

Motorcycle dependency index at household level: case of Yogyakarta urbanized area

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Abstract. Dependency on private vehicles has become a prevalent phenomenon in big cities experiencing urban sprawl. Related to that, there are still many unknown factors affecting the dependence on motorcycles. Various factors are suspected to influence this, ranging from spatial factors to aspatial factors. This research was conducted in Yogyakarta Urbanized Area (YUA) by taking 175 samples. Binomial Logistic Regression is used in order to find the factors that affect motorcycle dependency. The results showed that the index of dependency in YUA can be quite high. Motorcycle usage, bicycle ownership, and perception about the increase of fuel price are the factors that have a significant influence on motorcycle dependence in YUA. Even though the correlation between spatial factors and motorcycle dependency was weak, it cannot be said to have no effect. These factors are most likely to be influential if other indicators are included with more suitable proxies.

1. Introduction

The phenomenon of personal vehicle dependence is prevalent in major cities in the world experiencing urban sprawl, such as cities in developed countries like United States, Australia, and Canada [1]. Cities in Developing Nations (NSB) are also experiencing the phenomenon. Among them are countries in the Asian region such as Indonesia, Malaysia, Vietnam, Thailand which are experiencing the rapid growth of motorcycle usage. The dependence is influenced by various factors, ranging from spatial factors [2][3], socioeconomic factors [4][3] and lifestyle factors [5][6]. Nevertheless, existing studies related to private vehicle dependence only explain the phenomena occurring in developed countries but have not fully explained the phenomenon of motorcycles as a mode of transportation in developing countries in Asia.

The phenomenon of motorcycles in developing countries is allegedly due to differences in the characteristics of motorcycles and cars, which became the object of research in developed countries. The differences are, first, the motorcycles are relatively cheaper and more easily obtained through credit purchase schemes [7][8][9]**Error! Reference source not found.**. Second, the design of a small motorcycle makes it easy and agile in avoiding congestion that occurs in densely populated settlements with narrow roads **Error! Reference source not found.**. Third, the motorcycle is easier to operate than the car, so both women and men can use it [9]. In addition, there are differences in travel characteristics in developed and developing countries where in developing countries the condition and quality of public transport services is less suitable to the needs of the population. One of them relates to the cost, where the cost of using a motorcycle is cheaper than the cost of using public transportation [7]**Error! Reference source not found.**[8][9], and travel time by motorcycle is considered faster than public transportation **Error! Reference source not found.**[9].

In this regard, there is still a need for research on factors that affect the dependence on private vehicles, especially motorcycles in developing countries that have different travel characteristics to developed countries. Previous research in the urban area of Yogyakarta [11] by taking the location of Ngampilan Village, Notoprajan, Panggunharjo, and Sedangadi Villages has found that dependence on motorcycles is influenced by the availability of pedestrian paths to the shelter location, limited choice of residence location, job type, public transport, transportation costs using public transport, and public



transportation waiting time. However, there are still other factors that have not been included in the model, such as distance to the city center, the condition of pedestrian pathways, and the presence of alternative modes. Therefore, in this study the model will be tested on a wider sample, and also try to find the weight for each factor in the dependency index, as well as to know to what extent spatial factors influence dependence on motorcycle.

2. Factors affecting private vehicle dependency

Based on previous researches, the degree of dependence of private vehicles is influenced by several factors such as spatial factors, socioeconomic factors, and factors of public transport services.

2.1. Spatial factors

One of the spatial factors that affect dependence on private vehicles is the affordability of public facilities from residence. The layout of the city and the placement of public facilities are often a factor affecting the accessibility of a place on foot or by cycling or compulsion to use private vehicles (cars or motorcycles). According to [13], distance of residence to the city center and the stop is one of the things considered in the decision making of travel behavior. The farther the location of the facility, the more it will encourage someone to use private vehicles. In addition, the availability of parking area at a low cost can also encourage the use of private vehicles.

Other factors, such as road design and parking availability are also spatial factors that influence dependence on private vehicles [14]. The wide road design becomes one of the driving force for using cars. This is exacerbated by the design of roads within the city area that has no room for pedestrians, thus increasing the dependence on cars.

2.2. Socio-economic factors

The degree of dependence on private vehicles is influenced by the different socio-economic characteristics of each person. Social characteristics of society in relation to travel behavior can be seen from several indicators such as ownership and use of private vehicles in the form of cars, motorcycles, bicycles; use of public transport; and use of pedestrian paths [13][14][14]. Meanwhile, the economic characteristics can be seen from the magnitude of income [15].

