Study of Standard Trip Attraction Models of Various Land Use in the Surakarta City

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Abstract. The law states that every activity centre, settlement and infrastructure development plan that causes disturbance to safety, order and smoothness of traffic and road transport must be carried out traffic impacts analysis. The magnitude of traffic impact that occurs due to the building construction is influenced by the amount of trip generation and attraction that generated by the building activities. Standard value of trip generation and attraction of certain land use is important to be used as a reference in calculating performance of road network. The aim of study is to determine the trip attraction model of various land use including hotel and minimarket in the Surakarta City. Modelling analysis requires data such as vehicle volume in and out of land use and land use parameter such as the number of rooms for hotel and size of building floor area for minimarket. Based on these data then a modelling analysis is carried out using regression analysis to obtain a land use trip attraction model. The result of analysis shows that regression trip attraction models of 3-star hotel, 4 and 5-star hotels and minimarket are $Y = 0.1123X + 12.55$; $Y = 0.2853X + 11.017$ and $Y = 0.2444X + 0.5623$ consecutively.

Keywords: trip attraction model, land use, regression analysis

1. Introduction

Urban growth is very influential on transportation activities within the city. The existence of new centres of activity (economy, education, health, etcetera) cause the pattern of transportation movements to change according to the new conditions of land use. Transport engineers have tried to developed model to forecast trip generation and attraction caused by a new centre of activity (zone). The trip generation and attraction is designed to calculate the number of trips generated from and attracted to activities of a zone [1]. The value of trip generation and attraction of certain land use is important to be used as a reference in calculating the road network performance in the traffic impact assessment study.

Several researchers have attempt to build models of trip generation and attraction such as [2], [3], [4] and [5]. The model of their results tend to be specific for certain areas (cities). It indicates that one pattern or model of trip generation and attraction resulted from an area cannot simply applied to other places although the type of land uses and variable accounted are similar. Hence, it is necessary to build a model that suitable for a certain city and its land uses.

The purpose of this study is to determine the trip attraction model of various land uses including hotel and minimarket in the Surakarta City. The trip attraction model of various land uses produced by this research is expected to be used by the Department of Transportation Surakarta City as a standard formula for calculating the value of the trip attraction model for consultants who conduct traffic impact analysis studies in the Surakarta City. A common approach that has been used to build a trip generation
and attraction is linear regression model. It comes in form of either simple linear regression model (one independent variable) and multiple linear regression model (more than one independent variable). The both models can be chosen according to the needs and requirements of the model developed.

2. Literature Review

2.1. Trip Generation and Attraction
Trip generation and attraction is the first part of the four steps of continuous transportation modelling namely trip generation and attraction, modal split, trip distribution and trip assignment. The trip generation and attraction can be split into two categories i.e. movement originated from a zone (production) and movement towards a zone (attraction). This modelling will represent the travel needs of the community towards a zone. The results of this model can be used to estimate the number of trips to and from a zone [2]. Zonal trip generation and attraction is divided into residential (generation) and non-residential (attraction) based movements [6]. A residential based movement is a trip that comes from residential to a desirable destination such as markets, workplaces, hospitals and schools, where a non-residential based movement is a trip that comes from a place other than residential.

2.2. Simple Linear Regression
Curve fitting is a common technique to forecast the unavailable value by using the existing data, either by interpolation or regression method [7]. The interpolation technique is done if there exists a good pattern of available data. The linear regression method is commonly used to calculate the trip generation. It can be in form of either multiple regression formula i.e. \( Y=a+b_1X_1+\ldots+b_nX_n \) or simple regression formula \( Y=a+bX \) where \( y \) is dependent variable, \( X \) is independent variable, \( a \) is a constant and \( b \) is coefficient of independent variable. The option of using one of both approaches depends on the result that analyst want to obtain. If a simple linear regression model can satisfy the requirements of the result, hence it is not necessary to use multiple one model.

In order to get the best regression results, it must meet the following statistical criteria \( R^2 \) (Coefficient of Determination) value. A good coefficient of determination has a value between 0 to 1 or \( 0 < R^2 < 1 \). The greater the value of \( R^2 \) (close to 1), the better the regression results, and the closer to 0, the overall independent variable cannot explain the dependent variable. The Correlation Coefficient (\( R \)) is used to determine the correlation between the dependent variable with the independent variable.

3. Research Method

3.1. Location
This research is conducted by surveying towards several hotels and minimarkets (non-residential land use) in the Surakarta City. Table 1 shows the land use location in the form of hotels and minimarkets used as research objects. Hotels are categorised into two types namely 3-star hotel and 4 and 5-star hotels, where minimarkets are grouped into one category.

