Complexity of small-scale commercial area on Menoreh Street in Semarang and its contribution to trip attraction model

Y Basuki¹, S Rahayu¹ and A F Andrika¹

¹Department of Urban and Regional Planning, Diponegoro University, Semarang, Indonesia

Corresponding e-mail: yudibasuki@yahoo.com

Abstract. The various small-scale commercial create complexity in estimating the travel impact, especially the congestion on collector roads that connect city center and sub-city center. The purpose of this study is to understand the complexity of commercial land use through trip attraction model and its contribution to traffic flow on Menoreh Street as one of the collector roads in Semarang City. The method that used are contribution trip attraction by classification of small-scale commercial activities and multiple linear regression with dependent variable Y is the trip attraction of small-scale commercial area (pcu/hour) and the independent variables are $X_1$ (store area), $X_2$ (parking area), $X_3$ (sales income), $X_4$ (number of employees), and $X_5$ (store operational hours). There are thirteen classification which apparel store has a biggest contribution and car wash has a lowest contribution to trip attraction. From that classification, there are five different model which number of employees and sales income influence the trip attraction. The model can estimate trip attraction in the small-scale commercial area that is growing rapidly in the Semarang City so that it can anticipate the transportation problems.

1. Introduction

The transportation system consists of several systems. They are activity system, network system, and flow system [1]. The relationship between these systems could described through a model. The Four Step Model (FSM) is the main tool for estimating travel demand and the performance of the transportation system [2]. The first step in The FSM is trip generation that consists of trip production and trip attraction [3]. Trip attraction is identified number of trips or travel that attract by certain land use except residential area [4, 5]. Commercial activities become the second important factor to trip attraction after work activities [6]. The contribution of commercial area’s trip attraction can vary according to the characteristics of commercial area. Commercial area can contribute to trip attraction by 5% within the city [7]. Furthermore, one of the potential congestion zone could be shopping district [8]. It shows that development of commercial area as an activity system will attract people and create a flow system that could cause the congestion. This phenomenon encourages the need for modelling of commercial area’s trip attraction, one of them with multiple linear regression models [9], so that it can anticipate the transportation problem. Some previous studies have explained that trip attraction on commercial area influenced by store characteristic. One research believed that store operational hours, product quality, and the provision of parking spaces has affected the trip attraction [10]. Another said that trip attraction depend on store area, number of stores, and number of employees [6], and the other believed that parking area, store area, number of shops, number of employees, number of vehicles and
the number of visitors during peak hour were the main factor to attracted visitors [3]. In the commercial area, number of commercial buildings, commercial area, and percentage of banks in commercial areas affected the number of trip attraction [11]. Furthermore, a trip rates guidelines for commercial activity types are already available in America [12]. Previous study in Indonesia found that the trip attraction of small-scale commercial area was influenced by socioeconomic characteristics, namely sales income [13]. Previous studies have not been widely applied to small-scale commercial area which more attract trips than medium or large scale commercial area [6]. Commercial sector in Semarang City contributes 13.78% of GRDP [14]. Growth in the commercial sector will affect land use that part of the activity system. Developments and changes in the activity system will have an impact on the transportation system [1]. Menoreh Street have a function as a commercial area corridor in Semarang City [15]. Menoreh Street is also a collector road that connect between the city center and sub-city center. Commercial area on Menoreh corridor is classified as single-used store and small-scale commercial area (store area less than 278.7 m² [6]). These characteristics of commercial area are different with the characteristics in the developed country and creates the complexity of travel impact. Several studies in Indonesia are rarely discuss about trip attraction for each type of commercial activities that can attract different trips and increase the travel impact complexity. Therefore, trip attraction modelling will needed to understand the relationship between characteristics of commercial area and trip attraction and its impact to traffic flow complexity. This research is useful for planning, monitoring, and controlling a commercial area on collector roads that actually can contribute to transportation problem, especially for other commercial area that have similar characteristics to Menoreh Street.

2. The Aim of Study
The purpose of this study is to give understanding of complexity in small-scale commercial area by modelling trip attraction on Menoreh Street as one of collector roads in Semarang City.