2.3. Transportation factors

[17][14][14] explain the factor of transport services in terms of market system that benefit private vehicles, and the quality of alternative transport modes as a substitute for private vehicles in meeting travel needs. Alternative transportation can be described as mass public transportation, bicycle, and pedestrian. A good pedestrian is considered a support facility for the community to walk to a nearby destination, while mass transportation and bicycles can reach further destinations so as to reduce the use of private vehicles.

3. Research methods

This section will explain the unit of observation and analysis of this study, sampling frame, and data analysis methods.

3.1. Unit of observation and unit of analysis

The observation unit in this research is the Yogyakarta Urbanized Area (YUA), consisting of 23 sub-districts (14 sub-districts in Yogyakarta City, 6 sub-districts in Sleman Regency, and 3 sub-districts in Bantul District). The unit of analysis in this study includes the variables and indicators that have been determined through the deduction of theory. The variables and indicators of this study are described in Table 1.

Table 1. Variables of motorcycle dependency

Variables	Indicators
Spatial	Distance from home to public transport stops
	Distance from home to city centre
	Availability of parking area
	Availability of pedestrian way
Socio-economy	Vehicle usage (to school, workplace, city centre, public facilities)
	Private vehicle ownership
	Bicycle ownership and usage
	Income
Transportation	Travel distance
	The use of public transport (to school, work place, city centre, public facilities)
	Accessibility to public transport
	Level of satisfaction of public transport services
	Quality of alternative transport modes (pedestrian, bicycle, public transport)
	Market system that benefits private vehicle users
	Traffic condition

These variables are tested in the model as predictors for the dependent variables, which are dependent or not dependent on motorcycle. Dependent group is defined as people who stated that they cannot do at least 3 of 4 activities (working, educational activities, shopping, and recreation) without motorcycle. Non-dependant group is people who can do at least 2 of 4 activities without motorcycle.

3.2. Population and sampling method

The population of this study is the residents of Yogyakarta Urbanized Area. The number of samples is determined using confidence level of 90%, which is 175 samples. Respondents in this research are households selected with convenience sampling method. Respondents were selected based on physical characteristics of the house and income. The standard income for the low-income people referred to in this study is not more than US \$ 2 / day / person, which is the standard of middle income according to the Asian Development Bank (ADB).

3.3. Data analysis method

The results of data collection were analyzed using inferential and descriptive statistical methods with the help of SPSS software. The inferential technique used is binomial logistic regression. This statistical technique is used to analyze factors affecting dependence on motorcycles in low-income households in Yogyakarta Urbanized Area, while the descriptive technique is further used as a supporting analysis to help interpret the results of hypothesis testing conducted before through inferential statistical techniques.

The assumptions used in the binomial logistic regression method are not as many as the assumptions on linear regression. The binomial logistic regression method does not assume homocedasticity, normality of errors, equality of covariance matrices, or multivariate normality such as in linear regression (Osborne, 2008). However, the assumptions for logistic regression have been fulfilled in this study, which are dependent variable is measured in dichotomous scale, independent variables are in categorical or continuous scale, and the dependent variable has mutually exclusive categories. Another assumption that must be met in binary logistic regression is linearity between the transformed criterion (i.e. log-odds) and a function of continuous independent variables in the model, which in this research has been done with Box-Tidwell test.

4. Result and discussion

Based on the results of data processing using statistical methods, the results are as follow:

4.1. Characteristics of the respondents

The sample of the research is 175 samples from all districts in Yogyakarta Urbanized Area (YUA). Based on the analysis of the samples, the level of motorcycle dependency in YUA is currently quite high. This can be seen from the proportion of people who depend on motorcycles, which is more than 50%. Both household groups that depend and do not depend on the motorcycle have the same family structure consisting of 4 people per family.

Nevertheless, there are slight differences in these two groups in terms of age and occupation. The non-dependent group was dominated by people with older age. This is because the older the age of a person, the ability to use the motorcycle is reduced so that the chance to depend on the motorcycle is smaller. In terms of work, both groups are dominated by traders. However, differences occur at the distance to their workplace locations. The motorcycle dependent group tends to engage in work activities that are far from where they live, whereas people in the non-dependent group work only in the vicinity of where they can walk. This difference can affect their level of dependence. The characteristics of the respondents can be seen in Table 2.

