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Structural Equation Modeling On the Calculation of Motorcycle Ownership Index Using Amos Software

Asma Massara[1], Abdul Hakim[2], Achmad Wicaksono[3],Lambang Basri[4]
[1]*(Doctoral program of Environmental Science, Postgraduate School, Universitas Brawijaya, Malang, Indonesia)*
[2]*(Department of Public Administration, Faculty of Administrative Science, Universitas Brawijaya Malang, Indonesia)*
3(Department of Civil Engineering, Faculty of Engineering, Brawijaya University Malang, Indonesia)
[4]*(Department of Civil Engineering, Faculty of Engineering, Makassar Islamic University, Makassar, Indonesia)*
Corresponding Author: Asma Massara

Abstract: *Motorcycle is one of the mainstay models of lower middle-income families to suit transportation need since motorcycle has a relatively affordable price. Thus, inflation phenomena of the number of motorcycles occur in almost all regions in Indonesia, even for low-income community in Makassar. The high frequency of travel and distance from the residence to the workplace and the existence of some areas of metro activity center becoming the community magnetism to go out and do some traveling activities is the citizens' main reason to make every endeavor to own a motorcycle. In this study, structural equation modeling was used to analyze the relationship between motorcycle ownership and travel characteristics. The SEM analysis was used to determine the best model on the calculation of motorcycle ownership index of low-income communities on travel characteristics. The method used in collecting data was judgment sampling method. Data were collected by distributing questionnaires to low-income communities in Makassar. To analyze the data, the researcher used SEM method with AMOS software. SEM analysis has seven stages: (1) development of theoretical model, (2) development of path diagram, (3) conversion of path diagram to structural equation, (4) selecting the matrix input and the estimate type, (5) identifying model, (6) assessing the criteria of goodness of fit, and (7) interpreting the results. Those stages aimed to measure the motorcycle ownership index of low-income communities on travel characteristics. Based on the research result, motorcycle ownership of low-income communities on travel characteristics had high index value of 99.3%. This figure showed a high value, this means motorcycle ownership of low-income communities in Makassar was quite high.*

Keywords: *motorcycle ownership, structural equation modeling, AMOS software, transportation, low-income communities.*

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I. Introduction

The purpose of the transportation system is to achieve the process of passenger and goods transportation optimally in a certain space and time, taking into account the safety factor, comfort and smoothness, and efficiency of time and cost. People need to move since their needs do not exist in the place they are living in. Activity system as the first micro-system has a certain type of activity that generates movement and interact the movement in the process of needs fulfillment. Movements in the form of human movement (population) and goods, absolutely require the mode of transportation (vehicle) and media (infrastructure) where the mode of transportation is operating. Transportation infrastructure that is needed is a second micro-system, commonly known as a network system including highway, railway, bus and train station, airport and seaport systems. The interaction between the activity system and the network system (infrastructure) results in the movement of people and goods in the form of vehicles (tools) and people (pedestrians).

The motorcycles ownership in this study is a thrust or strength that arises within the citizens to provide ease of mobility to achieve the desired goals. In the means of ownership, there is a process undertaken by the citizens to obtain the motorcycle in accordance with their affordability or their economic carrying capacity. Operational ownership of motorcycles in this study focus on the response of low-income community to a number of statements about the overall efforts that arises from within the community to encourage the motorcycle ownership since the role of a motorcycle is crucial for the continuity of the family economy, thus it is attained by the community to be achieved.

The study of motorcycle ownership, especially in some cities in Indonesia, is still difficult to find. In this study, the authors excerpt several studies of motorcycle ownership conducted in several cities in Asia and

Indonesia [1]. Vehicles ownership can be influenced by several factors; one of the factors is the socio-economic factor, which is related to the behavior of the community both as a road user and not a road user. Socio economy factor that can influence the motorcycle ownership is the number of family members and the total distance of all family members [2].

Motorcycle is the main transportation tool in any economically disadvantaged countries. This is mainly because motorcycles are affordable, more people can afford it. This is also due to high maneuverability in crowded streets. Cross-country statistics revealed the growth of motorcycles in developed countries and developing countries due to the increased of urbanization and personal wealth.