3. Data and Method
There are 92 small-scale stores observed and became 13 types based on Institute of Transportation Engineers (ITE) classification, such as apparel store, office supply superstore, copy-print-and express ship store, high-turnover (sit-down) restaurant, quality restaurant, hair salon, automobile parts and service center, variety store, bread shop, pharmacy/drugstore, arts and craft store, car wash, and hardware/paint store [12]. The scope of this study is on the Menoreh Street corridor along 600 meters. Menoreh Street chosen because a collector road that connects city center and sub-city center in Semarang City. Data has taken at peak hours, on Friday 16.00 - 17.00. The data used in this study based on the dependent variable number of customer vehicles (vehicles/ hour). While the independent variable, namely X1 = store area (m²), X2 = parking area (m²), X3 = sales income (million Rupiah), X4 = number of employees (person), and X5 = store operational hours (hours). The methods in this study are multiple linear regression and calculation of the contribution of trip attraction to traffic flow. Trip attraction model of commercial area can be analyzed using multiple linear regression by stepwise methods [9]. Through this method it can be seen the contribution of each variable to the trip attraction.
4. Result and Discussion

4.1. Trip Attraction based on Commercial Activities Classification

There are 13 types of commercial activities based on Institute of Transportation Engineers (ITE) classification. Every type has a different contribution of trip attraction on traffic flow that calculate on peak hour. The contribution of trip attraction in every type can shows how commercial activities characteristic can affect the traffic flow on collector road. Based on observations, number of vehicles that crossed on Menoreh Street is 4,887 vehicles consist of 2,515 vehicles headed to the city centre and 2,372 vehicles headed to the sub-city centre. Traffic flow is calculated by multiplying number of vehicles with equivalent (equivalent for car = 1 and equivalent for motorcycle = 0.25) [12] then sum up the result between traffic flow to city centre and to sub-city centre. Traffic flow of Menoreh Street reached by 1,738.95 pcu/hour which traffic flow to city centre is higher than to sub-city centre. It means that people tend to cross the Menoreh Street to get to the city centre, so the city centre attract more trips than the sub-city centre at peak hours. The traffic flow during peak hours has dominated by people return home after work. In addition, residential activities, commercial activities, and office activities also dominated traffic flow. The types of vehicles that dominated the traffic flow during peak hours were motorcycles with a contribution of 86.00%, followed by cars with a contribution of 13.57%, and heavy vehicles with a contribution of 0.43%. There are 537 vehicles consist of 490 units of motorcycles and 47 units of cars that entered the commercial area on Menoreh Street. Each type of commercial activities has a different trip attraction. From Table 1 it can be conclude that the three types of commercial activities that have the biggest trip attraction are variety store by 42.25 pcu/hour, high-turnover (sit-down) restaurant by 35.75 pcu/hour, and quality restaurant by 18 pcu/hour. Store type in this study is single-used type has an impact on the spread of trip attraction in each store. This is different from developed countries that have the characteristics of commercial area that provide various types of stores. Previous study examined various shopping centers in Delaware, America [16]. Shopping centers types in America tend to provide several stores that serve the needs of clothing, salons, restaurants, laundry, stationery, and other needs that are in the same point. Thus, trip attraction will accumulate on that point and not conduce the spread of trip attraction in each store.
| No. | Commercial Activity Type                      | Number of Vehicles that Entered Commercial Activity (vehicle/hour) | Trip Attraction of Commercial Activity (pcu/hour) | Contribution of Trip Attraction to Traffic Flow | Percentage of Contribution |
|-----|---------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|-----------------------------|
|     |                                            | Car  | Motorcycle |                                               |                                              |                            |
| 1   | Apparel Store                              | 1    | 25         | 7.25                                            | 0.42%                                        | 4.28%                       |
| 2   | Copy-Print-and Express Ship Store           | 3    | 37         | 12.25                                           | 0.70%                                        | 7.23%                       |
| 3   | Office Supply Superstore                    | 2    | 15         | 5.75                                            | 0.33%                                        | 3.39%                       |
| 4   | High-Turnover (Sit-Down) Restaurant         | 18   | 71         | 35.75                                           | 2.06%                                        | 21.09%                      |
| 5   | Quality Restaurant                          | 4    | 56         | 18.00                                           | 1.04%                                        | 10.62%                      |
| 6   | Hair Salon                                  | 2    | 5          | 3.25                                            | 0.19%                                        | 1.92%                       |
| 7   | Automobile Parts and Service Center         | 0    | 43         | 10.75                                           | 0.62%                                        | 6.34%                       |
| 8   | **Variety Store**                           | **13** | **117** | **42.25**                                     | **2.43%**                                   | **24.93%**                  |
| 9   | Bread Shop                                  | 3    | 41         | 13.25                                           | 0.76%                                        | 7.82%                       |
| 10  | Pharmacy/Drugstore                          | 0    | 33         | 8.25                                            | 0.47%                                        | 4.87%                       |
| 11  | Arts and Craft Store                        | 1    | 43         | 11.75                                           | 0.68%                                        | 6.93%                       |
| 12  | Car Wash                                    | 0    | 1          | 0.25                                            | 0.01%                                        | 0.15%                       |
| 13  | Hardware/Paint Store                        | 0    | 3          | 0.75                                            | 0.04%                                        | 0.44%                       |
|     | **Total**                                   | **169.5** |          | **9.75%**                                     | **100%**                                     |                             |