Table 2. Characteristics of respondents

Characteristics	Motorcycle Dependent Group	Motorcycle Non-dependent Group
Average family member	4	4
Average HH income	Rp 1,64 million (US\$ 120,5)	1,75 million (US\$ 128,7)
Average age of the respondents	44 years old	48 years old

4.2. Socio-economic factors

Motorcycle use among respondents can be categorized as high, which is about 79.5% of the total respondents. They claim to routinely use the motorcycle in every activity. Most of the respondents in the dependent group use the motorcycle for all their activities from school to recreation and sports. However, respondents in the non-dependent group use motorcycles more for shopping and work activities (Figure 1).

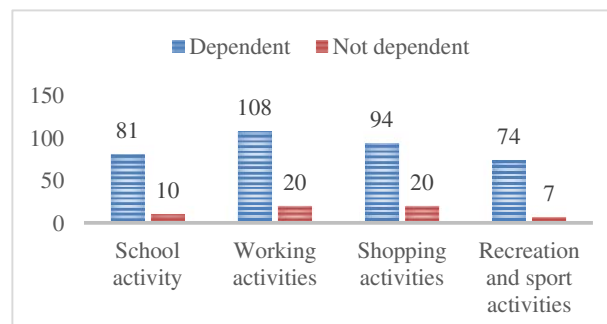


Figure 1. Motorcycle usage in various activities

Motorcycle ownership among respondents is also quite high, i.e., as many as 98.5% of respondents have at least one motorcycle. As many as 58% of them even have more than one motorcycle. This means that people who do not rely on motorcycles for their daily activities may also have more than one motorcycle. That way, the non-dependent group here are not entirely people who do not use motorcycles. A person in the motorcycle non-dependent group in YUA is person who only uses the motorcycle for activities that are considered important only and can only be done on a motorcycle.

In addition, based on travel destinations, it can be said that the pattern of travel is still local. This means that most activities are done in the local environment from school, work, shopping, to recreation. This condition is evidenced by most respondents (81%), both who are dependent and non-dependent on

motorcycles, having a total travel time of less than 3 hours per day.

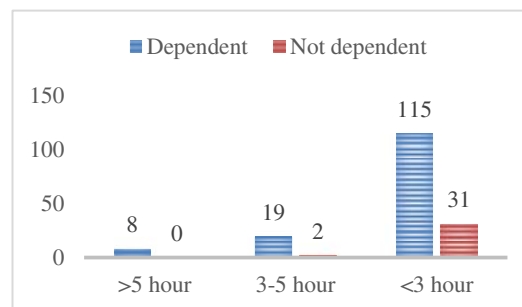


Figure 2. Duration of motorcycle usage per day

4.3. Transportation factors

In this study, the majority of respondents live in neighbourhoods with low to moderate traffic speeds, as can be seen in Figure 3.

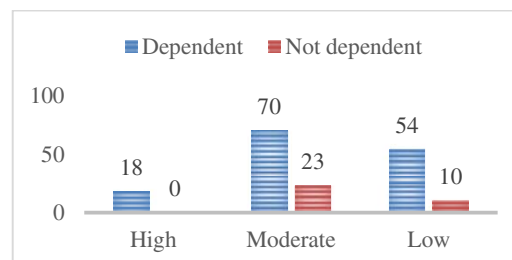


Figure 3. Traffic speed

With such conditions, the chances of people not to rely on motorcycles should be greater. With low traffic speeds, pedestrian and cyclists' activities and other non-motorized alternatives are still possible in this area. But the reality in the Yogyakarta Urbanized Area is not the case. Both in neighbourhoods with low to moderate traffic speeds, the proportion of people who depend on motorcycles is not much different. Likewise, the case is the same with people who do not depend on the motorcycle.

On the other hand, there are other alternative modes that can be used in YUA. Two of them are bicycles and buses.

1. Bicycle

Unlike the less desirable pedestrian spaces, bicycles are an alternative transportation that is widely selected and still used today in YUA. This condition applies especially to groups of people who are not dependent on motorcycles. As many as 57% of the group of people who did not rely on motorcycles were recorded to have bicycles in this study. In general, bicycles are used for school activities to recreational and sports activities. Bicycle usage for various activities can be seen in Figure 4.