Motorcycles are the main means of transportation in many economically disadvantaged countries. This is mainly because of the affordability of motorcycles [3]. This is also due to high maneuverability in crowded streets. Cross-country statistics have revealed the growth of motorcycles in developed countries with developing countries due to increased urbanization and personal wealth. On the contrary, the developing country car ownership increased by the increasing incomes [4]. Motor vehicles are a high consequence of motorcycle population. Vehicle ownership is usually influenced by socioeconomic factors [5] and can be modeled on aggregate or disaggregated models. The aggregate model predicts changes in vehicle ownership, especially for geographic areas over a period of time.

Transportation can be one of the means in achieving the goal of social policy, namely by providing access to participation that can lead to equality. Inadequate transportation systems lead to social exclusion and encourage ownership of motor vehicles for people in the suburbs as well as inaccessible mass transportation modes [6].

In spite the previous empirical studies discussed the relationship between motorcycle ownership and income. This study focused on the perceptive of how economic growth affects motorcycles ownership and what factors underlie this relationship. In particular, some variables which correlated with economic growth of a country, such as urbanization, the main factor of high purchasing power of the community to own a private vehicle especially motorcycle is accessible. Everything related to the vehicle purchase explain this relationship. The findings of this study aim to improve understanding of the determinants of passenger vehicles and motorcycle ownership and the mechanisms that affect the growth of passenger vehicles and motorcycle ownership. From the description above, this study aims to calculate the motorcycles ownership index that served to measure the extent of motorcycles ownership by the low-income communities in Makassar to the travel characteristics.

II. Material And Methods

There are 7 stages in modeling and structural analysis:

1. Development of theoretical models
2. Development of path diagram
3. Conversion of path diagram into structural equations and measurement models
4. Selecting the type of input matrix and the proposed model estimation
5. Assessing the identification of structural models
6. Assessing the Goodness-of-Fit criteria
7. Interpretation and modification of the model

The steps above have requirements that have to be fulfilled. All these requirements have to be fulfilled so that the tested model can be regarded as a good model.

Development of theoretical models

The first step of SEM is identifying theoretically to the research problem. Research topics are examined in depth and the relationships among the hypothesized variables must be supported by firm theoretical justifications.

For example, when going to research on motorcycle ownership, researchers must recognize the theory of transportation on what matters that will affect the ownership of motorcycles. This is because SEM is to confirm whether the observation data matches to the theory or not. This step is absolutely necessary and any relationship to be described in further steps must have firm supporting theories. The statements of the relationships among variables in the model must fulfill the causality requirements [7]. The three conditions of causality are:

a. Between two variables (e.g. X and Y) are equally changed in value. In other words, there is a covariance or correlation between X and Y. However, this requirement is not sufficient when there is the third variable that causes both.
b. The cause of (e.g. X) occurs first (in term of time) compared to what is caused by (e.g. Y). This requirement is obviously influenced by positivist views.

c. The researcher eliminated the possibility of other factors that are as the cause of alterations in the dependent variable (e.g. Y). This requirement is quite difficult to fulfill, because in reality in this world there are many variables that affect each other.

Development of Path Diagram

After ensuring a cause and effect relationship in the first stage, the next step is to arrange a path diagram for the relationships. There are two things that need to be done, they are; constructing a structural model that relate between latent variables (both endogenous and exogenous) and set up the model of connecting endogenous or exogenous latent variables with manifest variables.

The arrangement of path diagram has been developed by LISREL, thus the researchers just use the developed path diagram without changing anything [8]. How to arrange the diagram has been described in the sub-section of the writing and drawing of variables.

Conversion of Path Diagram into Structural Equations and Measurement Models

The third step is to convert the path diagram into equations, both structural equations and measurement model equations. This step literally has been done automatically by the available SEM program (AMOS). Here is an example of a common structural equation

Endogen Variable = Exogenous Variable + Estimation error

As the illustration, the equation model is the influence of motorcycle ownership (MO) on the travel characteristics (TC). So the structural equation is:

$TC = \gamma 1\ MO + z1$

Z1 is an estimation error between motorcycle ownership on travel characteristics; and $\gamma 1$ is the regression coefficient of motorcycle ownership.