Table 1. Contribution of trip attraction to traffic flow

*a* trip attraction is calculated by multiplying number of vehicles with equivalent (equivalent for car = 1 and equivalent for motorcycle = 0.25) then sum up the result between trip attraction of car and motorcycle

*b* contribution of trip attraction is calculated by dividing trip attraction of each type with total of traffic flow then multiplying the result by 100%

*c* percentage of contribution is calculated by dividing contribution per type with total contribution then multiplying the result by 100%

Based on the data of trip attraction and traffic flow, it can calculate the contribution of trip attraction to the traffic flow on Menoreh Street. Trip attraction of commercial area contribute 9.75% to traffic flow [see Table 1]. Research on shopping center sections in Kerala explained that the trip attraction of commercial area can contribute within 5% to the city [7]. Thus, there is a difference between the contributions of travel attraction in this study with previous studies. This is because the study examined aggregate road sections, while more specifically this study found that commercial area could contribute 9.75% on collector road that connect city center and sub-city center. While 90.25% is the flow of vehicles that pass or enter other activities, such as residential areas, offices, and so on. Each type of commercial activities contributes to traffic flow. Previous study on Ngesrep Street Semarang City corridor found that trip rates of eatery or restaurants is the biggest contribution to traffic flow by 29% [17]. This study found that variety store has a biggest contribution of all types by 24.93%
because the commercial area is close to the residential area. This makes people tend to use variety store for their daily needs. The other biggest contribution is high-turnover (sit-down) restaurant by 21.09% and quality restaurant by 10.62% that these types make it easier for people to get food ready to eat. The smallest contribution was car wash by 0.19% that indicate this type did not attract trips as high as other types of commercial activities.

4.2. Trip Attraction Modelling
Trip attraction model is built to understand the store or outlet variable that affect attracted people to visit the commercial activities. From 13 types of commercial activities in this study, the multiple regression linear reduce the number of commercial activities types. There are five types that could modelled with multiple linear regression by stepwise method. They are apparel store, copy-print-and express ship store, high-turnover (sit-down) restaurant, quality restaurant, and variety store. Table 2 shows the trip attraction model for each type of commercial activities.

Table 2. Trip attraction model of commercial activity types

| No. | Commercial Activity Type                  | Trip Attraction Model                                      | Predictor Variable |
|-----|------------------------------------------|------------------------------------------------------------|-------------------|
| 1   | Apparel store                            | \( Y = -0.352 + 0.530X_4 \)                               | Number of employees |
| 2   | Copy-print-and express ship store        | \( Y = 0.329 + 0.082X_3 \)                                | Sales income       |
| 3   | High-turnover (sit-down) restaurant      | \( Y = 1.672 + 0.021X_3 \)                                | Sales income       |
| 4   | Quality restaurant                       | \( Y = -0.018 + 0.398X_4 \)                               | Number of employees |
| 5   | Variety Store                            | \( Y = -1,310 + 1,743X_4 \)                              | Number of employees |

According the Table 2, the variable that influence the apparel store is number of employees (X4) by the equation obtained is \( Y = -0.352 + 0.530X_4 \). Same as apparel store, the variable that influences the trip attraction of quality restaurant is number of employees (X4) which equation is \( Y = -0.018 + 0.398X_4 \). The variable that influences the trip attraction of variety store is number of employees (X4). This model produces the equation \( Y = -1,310 + 1,743X_4 \). The result shows that trip attraction of quality restaurant and variety store influenced by number of employees. This is in line with previous study in Kerala which produced the equation \( Y = 93.579 + (0.169X_1) - (5.653X_2) \). In this equation, \( X_1 \) is total number of employees in the commercial node and \( X_7 \) is percentage of number of office in the commercial node [7]. Copy-print-and express ship store has influenced by the variable sales income (X3). This shows if different types of commercial activities have different variables that affect the trip attraction. The variable that affects trip attraction of high-turnover (sit-down) is also sales income (X3) with the equation \( Y = 1,672 + 0.021X_3 \). Previous study on small-scale commercial area produces the equation \( Y = 0.428 + 8.224E7X_4 \) where \( X_4 \) is the sales income [13]. Meanwhile, this study found that the trip attraction influenced by sales income, especially for copy-print-and express ship store and high-turnover (sit-down) restaurant. This study concluded that the influenced factors the trip attraction of commercial area could be different, so that it shows how complex a commercial area. This study concerns on small-scale commercial area that may different with the characteristics of commercial area on others place, especially on developed countries. Table 2 shows that number of employees influenced the trip attraction in apparel store, quality restaurant, and variety store. However, trip attraction in other type like copy-print-and express ship store and high-turnover (sit-down) restaurant has influenced by sales income. Number of employees and sales income can increase if the stores are more attract people. It can conclude that the store can attract more trips. The factors that influenced the trip attraction could be complex depends on the characteristics of commercial area. This could affect the traffic flow and increase the travel impact complexity.

