validation test of a disaggregate mode choice model. *Transportation Research, 12*(3), 167-174. (cit. on p. 2). doi: https://doi.org/10.1016/0041-1647(78)90120-X.

Train, K. (1980). A structured logit model of auto ownership and mode choice. *The Review of Economic Studies, 47*(2), 357-370. (cit. on p. 2). doi: https://doi.org/10.2307/2296997.

Widiarta, I. B. (2010). Analisis pemilihan moda transportasi untuk perjalanan kerja. *Jurnal Ilmiah Teknik Sipil, 14*(2), 218-225. (cit. on p. 3).

Wiradnyana, I. G. N. P., Suthanaya, P. A., Wedagama, D. M. P., Yana, A. A. G. A., & Dissanayake, D. (2021). Analysing the choice and pattern of needs of transportation mode for domestic tourists in Bali. *IOP Conference Series: Earth and Environmental Science, 673*(1), p. 012019. (cit. on p. 4).

Wulandari, N. P. C., & Sudiana, I. (2018). Analisis tingkat efektivitas Trans Sarbagita sebagai transportasi publik di Provinsi Bali. *E-Jurnal Ekonomi Pembangunan, 7*(11), 2490-2517. (cit. on p. 4). doi: https://doi.org/10.1088/1755-1315/673/1/012019.

Gedung LPEM FEB UI
Jl. Salemba Raya No. 4, Jakarta 10430
Phone : +62-21 3143177 ext. 621/623;
Fax : +62-21 3907235/31934310
Web : http://www.lpem.org/category/publikasi/workingppers/