| Name of Places | Land use | Address |
|----------------|----------|---------|
| Asia Hotel     | Hotel ***| Jl. Monginsidi No. 1, Banjarsari, Kota Surakarta |
| Aziza Hotel    | Hotel ***| Jl. Kapten Mulyadi No.115, Kedung Lumbu, Kota Surakarta |
| Fave Hotel     | Hotel ***| Jl. Adi Sucipto No.60, Laweyan, Kota Surakarta |
| Grand Hap Hotel| Hotel ***| Jl. Slamet Riyadi 331, Laweyan, Kota Surakarta |
| Pose In Hotel  | Hotel ***| Jl. Monginsidi No.125, Kestalan, Kota Surakarta |
| Red Planet Hotel| Hotel ***| Jl. Prof. DR. Supomo No.49, Mangkubumen, Kota Surakarta |
| Name of Places          | Land use | Address                                      |
|-------------------------|----------|----------------------------------------------|
| Sala View Hotel         | Hotel ***| Jl. Slamet Riyadi No.450, Purwosari, Kota Surakarta |
| Alana Hotel             | Hotel ****| Jl. Adi Sucipto, Blulukan, Kabupaten Karanganyar |
| Alila Hotel             | Hotel *****| Jl. Slamet Riyadi No.562, Jajar Kota Surakarta |
| Heritage Hotel          | Hotel *****| Jl. Slamet Riyadi No.6, Kp. Baru, Kota Surakarta |
| Sahid Jaya Hotel        | Hotel *****| Jl. Gajahmada No.82, Ketelan, Kota Surakarta |
| Solo Paragon Hotel      | Hotel ****| Jl. Dr. Sutomo, Mangkubumen, Kota Surakarta |
| Sunan Hotel             | Hotel *****| Jl. A. Yani No.40, Kerten, Kota Surakarta |
| Alfamidi Garuda Mas     | Minimarket| Jl. Garuda Mas, Gonilan, Kabupaten Sukoharjo |
| Indomaret Agus Salim    | Minimarket| Jl. Agus Salim No.13, Sondakan, Kota Surakarta |
| Indomaret Garuda Mas    | Minimarket| Jl. Garuda Mas, Gonilan, Kabupaten Sukoharjo |
| Indomaret Kartika       | Minimarket| Jl. Kartika No.168, Jebres, Kota Surakarta |
| Indomaret Plus Jaya Wijaya | Minimarket| Jl. Jaya Wijaya No.99, Mojosongo, Kota Surakarta |
| Indomaret Veteran       | Minimarket| Jl. Veteran No.165, Kratonan, Kota Surakarta |

Figure 1 shows the land use location of hotels and minimarkets researched on the Google Earth map. As the land uses observed are widespread around the Surakarta City and its nearby cities, so that is expected the result of modelling will reflect the real situation of whole areas in the Surakarta City.

3.2. Research Stages
This research is conducted into several phases. This first is preparation phase, the steps taken are formulating the problem and determining the purpose of the study, which then determines the method.
to be used in completing the study. This stage includes conducting a study of previous research literature. Prior to data collection process, a preliminary survey must be conducted to determine the location of the study to be analysed, the placement of surveyors in data collection and the timing of the peak activity of each land use observed. The next phase is data collection namely collecting primary and secondary data. Data analysis phase is the last step to be done before conclusion. It contains the calculation of trip attraction value process and development of simple regression model from the data. The regression model includes equation, line chart of the equation and value of $R^2$ and $R$ of the equation. The conclusion is the regression trip attraction model with the $R^2$ value is very good.

3.3. Data Collection
Primary data is obtained by recording the number of vehicles entering the surveyed land use area. The types of vehicles recorded during the survey were cars (LV), trucks / buses (HV), motorcycles (MC), non-motorized vehicles (UM), which were then converted into passenger car units (PCU). From the results of the survey that have been carried out, it is obtained different peak hours from each location of each land use. Provisions regarding the equivalence of passenger cars are adjusted to the standard Indonesian Highway Capacity Manual (IHCM) 1997 [8], where the emp value for LV is 1.0; HV is 1.3 and MC is 0.4. Whereas the UM uses an emp value of 0.8. Secondary data is obtained from hotel and minimarket managements, related to the number of hotel rooms, floor area of the minimarkets, and so on.

In the process of collecting primary data, surveyors work on shifts to avoid data recording errors due to exhausted surveyor physical condition. The time interval used to record the number of attractions of movement is every 15 minutes. The timing of the survey varies according to the characteristics of the land use. For example, hotels are held on Saturdays from 09.00 AM - 21.00 PM and minimarkets on Friday from 18.00 PM - 23.00. Primary data obtained from the survey results are directly then classified according to a predetermined time interval to get the attraction value of vehicles that occur at time interval.

4. Result and Discussion

4.1. Analysis
Data analysis aims to produce an equation model between dependent variables and independent variables. The dependent variable used in this model is the attraction of traffic movement to hotels and minimarkets. In this study, the independent variables used are the number of hotel rooms and the size of building floor area of a minimarket.