As the illustration, motorcycle ownership is measured by seven indicators MO1, MO2, MO3, MO4, MO5, MO6 and M7, thus the equation of the measurement model is:

$MO\ 1 = \beta 1\ MO + e1$
$MO\ 2 = \beta 2\ MO + e2$
$MO\ 3 = \beta 3\ MO + e3$
$MO\ 4 = \beta 4\ MO + e4$
$MO\ 5 = \beta 5\ MO + e5$
$MO\ 6 = \beta 6\ MO + e6$
$MO\ 7 = \beta 7\ MO + e7$

$\beta 1$ is factor loading of the MO1 indicator to the motorcycle ownership construct, $\beta 2$ is factor loading of MO2 indicator to the motorcycle ownership construct, $\beta 3$ is factor loading of MO3 indicator to the motorcycle ownership construct, $\beta 4$ is factor loading of MO4 indicator to the motorcycle ownership construct, $\beta 5$ is factor loading of MO5 indicator to the motorcycle ownership construct, $\beta 6$ is factor loading of MO6 indicator to the motorcycle ownership construct, and $\beta 7$ is factor loading of MO7 indicator to motorcycle ownership construct; e1 is the measurement error of MO1 indicator, e2 is the measurement error of MO2 indicator, e3 is the measurement error of MO3 indicator, e4 is the measurement error of MO4 indicator, e5 is the measurement error of MO5 indicator, e6 is the measurement error of MO6 indicator, and e7 is the measurement error of MO7 indicator.

Selecting the Type of Input Matrix and the Proposed Model Estimation

Initially the structural equation model is formulated by using variant / covariant matrix input. The covariance matrix has advantages over the matrices of correlation in providing comparative validity between different populations or different samples [9]. However the interpretation is based on unit variable measurement.

The correlation matrix in structural equation model is none other than standardized variance and covariance. The use of correlation approach is appropriate if the objective of the study is only to understand the relationship pattern among the variables. In addition, it is used to compare several different variables.

Assessing the Identification of Structural Models

The structural model is considered to be good if it has one solution for one parameter estimation. In one model it is possible to have many solutions, thus the appropriate solution is chosen. The selection of appropriate solutions is often called as problem identification.

Regarding to the problem of structural model identification is that when the estimation process occurs, it is usually followed by an illogical estimation result. The way of recognizing the problem identification is by looking at the estimation results including:

a. The existence of a high standard error for one or more coefficients
b. The impossible estimated value, for example the error variance is negative
c. The existence of a high correlation value (> 0.90) between the estimated coefficients.

Assessing the Goodness-of-Fit Criteria

Prior to assessing the expedience of the model, the step to be taken was assessing whether the data to be processed fulfill the assumptions of structural equation. There are three basic assumptions that must be fulfilled in order to use SEM:

a. Observation of independent data
b. Respondents taken at random (random sampling)
c. Having a linear relationship.

Interpretation and Modification of the Model

Once the model is accepted, the researcher can consider the modification of the model to correct the theoretical explanation or goodness of fit. Modifications of the initial model should be done after reviewing many considerations. If the model is modified, the model should be estimated with separated data before the modified model is received.

III. Result

This analysis aimed to calculate motorcycle ownership index and traveling characteristics using SEM (Structural Equation Modeling) method. SEM analysis was done using AMOS Software 22. AMOS was chosen since it is relatively easy to use, and AMOS software is quite popular used in SEM data analysis. The steps of SEM analysis were presented as follows (Table 1). The calculation of motorcycle ownership index on travel characteristics consists of 2 major components as the basis of calculation. First, motorcycle ownership, vehicles ownership can be influenced by several factors, one of the factors is the socio-economic factor which is related to the behavior of the community both as a road user and not a road user.

Second, the characteristics of traveling, i.e. the needs and daily activities of the low-income community is relatively varied causing the location and purpose of travel variously as well. Some of the factors that underlie travel characteristics are related to their travel purposes such as the need of public facilities and infrastructures that are not or not yet available both within and around their residential areas such as working places, schools, shopping centers, recreation spots, area of sports, health services center, and visiting relatives. Based on the theory, it arranges 2 constructs and each construct has 7 indicators (Table 1).

Table 1. The construct of motorcycle ownership and traveling characteristics

No.	Construct	Indicator	Variable
1	Motorcycle Ownership	Distance	X_1
		Cost	X_2
		Time	X_3
		Working Capital	X_4
		Hobby	X_5
		The symbol of success and establishment	X_6
		Asset or Hoard	X_7
2	Travel Characteristics	Working	Y_1
		Studying	Y_2
		Health needs	Y_3
		Shopping	Y_4
		Recreations	Y_5
		Sports	Y_6
		Visiting relatives	Y_7

Based on transportation theory mentioned above, then the path diagram of causality relationship among the factors was made. Graphics input created with the AMOS program are as Figure 1.

