Travel behaviour regression modeling of urban housewives in the great metropolitan Bandung area

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Abstract. The Millennial Situation and Condition are now changing the lifestyles of the urban societies, especially for women. It is also changing their travel behaviour to do their daily activities to meet their family needs. Including in The Great Metropolitan Bandung Area, the urban women have high demand for their daily journey and tend to increase. By the theme of Gender Mainstream philosophy, urban women have the freedom to get their accessibilities of going anywhere with their own transportation modes, including non-working urban women or as housewives in the region of Bandung. As WRI (2015) said that was more than 50% of women's mobility have a complex daily trip to meet their needs by doing their daily activities. It was done to meet the needs of family and home care in the terms of rising family's welfare. While less than 60% of men's travel behaviour have a simple trip. This kind of condition is very interesting to be analysed, especially in The Great Metropolitan Bandung Area. This study explains how complex the daily travel behaviour of non-working urban women and as housewives with activities based approach that were done outdoor in a week. The quantitative data that is performed by socioeconomic and household demographic variables serve as the basis to measure the independent variables affecting family welfare, as well as the type, time, and duration of each daily activities and daily traveling data of non-working urban women. Using Clustering Methods approach to describe the width of research area, we could find the differences of models by Regression Analysis. So, we have 3 kinds of Regression Models to figure out the each of cluster from 3 Clusters that we find by Clustering Method in The Great Metropolitan Bandung Area. The result of this study could be used to make a change of city transportation policy and also to analyse the economic potential area by the models for the government officers and the business owner to increase their profit. By the regression models result, it could be used to estimate many variables in the future to increase the economic growth of the City from the transportation by user's perspective.

1. Introduction

The Millennial situation and conditions now changes the lifestyle of urban communities, especially for women including housewives. Increasing their access to private vehicles, both cars and motorbikes, improves their confidence in managing their lifestyle. It also changes their travel behavior to carry out daily activities to meet the needs of their families and themselves. These conditions occur
simultaneously in various major cities in Indonesia, including in The Great Metropolitan Bandung. In the big city of Bandung, women especially housewives, have high enough freedom and confidence to take private trips out of home with their vehicle access in order to carry out daily activities, both mandatory and discretion activities, to fulfill the necessities of life for themselves and their families. The compulsory activities consist of: picking up school-children and extramural activities such as tutoring and extracurricular activities, as well as shopping for daily family needs, such as foods, drinks and daily household needs, including payment of various bills for housing costs stairs. Also includes their own business activities to increase family income. In other side of discretion activities, consist of: socialite activities such as hang-out in cafes, or just hanging out in city parks, shopping for personal needs or just window shopping at the mall, also includes family recreation at the tourist places inside and outside Bandung.

In general, all activities outside the home carried out by women as housewives are influenced by various things, namely, the social, economic, and demographic conditions of their respective households. This is indicated by the very varied travel patterns that occur from day to day.

This paper will discuss the daily trip-chain activities based that carried out by housewives in The Great Metropolitan Bandung with the regression method approach. This method is based on primary survey data on the activities and travel patterns of the respondents' by the social, economic and demographic conditions, which were conducted on more than 500 housewives around The Great Metropolitan Bandung. The intent and purpose of the methodology in this paper is to determine the extent of the influence of the respondent's social, economic and demographic conditions on activities and travel patterns that are undertaken daily to support the family's daily needs.

2. Discrete choice for trip-chain patterns

As we know that women especially housewives, both working and non-working, have many tasks in their households. The housewives must be able to become wives, mothers, friends, teachers, assistants, and even become a driver as well as being a housemaid. This has already a kind of natural law that is owned by women for the success and welfare of their families. In the Millennial era, where the issue of gender mainstreaming is increasingly understood by women, so they become more confident in managing and determining their lives, including their families and households.

That also happens in the decision setting to choose their activities outside the home, where those needs are available. So this each housewife has to make the out-home trips to fulfil these needs. Discrete choice to carry out activities and trips to the location of these activities is entirely decided by the woman herself, related to the time, location, mode of vehicle used as well as the sequence of activities and types of activities chosen. It also has an impact on the choice of the travelling route undertaken. All of these situations and conditions are certainly adjusted to the priority setting of daily needs both for each related family member and for herself. Due to the complexity of the daily activities carried out, the various locations to be addressed and the complicated travel routes, making the daily trip like a chain that continues from one location to another destination for the activity to be achieved, when starting from home until arriving back at home. The activity carried out at one location becomes the destination of each trip, consists of mandatory and discretion activities.

Mandatory activities include routine activities that have the higher priority to do, such as the transfer of children to school, tutoring, and extra-curricular activities, as well as vital activities to meet household needs, such as shopping for kitchen and home needs (groceries), as well as payment for various household costs, such as electricity, gas, water, cable tv, etc. Whereas discretion activity is an activity of moderate or lower priority, so it is often not related to binding time, tends to be relaxed and for pleasure. This discretion activity can also be done alone by herself, with friends, or with family, such as: hanging out at a cafe alone or gathering with friends, shopping for personal needs or just window shopping at the mall, or recreation with family in city parks or in other place to entertain both inside and outside the city of Bandung.
This activity is the basic idea of writing this paper based on a survey of primary data related to the type and time of activity, travel patterns, as well as social, economic and demographic data from respondents.