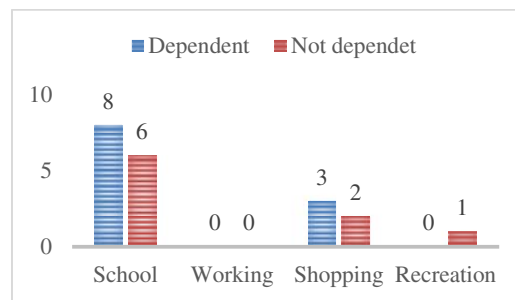


Figure 4. Bicycle usage for various activities

As many as 40% of the group of people who depend on motorcycles also have bicycles. However, in general this bicycle is limited to use for school activities. Until now, bicycles are still considered suitable for use in the YUA region as an alternative transportation. That way, bicycle access can affect the condition of their dependence on a motorcycle.

2. Bus

Buses are also an alternative transportation besides bicycles that people use in YUA to perform activities from school to work. People who do not rely on motorcycles are more likely to use buses than people who do not rely on motorcycles. As many as 55% of the dependent group stated that they often used buses because of the urgency and had no option to use private transportation, such as having no motorcycle, broken motorcycle, no motorcycle parking, and so on. Therefore, the use of public buses in this study cannot be used as a reference level of one's dependence on motorcycles.

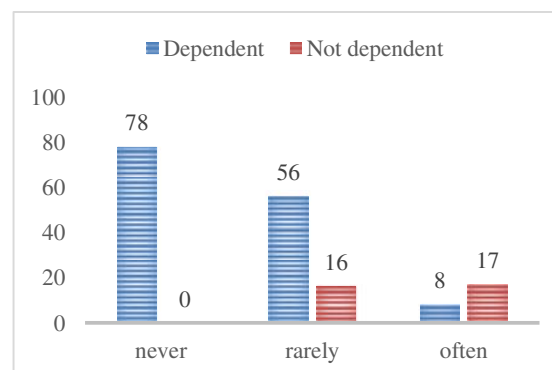


Figure 5. Public transport usage

Most respondents argued that comfort was also a determinant factor in their decision to use public bus transportation. As many as 47% of them argued that the current quality of the bus is less convenient to use. This may be due to personal circumstances (travel sickness when traveling by bus) and the efficiency of travel time (inefficient routes, long bus waiting times, and unreachable destinations by bus routes). This condition makes 57.5% of respondents feel less satisfied with public transportation buses at YUA. This factor contributed to the use of bicycles more than the use of Transjogja buses, in addition to the habits of people who are lazy to walk to the Transjogja shelter.

4.4. Spatial factors

The city center is always identified as a center of public facilities. In this study, most respondents live within a radius of more than 5 kilometers from the city center as can be seen in Figure 6.

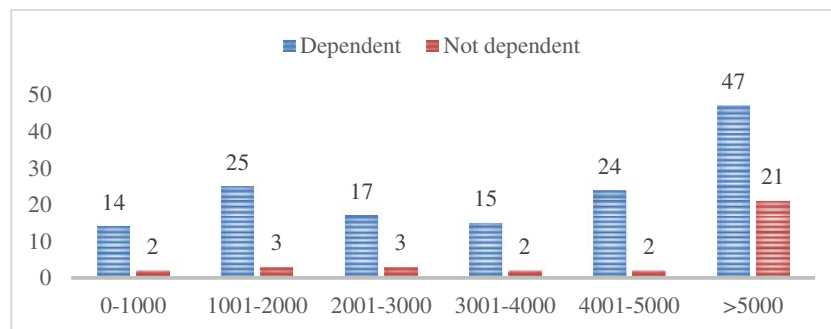


Figure 6. Distance to the city center (in meter)

This condition applies equally well to the motorcycle dependent and non-dependent groups. This indicates that motorcycle use is not affected by distance to the city center. Apparently, this happens because not all their activities can be done in the city center. With regards to pedestrian activity, as many as 54% of respondents considered that their neighbourhood has no pedestrian access. Pedestrian access is only utilized by 35% of respondents despite its poor condition. The reasons ranged from inappropriate pedestrian design, pedestrian closing by street vendors (PKL), and motorcycles that often crossed the pedestrian path. Pedestrian lane conditions that are less comfortable is what makes the pavement has not been fully utilized to reach the facilities that are within walking distance. Although they also live in a neighbourhood served by public bus routes, this condition does not make people switch to using buses.