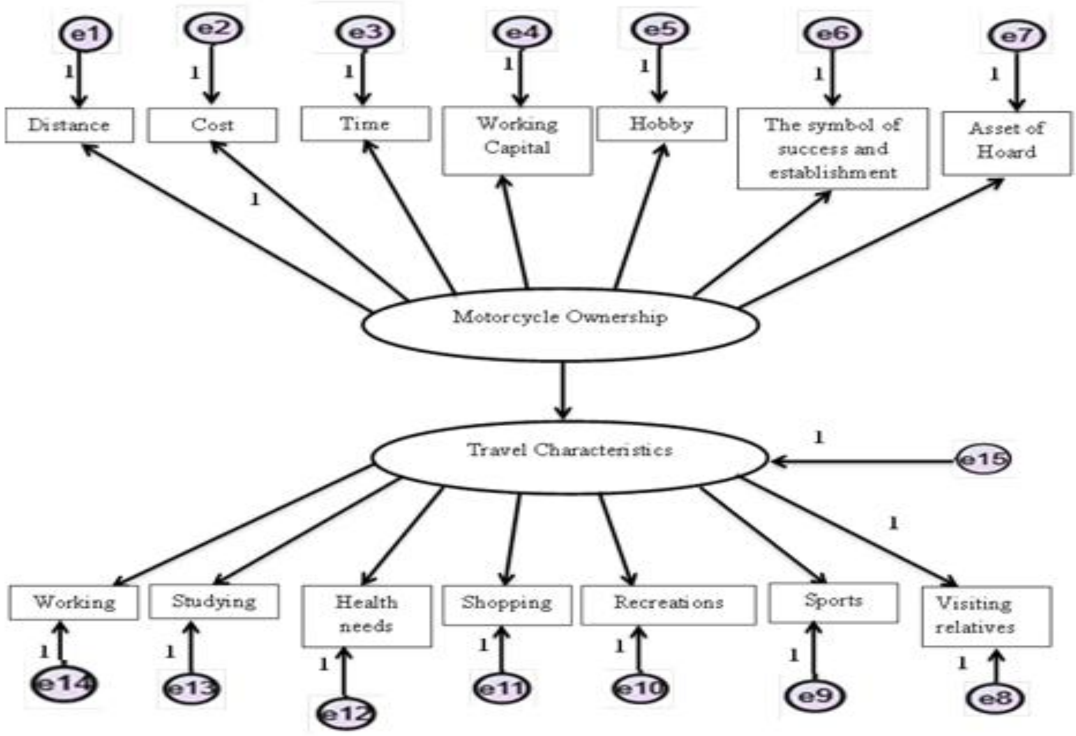

Figure 1. Graphical Input of Path Diagram of motorcycle ownership and travel characteristics by motorcycle ownership and traveling characteristics constructs

This study aims to explore the pattern of mutual relations, so that the matrix used was the matrix in the form of correlation. AMOS program converted from raw data to covariance, in other words correlating was done first as input analysis. The AMOS standard estimation model was using the maximum likelihood estimation (MLE). The MLE estimation requires the fulfillment of assumptions:

- Large sample sizeThe number of samples used in this study was 371 samples; the number can be categorized into large samples.
- Multivariate Normal Distribution DataBased on the AMOS software output, the data fulfilled the assumptions of multivariate normal.
- The hypothesized model is valid

The hypothesized model was based on the existing transportation theory. It was also supported by the validity of standardized regression weight that there was no variable with value of below 0.5, thus the formation variables presented in the model considered to be able to fulfill the valid assumption.

After hypothetical model and data matrix were inputted, then the results of the analysis were obtained as figure 2.