4.1.1. Attraction Model of Hotel’s Land Use. In this type of land use of 3-star hotel, dependent variable data is presented in the form of trip attraction (pcu/hour) and independent variables in the form of room number can be seen in Table 2.

| No | Name            | Trip attraction (pcu/h) | Room number |
|----|-----------------|-------------------------|-------------|
| 1  | Aziza Hotel     | 21                      | 93          |
| 2  | Pose In Hotel   | 23                      | 95          |
| 3  | Sala View Hotel | 26                      | 111         |
| 4  | Asia Hotel      | 26                      | 114         |
| 5  | Grand Hap Hotel | 28                      | 145         |
| 6  | Red Planet Hotel| 30                      | 153         |
| 7  | Fave Hotel      | 34                      | 190         |

Source: result of Analysis
The results of the processing of the data in Table 2 using the MS Excel program results a regression equation of the attraction model of 3-star hotel movements, \( Y = 0.1123X + 12.55 \) with a coefficient of determination \( (R^2) \) of 0.9319 and the correlation value \( (R) \) of 0.9653, which shows the relationship between the dependent variable and the independent variable is very good. It means that the independent variable is very influential on the dependent variable. Figure 2 shows the graph of regression model developed for 3-star hotel, where the number of rooms as independent variable \( (X) \) and trip attraction \( (\text{pcu/h}) \) as dependent variable.

Figure 2. The simple regression model of 3-star hotel.

The 4 and 5-star hotels are analysed in separated group as their characteristics is quite different from that of 3-star hotel in order to get more accurate results.

Table 3. Dependent and independent variables of 4 and 5-Star Hotels.

| No | Name                  | Trip attraction (pcu/h) | Room numbers |
|----|-----------------------|-------------------------|--------------|
| 1  | Alana Hotel           | 80                      | 247          |
| 2  | Alila Hotel           | 91                      | 288          |
| 3  | Heritage Hotel        | 30                      | 150          |
| 4  | Sahid Jaya Hotel      | 46                      | 138          |
| 5  | Solo Paragon Hotel    | 119                     | 253          |
| 6  | Sunan Hotel           | 77                      | 203          |

Source: result of Analysis

The analysis result of Table 3 data is a simple regression model namely \( Y = 0.4469X - 21.3 \) with a \( R^2 \) value of 0.7122. Based on \( R^2 \) value, it is concluded that the model developed is considered still at good level. After several evaluations of the hotel characteristics, it was found that the number of trip attraction of the Solo Paragon Hotel is relatively large compared to other hotels because of its other function as an apartment. Whereas, the Heritage Hotel has a relatively low number of trip attraction compared to other hotels due to its characteristics is quite different to other hotels. For these reasons, the remaining data used to obtain the hotel trip attraction regression equation are the Alana Hotel, Alila Hotel, Sahid Jaya Hotel and Sunan Hotel. Improvements to the trip attraction of 4 and 5-star hotels model namely \( Y = 0.2853X + 11.017 \) with a \( R^2 \) of 0.9097 and the \( R \) value of 0.9538, which indicate the relationship between the dependent variable with the independent variable is very good. Figure 3 shows the graph of the simple regression trip attraction model of 4 and 5-star hotel, where the number of rooms as independent variable \( (X) \) and trip attraction \( (\text{pcu/h}) \) as dependent variable.
4.1.2. Attraction Model of Minimarket’s Land Use. In this type of land use of minimarket, dependent variable data is presented in the form of trip attraction (pcu/hour) and independent variables in the form of building floor area can be seen in Table 4.

| No | Name                      | Attraction (pcu/h) | Building floor area (m²) |
|----|---------------------------|--------------------|--------------------------|
| 1  | Alfamidi Garuda Mas       | 46                 | 228                      |
| 2  | Indomaret Agus Salim      | 34                 | 132                      |
| 3  | Indomaret Garuda Mas      | 64                 | 240                      |
| 4  | Indomaret Kartika         | 58                 | 250                      |
| 5  | Indomaret Plus Jaya Wijaya| 75                 | 278                      |
| 6  | Indomaret Veteran         | 37                 | 142                      |

Source: result of Analysis

The results of the processing of the data in Table 4 is simple regression equation of the minimarket trip attraction model, $Y = 0.2444X + 0.5623$ with the $R^2$ value of 0.8587 and the $R$ value of 0.9267, which shows the relationship between the dependent variable and the independent variable is very good. In this case, it means that the independent variable is very influential on the dependent variable. Figure 4 shows the graph of regression model developed for minimarket, where the size of building floor area as independent variable (X) and trip attraction (pcu/h) as dependent variable.

**Figure 3.** The Simple regression trip attraction model of 4 and 5-star hotel.

**Figure 4.** The Simple regression trip attraction model of minimarket.
5. Conclusions
This research has resulted in three trip attraction models from three non-residential land use type namely 3-star hotel type, 4 and 5-star hotel type and minimarket type. Statistical analysis values of coefficient of correlation (R) and coefficient of determination (R²), which are close to 1.0 indicate that the developed models are valid and applicable to predict the value of trip attraction based on given independent variables. The result of analysis shows that regression trip attraction models of 3-star hotel, 4 and 5-star hotels and minimarket are Y = 0.1123*X + 12.55; Y = 0.2853*X + 11.017 and Y = 0.2444*X + 0.5623 consecutively. The resulting trip attraction models of hotel and minimarket land use can be used as a standard for calculating value of land use trip attraction for consultants who conduct traffic impacts analysis studies in the Surakarta city.

6. References
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