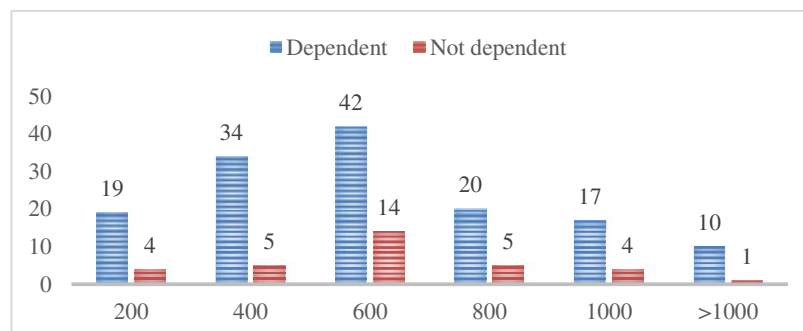


Figure 7. Distance to the nearest bus stop (in meter)

Based on Figure 7 it can be said that the majority of correspondents are within walking distance to the bus stop. However, this condition did not affect their decision to use the bus. This condition is also supported by the ease in finding parking spaces.

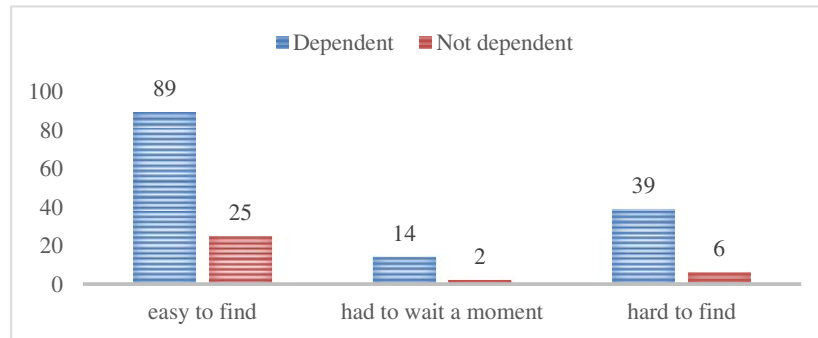


Figure 8. Parking space availability

Both dependent and non-dependent groups have the similar opinion that it is currently still easy to find available parking lots. This is what makes people from both groups still choose to use a motorcycle and only some who choose to use other alternative modes.

4.5. Motorcycle dependency model

In this study, there are 19 independent variables used with categorical measurement scales. Meanwhile, the dependent variable used is a dichotomous variable with the criteria of "dependent" and "not dependent" on the motorcycle. In the independent variable verification process, 11 independent variables are declared feasible. The test criteria used are: if the significance level of p_value is less than 0.25 then the variable can be considered a predictor in the model (Table 3).

Table 3. Verification results of independent variables

Variable	Chi-Square	p_value
Motorcycle usage	7,636	0,022
Motorcycle ownership	1,311	0,034
Bicycle access	11,660	0,001
Duration of motorcycle usage	3,736	0,154
Pedestrian access	9,056	0,011
Speed of traffic	6,682	0,035
Quality of bus	4,906	0,086
Satisfaction of public transport	4,623	0,099
Quality of bicycle	8,428	0,015
Economic burden	3,727	0,155
Fuel price	9,115	0,005

In this study, binomial logistic regression analysis was performed in twelve iterations to produce twelve models. This process is done to obtain the required level of significance that is less than 0.05. Twelve models are then selected to produce the best model. Selection process is done through several stages so that it produced only one model that is considered the most representative in explaining the factors that affect motorcycle dependence. In the selected model, the binomial logistic regression test output is generated as can be seen in Table 4.

Tabel 4. Logistic regression output

	B	SE	Wald	df	Sig.	Exp(B)
Step1 ^a Motorcyle_usage			6.973	2	.031	
Motorcyle_usage(1)	2.164	.965	5.029	1	.025	8.705
Motorcycle_usage(2)	2.306	.837	6.972	1	.008	10.031
Fuel price(1)	.953	.447	4.545	1	.033	2.593
Bicycle_ownership(1)	1.380	.446	9.563	1	.002	.251
Constant	-.717	.862	.693	1	.405	.488

Based on the output, the equation is:

$$Y = a + \beta_1 X_1 + \dots + \beta_i X_i$$

$$Y = -0,717 + 2,164 \times \text{motorcycle usage (1)} + 2,306 \times \text{motorcycle usage (2)} - 1,380 \times \text{access to bicycle (1)} + 0,953 \times \text{fuel price(1)}$$