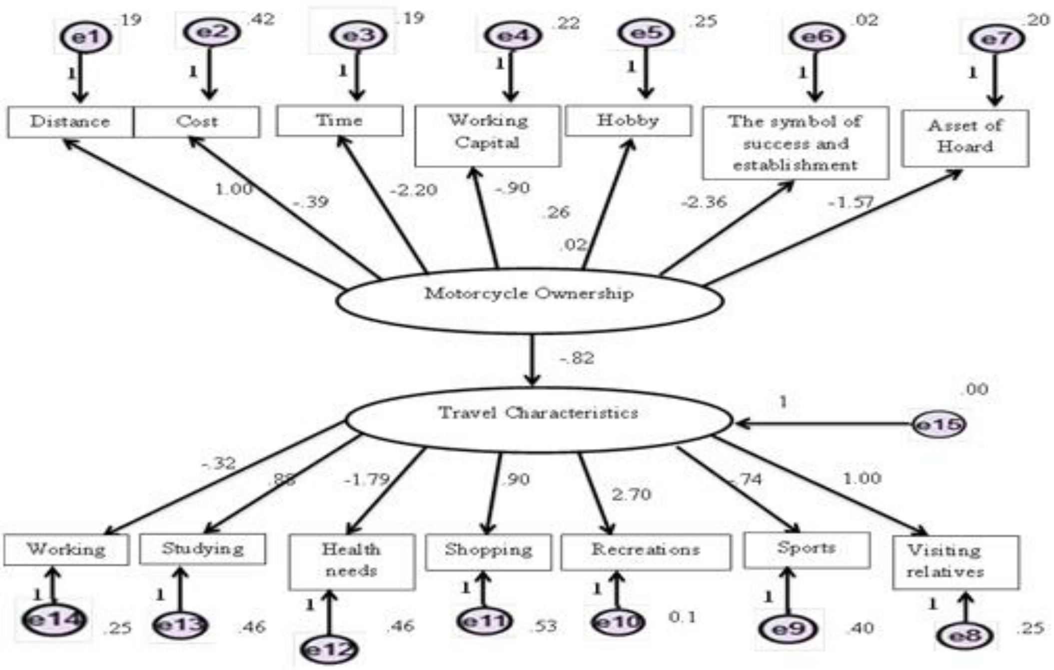

Figure 2. Graphical Output of Path Diagram of motorcycle ownership and traveling characteristics

The hypothesized model fulfilled all the required criteria, thus it did not need modifying the model. The previous hypothesized model was appropriate for the calculation of motorcycle ownership index and traveling characteristics. Therefore, the next step to do was interpreting the model. Prior to the model interpretation of structural equation formed, descriptive statistics was explained from the data into the research sample.

There are some reasons underlie the motorcycle ownership, such as the distance, transportation cost that is relatively economical, travel time is relatively faster, most motorcycles are used as tools and / or working capital, motorcycling as a hobby, as an asset and hoard of the family, as well as a symbol of success and establishment of a person.

Conversion of Path Diagram into Structural Equations and Measurement Models

- Model of structural equations

$$\eta 1 = \gamma 11\xi 1 + \beta 11\xi 1 + \zeta 1 \quad \text{.................................... (1)}$$

Note:
$\eta 1$= Travel Characteristics Construct
$\xi 1$= Motorcycle Ownership Construct
$\zeta 1$= Structural Error of Motorcycle Ownership Construct

- The Measurement Model of Dependent Variable

$$\begin{aligned} Y_1 &= \lambda_{11}\eta_1 + \varepsilon_1 \\ Y_2 &= \lambda_{21}\eta_1 + \varepsilon_2 \\ Y_3 &= \lambda_{31}\eta_1 + \varepsilon_3 \\ Y_4 &= \lambda_{41}\eta_1 + \varepsilon_4 \quad \text{....................................... (2)} \\ Y_5 &= \lambda_{51}\eta_1 + \varepsilon_5 \\ Y_6 &= \lambda_{61}\eta_1 + \varepsilon_6 \\ Y_7 &= \lambda_{71}\eta_1 + \varepsilon_7 \end{aligned}$$

Or in the form of matrix

$$\begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \\ Y_5 \\ Y_6 \\ Y_7 \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 \\ \lambda_{21} & 0 \\ \lambda_{31} & 0 \\ \lambda_{41} & 0 \\ \lambda_{51} & 0 \\ \lambda_{61} & 0 \\ \lambda_{71} & 0 \end{bmatrix} \begin{bmatrix} \eta_1 \\ 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix}$$

- The Measurement Model of Independent Variable

$X_1 = \lambda_{11}\xi_1 + \delta_1$
$X_2 = \lambda_{21}\xi_1 + \delta_2$
$X_3 = \lambda_{31}\xi_1 + \delta_3$
$X_4 = \lambda_{41}\xi_1 + \delta_4$.. (3)
$X_5 = \lambda_{51}\xi_1 + \delta_5$
$X_6 = \lambda_{61}\xi_1 + \delta_6$
$X_7 = \lambda_{71}\xi_1 + \delta_7$