5. Conclusion
The commercial area as an activity system affects the network system and the flow system. The relationship of them could explained through the trip attraction model. Based on this study, it can be
concluded that each type of commercial activity has a different contribution of traffic flow so that the modelling could not processed by aggregate on one corridor. Factors that influenced the trip attraction model could be different depends on the characteristics of commercial activities. It shows that how a complex commercial area affects a complexity of travel impact. Furthermore, if number of employees and sales income increase as factors that influence trip attraction, it can increase the contribution of commercial activities to traffic flow and might cause the congestion. Menoreh Street as a connection between city center and sub-city center have potentially cause the congestion. Thus, a complexity of commercial area might cause the transportation problem if there is no anticipation for it. Monitoring and controlling of land use as commercial area are need to decrease the travel impact that may cause congestion in the future. When it is being monitor and controlled, so commercial area can provide people’s needs and the street can connect the city center and sub-city center, definitely better than not being monitored and controlled. The importance of this study can be a starter research for commercial area planning that growing rapidly on collector road or others road that have same characteristics with Menoreh Street.

References
[1] Manheim M L 1979 Fundamentals of Transportation Systems Analysis Volume I ; Basic Concept (Massachusetts: Department of Civil Engineering, Institute of Technology Massachusetts)
[2] McNally M G 1986 The Four Step Model (Irvine: Department of Civil and Environment Engineering and Institute of Transportation Studies, University of California)
[3] Al Razib M S and Rahman F I 2017 Determination of trip attraction rates of shopping centers in Uttara area, Dhaka Am. J. Manag. Sci. Eng. 2 150–5 [crossref]
[4] Jayasinghe A, Sano K and Rattanaporn K 2017 Application for developing countries: estimating trip attraction in urban zones based on centrality J. Traffic Transp. Eng. (English Ed.) 4 464–476 [crossref]
[5] Uddin M M, Hasan M R, Ahmed I, Das P, Uddin M A and Hasan T 2012 A comprehensive study on trip attraction rates of shopping centers in Dhanmondi area Int. J. Civ. Environ. Eng. 12 12–16
[6] Sasidhar K, Vineeth Y, Vineethreddy and Subbarao S S V 2016 Trip attraction rates of commercial land use: a case study Indian J. Sci. Technol. 9 1–5 [crossref]
[7] George P, Kattor G J and Malik A 2013 Prediction of trip attraction based on commercial land use characteristics Proc. Int. J. Innov. Res. Sci. Eng. Technol. vol 2 352–9
[8] Wen T H, Chin W C B and Lai P C 2017 Understanding the topological characteristics and flow complexity of urban traffic congestion Physica A: Stat. Mech. its. Appl. 473 166–177 [crossref]
[9] Zenina N and Borisov A 2013 Regression analysis for transport trip generation evaluation Inf. Technol. Manag. Sci. 16 89–94 [crossref]
[10] Innes J D, Ircha M C and Badoe D A 1990 Factors affecting automobile trip destination shopping J. Urban Plan. Dev. 116 126–136 [crossref]
[11] George P and Kattor G J 2013 Forecasting trip attraction based on commercial land use characteristics Int. J. Res. Eng. Technol. 2 471–9 [crossref]
[12] Institute of Transportation Engineers 2017 Trip Generation Manual 10th Edition (America: Institute of Transportation Engineers)
[13] Basuki Y, Rahayu S and Rahmawati N W 2020 Analysis of Backward Methods for Determining Trip Attraction Model on Commercial and Service Area in Sukun Road, Banyumanik IOP Conf. Series: Earth Environ. Sci. 409 012018 [crossref]
[14] Badan Pusat Statistik Kota Semarang 2019 Produk Domestik Regional Bruto Kota Semarang Menurut Lapangan Usaha (Semarang: BPS Kota Semarang)
[15] Badan Perencanaan Pembangunan Daerah Kota Semarang 2011 RTRW Kota Semarang Tahun 2011-2031 (Semarang: BAPPEDA Kota Semarang)
[16] Kikuchi S, Felsen M, Mangalpally S and Gupta A 2004 Trip Attraction Rates of Shopping Centers
in Northern New Castle Country, Delaware (Delaware: Department of Civil and Environmental Engineering University of Delaware)

[17] Manullang O R, Rakhmatulloh A R, Sihaloho D A, and Samosir N M 2019 Changes of landuse in the campus area and their implications toward traffic condition *IOP Conf. Series: Earth Environ. Sci.* **340** 012034 [crossref]