Based on the equation, it can be concluded that from 11 independent variables tested only 3 variables that are related significantly with the variable of motorcycle dependence. The three variables are based on the following hypothesis test:

H0: $\beta = 0$ (constants not significant in model)

H1: $\beta \neq 0$ (constants of significance in the model)

The testing criteria, i.e., H0, is accepted if p value > 0.05 . Since all values of p value are less than 0.05 then hypothesis 0 is rejected. Thus, it can be interpreted that the three variables are considered to have a significant effect. Three variables that significantly influence motorcycle dependence are motorcycle usage, access to bicycle, and fuel price. According to this study, these three variables are the factors affecting the motorcycle dependency in YUA.

a. Motorcycle usage factor

Based on the analysis (see Table 5), the OR number of people who rarely ride motorcycles (motorcycle_user 1) than people who never ride motorcycles (motorcycle_user) is 8.705. It can be interpreted that people who rarely ride motorcycles (motorcycle_user 1) are 8.7 times more likely to rely on motorcycles than people who never ride motorcycles (motorcycle_user). On the other hand, the OR rate of people who frequently ride motorcycles (motorcycle_user2) compare to people who never ride motorcycles (motorcycle_user) is 10,031. It can also be interpreted that people that frequently ride motorcycles are 10 times more likely to depend on motorcycles than people who have never ridden a motorcycle. In this case people who have a higher intensity in the use of motorcycles will have more chance to depend on motorcycles .

Tabel 5. Interpretation of odd ratio (OR) of motorcycle usage

	B	SE	Wald	df	Sig.	Exp(B)
Step1 ^a Motorcyle_usage			6.973	2	.031	
Motorcyle_usage(1)	2.164	.965	5.029	1	.025	8.705
Motorcycle_usage(2)	2.306	.837	6.972	1	.008	10.031
Fuel price(1)	.953	.447	4.545	1	.033	2.593
Bicycle_ownership(1)	1.380	.446	9.563	1	.002	.251
Constant	-.717	.862	.693	1	.405	.488

b. Bicycle usage factors

Based on the Table 6, the OR number of people who do not have bicycles (bicycle access1) compared to the people who do not have bicycles is 0.251. It can be interpreted that the possibility of a person without a bicycle (Bicycle Access1) to depend on a motorcycle is 0.2 times the likelihood of a person who has a bicycle. Bicycles as an alternative mode is still a choice that is widely used in addition to using a motorcycle.

Table 6. Interpretation of OR bicycle access

	B	SE	Wald	df	Sig.	Exp(B)
Step1 ^a Motorcycle_usage			6.973	2	.031	
Motorcycle_usage(1)	2.164	.965	5.029	1	.025	8.705
Motorcycle_usage(2)	2.306	.837	6.972	1	.008	10.031
Fuel price(1)	.953	.447	4.545	1	.033	2.593
Bicycle_ownership(1)	-1.380	.446	9.563	1	.002	.251
Constant	-.717	.862	.693	1	.405	.488

c. Fuel price factors

Based on Table7, OR people who do not consider the increase in fuel price as an economic burden (Fuel_price(1)) compared to the people who consider the fuel price increase as economic burden is 2,593. It can be interpreted that the possibility of people who do not consider the increase in fuel price as an economic burden is 2.5 times the likelihood of people who consider the increase in fuel as an economic burden. In this case, the increase in fuel prices was able to influence people's decisions to use motorcycles.

Table 7. Interpretation of OR fuel price

	B	SE	Wald	df	Sig.	Exp(B)
Step1 ^a Motorcycle_usage			6.973	2	.031	
Motorcycle_usage(1)	2.164	.965	5.029	1	.025	8.705
Motorcycle_usage(2)	2.306	.837	6.972	1	.008	10.031
Fuel_price(1)	.953	.447	4.545	1	.033	2.593
Bicycle_ownership(1)	-	.446	9.563	1	.002	.251
Constant	1.380	.862	.693	1	.405	.488
	-.717					

In this model, eight other variables, including spatial variables, are said to have less meaningful effects simultaneously with other variables. Nevertheless, among the four existing spatial variables there is one variable that directly affects motorcycle dependence. The variable is the distance to the city center. It is seen from the value of p value smaller than 0.05.