Or in the form of matrix

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \\ X_7 \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 \\ \lambda_{21} & 0 \\ \lambda_{31} & 0 \\ \lambda_{41} & 0 \\ \lambda_{51} & 0 \\ \lambda_{61} & 0 \\ \lambda_{71} & 0 \end{bmatrix} \begin{bmatrix} \xi_1 \\ 0 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix}$$

Based on the output of data analysis, the model of motorcycle ownership and traveling characteristics was over identified. With the number of samples n = 371, the total amount of covariance data was 119 and the number of parameters to be estimated was 43. Based the result above, the degree of freedom produced was 119-43 = 76, 76> 0, thus the model was over identified, so the estimation of the model could be identifiable.

Assessing goodness of fit was the main objective in SEM, which was to know how far the hypothesized model 'fit' or match with the data sample. First, it assessed goodness of fit criteria based on Chi Square value:
$H_0 : \Sigma = \Sigma(\theta)$ means that the model did not match with the observed data
$H_1 : \Sigma \neq \Sigma(\theta)$ means that the model matched with the observed data

Decision criteria: H0 rejected if value (n − 1) FML (S,Σ(θ)) ≤ X21-α (db), expected probability value is <0.05 [10]. The result of goodness of fit as shown in Chi-square 945.824, with df = 76 and probability value is 0.00 which indicates that the value of X21-α (db) = 991.2138. This means that the hypothesized model matches the observed data. Model compatibility is also supported by GFI = 0.964, TLI = 0,915, RMSEA = 0,068. The GFI and TLI values were over 0.9 and the RMSEA values were between the intervals of 0.03 to 0.08, thus the model was considered to be matched to the observed data.

Based on the Figure 3, it is known that the factor of distance had the highest percentage of 16.8% followed by hoard and working capital with the percentage of each were 15.6% and 15.5%, while the most low-impact factor was the cost factor with the percentage of 11.7% (Figure 3). This shows that cost was not a major factor affecting motorcycle ownership among low-income communities in Makassar, but the distance became the main factor. This value reinforced the observation data and interviews that show almost the entire of low-income communities were experiencing the constraints of the distance from home to public facilities and infrastructure. It was due to the location of the residential area which was far from the downtown and the facilities of transportation in the residential area were not adequate.

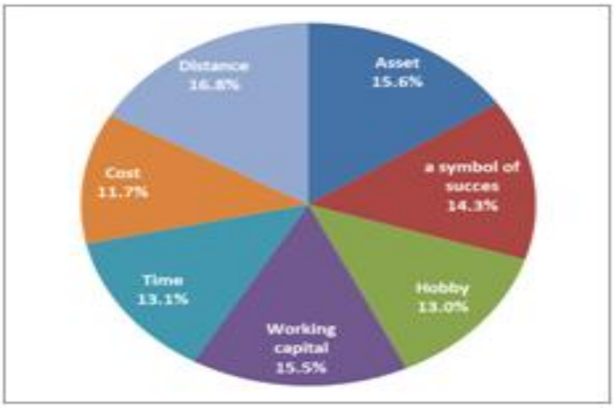

Figure 3. Motorcycle ownership factors

Based on Figure 4 it is known that workplace factor had the highest percentage that was 16.6% followed by visiting relatives and recreation factors that were 15.1% and 14.8% respectively. Meanwhile the most low-impact factor was the sport factor with the percentage of 11.8%. This indicates that workplace factor was the main factor for the most low-income communities in Makassar (Figure 4).

In the pie chart the traveling characteristics factor shows that the low-income communities had a variety of travel destinations since the communities' needs of clothing, food and shelter were not fully available around them, the available options were limited, the minimal range of public facilities became the cause of the traveling characteristics of low income communities, predominantly for those who lived in suburban areas.