Although in the selected model spatial variables are said to be insignificant, it has not been able to conclude the absence of influence from these variables. Spatial variables may influence motorcycle dependency if other variables are included in the model. For example, the city center distance variable used in this study is the distance to the center of Yogyakarta City. This variable has no effect because the population activity is not always done in Yogyakarta City Centre. Therefore, other variables that can be included in the future model is the distance to the nearest facility used such as work place, schools, shops, and recreation centre.

In addition, the distance variables to the bus stop in this study also had no effect. In the case of YUA, dependence on motorcycles at the household level is very high. Their laziness to walk and wait can also be the cause of the lack of influence of these variables. The general assumption is that the closer the person to the bus service, the more likely they will use the bus. But it is not the case in YUA. This

condition depends on motorcycle ownership and location of activity. Those who own a motorcycle would prefer to use it even if it is close to the bus stop. Although they did not have any motorcycles, they even opted to borrow a neighbor's motorcycle instead of using public transport

4.6. Motorcycle dependency index

In this study, the motorcycle dependency index was measured at the household scale. This dependency index is divided into two: high motorcycle dependence and low motorcycle dependence. Based on the model generated in this study it can be concluded that the dependency opportunities are based on three main aspects: the use of motorcycles, bicycle ownership, and perception of fuel price.

A household can be categorized as having high dependence on motorcycles if frequently using a motorcycle, not having a bicycle, and assuming that the fuel price increase is not an economic burden. Conversely, a household can be categorized as having low dependence on a motorcycle if it has never used a motorcycle, owning a bicycle, and presuming that the increase in fuel is an economic burden. Based on the model, the probability of motorcycle dependency can be calculated. The probability of a household to depend on motorcycle can be seen in the Table 8.

Table 8. Probability of motorcycle dependency

Influence factors		Motorcycle usage		
		Never	Rarely	Often
Increase in fuel price is a burden	Have bicycle	0,122	0,935	1,328
	Do not have bicycle	0,488	4,250	4,898
Increase in fuel price isn't a burden	Have bicycle	0,318	2,989	2,356
	Do not have bicycle	1,266	11,02	12,75

5. Conclusion

In this research, there are only three variables that significantly influence motorcycle dependency index in YUA, namely motorcycle use, bicycle ownership, and fuel price increase. These results strengthen and correct the research conducted by Litman, Gillingwater, and Kodukula [14][13][17] stating that socioeconomic, transport, and spatial services factors can affect dependency on motorized vehicles. However, not all aspects of this study show such results in the case of motorcycle.

In terms of the use of public transport, this study provides different results in household groups with high and low motorcycle dependency. Their tendency is to follow the cheapest price they can afford. Household groups with low motorcycle dependency prefer bicycles as alternative transportation compared to public transportation. This is because the use of bicycles is considered free and its use is more flexible than public transportation in terms of travel routes and travel time. However, for groups with high dependency on motorcycles, they tend to use motorcycles rather than using public transportation. In line with previous research conducted by Herwangi et al [11], the cost of using a motorcycle is even cheaper than using public transportation.

Perceptions of fuel price also significantly influences people's decisions to depend or not on motorcycle. Those who consider the fuel price increase not as an economic burden tend to have high motorcycle dependence. A previous research by Herwangi et al [18] also mentioned that people are still willing and able to bear the fuel price increase between IDR 500 to IDR 2000 per litre. This is in contrast with non-dependant groups who prefer to limit the use of motorcycles rather than pay for fuel price increases. This condition is done because of their limited income.

Based on these results, government intervention is needed to overcome dependence on motorcycles. One of them is by applying public transportation rates that can compete with the cost of using a motorcycle. In addition, supply-side policies are also required, by limiting the number and use of motorcycles. This needs to be done because based on this research, land use factors have little role in

influencing the influence of motorcycle. The number and use of motorcycles can be done through increasing motorcycle prices as well as increasing motorcycle taxes.

The spatial factor in this study does not necessarily have any effect on motorcycle dependency even though the model formed states so. Allegedly this factor is less influential because there are other indicators more appropriate to measure the influence of spatial factors, rather than indicators used in this study. Therefore, it is necessary to do further research by using other indicators. In addition, in this study the motorcycle dependency index is only measured in household level. In this case, research on area level needs to be done to test whether the spatial factor does affect the dependence on motorcycles. Therefore, further research should be conducted to see the dependence index on motorcycles in YUA as a whole.

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