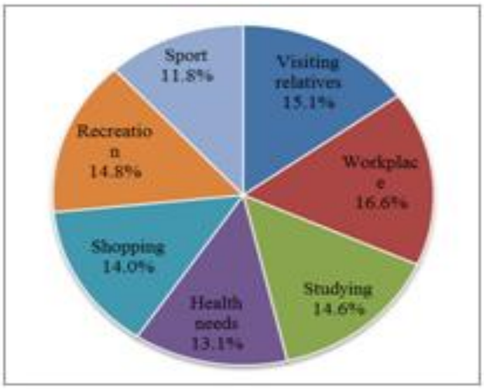

Figure 4. Traveling characteristics factor

IV. Discussion

Model Interpretation and Modification Models

In this study, data were obtained by surveying the encouragement of motorcycle ownership on the traveling characteristics of 371 low-income communities. The number of respondents was 371 patriarchs, they were chosen since SEM required a large number of samples, and to make the estimation with maximum likelihood method, it requires minimum sample that is 100 [10]. Data were collected by distributing 371 questionnaires to the respondents from four different locations; they were residential area in Untia urban village, residential area in Buloa sub-district, residential area in Banta-bantaeng urban village, and residential area in Baraya sub-district. Assisted by several parties, the questionnaires were distributed to each respondent's home.

As the previous statement mentioned that the hypothesized model was valid. Then the next step was to test the reliability of each constructed construct. Reliability is a measurement of internal consistency of indicators as long as the formation variable designated the degree of each indicator that indicated a common variable. The value of construct reliability was at least 0.70.

- Sum of standardized loading for:
  - Motorcycle Ownership = 1 – 0,39 – 2,12 – 0,90 + 0,26 – 2,36 – 1,57 = - 6,08
  - Travel Characteristics = 1 – 0,74 + 2,70 + 0,90 + 0,88 – 1,79 – 0,32 = 2,63

- Sum of measurement error for:
  - Motorcycle Ownership = 0,19 + 0,42 + 0,19 + 0,22 + 0,25 + 0,02 + 0,20 = 1,49
  - Travel Characteristics = 0,25 + 0,46 + 0,46 + 0,53 + 0,01 + 0,40 + 0,25 = 2,36

The construct reliability values for each construct are:

$$\text{Motorcycle Ownership} = \frac{(-6{,}08)^2}{(-6{,}08)^2 + 1{,}49} = 0.96$$

$$\text{Travel Characteristics} = \frac{(2{,}63)^2}{(2{,}63)^2 + 2{,}36} = 0.75$$

It shows that the construct reliability of each construct had a value over 0.70, thus it can be concluded that each construct had fulfilled the reliability requirements. As for the index of each construct was shown by the amount of variance extracted by the formation variable developed. High extracted values indicated that the indicators had been well represented in the developed formation variables. The value can be obtained by the formula of [9]:

- Sum of square standardized loading for:

$$\text{Motorcycle Ownership} = 1^2+(-0{,}39)^2+(-2{,}12)^2+(-0{,}90)^2+0{,}26^2+(-2{,}36)^2+(-1{,}57)^2= 14{,}56$$
$$\text{Travel Characteristics} = 1^2+(-0{,}74)^2+2{,}70^2+0{,}90^2+0{,}88^2+(-1{,}79)^2+(-0{,}32)^2= 13{,}73$$

Then the percentage of index for each construct is:

$$\text{Motorcycle Ownership} = \frac{(14{,}56)^2}{(14{,}56)^2+1{,}49} = 0{,}993$$

$$\text{Travel Characteristics} = \frac{(13{,}73)^2}{(13{,}73)^2+2{,}36} = 0{,}987$$

From the calculation above, motorcycle ownership index was 99.3%. The value was a high value for motorcycle ownership index as well as traveling characteristics that required a minimum value of 50% [11]. The 99.3% figure was an encouraging result. It is expected that this index number can be maintained, as well as the traveling characteristic construct which had a figure of 98.7%.

Motorcycle use depends on a combination of demographic, social and economic factors. A study in Taiwan showed that motorbike ownership and usage was influenced by economical factor. The study showed that motorcycles ownership may achieve unaccompanied, short-distance, multi-stop trips; motorcyclists under the age of 25 who were inferior in economic terms and did not use an automobile showed relatively higher measures of motorcycle dependence [3]. Other study in Spanyol indicated that motorbike is seen as a fast and reliable mode of transport in dense urban areas. This motorized two-wheeled mode of transport in everyday mobility is also user friendly. Second reason emphasizes the role of the affordability factor to help understand the rise of motorcycle [13].

V. Conclusion

Based on SEM analysis, it is known that motorcycle ownership index was 99.3%. This figure shows a high value, this means motorcycle ownership of the low-income communities in Makassar was quite high. In addition, the path coefficient value of the output diagram of the SEM analysis that was 0.82 or equivalent to 82% shows the index of motorcycle ownership on the travel characteristics was relatively great.

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