3. Research methodology

3.1. Clustering method
In this paper we choose the clustering method to separate the district of sampling [1]. The Great Metropolitan Bandung is very wide to explore and find the right respondents to spread the questionnaires. By the clustering Method, The Great Metropolitan Bandung is divided into 2 regions that consists of Bandung City and Outer Bandung City.

![Figure 1. Clustering procedure.](source)

3.2. Discrete choice approach
The purpose of this paper is to estimate the influence of respondents' social, economic and demographic conditions, in The Great Metropolitan Bandung who carry out daily trip-chain activities based out of the home with accessing to various modes of transportation. The activity-based travel model through a regression model approach by the maximum utility theory of the activities and daily trips patterns. Starting from the four-step model approach in transportation theory, consists of: trip generation, trip distribution, modal split, and route assignment. Then the maximum utility theory approach develops the limitations of the four-step model.

This activity-based model is taken as an alternative to the limitations of the four-step model, so that it can improve predictions of related variables and also increase the sensitivity of the independent variables to the activities and travel patterns [2]. This activity-based travel model is able to reflect individual needs, desires, and households commitment, and predicts where the sequence of activities and related trips are carried out by all individual of households, especially housewives, regarding where, when, how long, the modes of transportation involved, and also related to spatial, temporal, institutional and possibly the budget constraints. The focus of this model is not only on the total number of trips, but also more on the comprehensive and integral trip-activity, which involves assignments and allocation of resources, travel arrangements, participation of joint activities, tours and single trips.

3.3. Utility-maximizing models
Prasetyo, et al, used this Utility Maximum Model to analyze transportation users' perceptions of travel time savings on holidays with discretion activities for family welfare purposes [3]. Whereas Ettema, et al, use this model to optimize time allocation and achievement of activities on individual travel patterns [4]. The model developed by Ben-Akiva and Lerman, has the concept of mathematical equations as follows [5]:
\[ U_i = U_i(y_i, t_i) \] .......................... (1)

where:
\[ y_i = y_i(\alpha_j, \beta_j) = \alpha_i \beta_{ij} \] .......................... (2)

with
\[ \alpha_j = \alpha_j(\omega, X) = \omega X \] .......................... (3)

so
\[ y_i = \sum_j \alpha_j \beta_{ij} = \sum_j \sum_k \omega_{ik} X_{k} \beta_{ij} \] .......................... (4)

Maximum Utility for all activities is:
\[ U_i = U_i(y_i, t_i, \theta_i) = y_i t_i^{\theta_i} \] .......................... (5)

Lagrange Equation for Maximum Utility with subject to time and price is:
\[ L = \sum_i y_i t_i^{\theta_i} + \lambda_T(T - \sum_i t_i) + \lambda_C(C - \sum_i p_i t_i) \] .......................... (6)

when the marginal rate of substitution (MRS) between time and price for each activity is:
\[ \frac{y_i t_i^{\theta_i - 1}}{1 + \frac{p_i}{p_j}} = \frac{y_j t_j^{\theta_j - 1}}{1 + \frac{p_i}{p_j}} = \cdots = \frac{y_i t_i^{\theta_i - 1}}{1 + \frac{p_i}{p_j}} \] .......................... (7)

then make the Marginal Utility Time Extension Choice equation, that is:
\[ U_i' = U_i + \frac{\partial U_i}{\partial t_i} \Delta t_i + \varepsilon_i = y_i \left( t_i^{\theta_i} + \theta_i t_i^{\theta_i - 1} \Delta t_i \right) + \varepsilon_i \] .......................... (8)

Irwan Prasetyo, et al [3], Bhat, et al [6], Ettema, et al [4], and Habib, K. [7], used these models in their papers. Maximum utility by linearity approach is:
\[ U_{nj} = \beta X_{nj} + \varepsilon_{nj} = V_{nj} + \varepsilon_{nj} \] .......................... (9)

The probability model to distribute the model component is described as Marginal Utility Time Extension Choice [3]:
\[ U_i' = U_i + \frac{\partial U_i}{\partial t_i} \Delta t_i + \varepsilon_i = y_i \left( t_i^{\theta_i} + \theta_i t_i^{\theta_i - 1} \Delta t_i \right) + \varepsilon_i \]

with
\[ P_{in} = \Pr(\Delta U_{in} \geq \Delta U_{kn}, \forall j \in C_n, k \neq i) \] .......................... (10)
\[ P(i|\Delta T) = \Pr(\Delta U_{i} \geq \Delta U_{j}) = \Pr(\Delta V_{j} + \varepsilon_{j} \leq \Delta V_{j} + \varepsilon_{j}) = \Pr(\varepsilon_{j} \leq \Delta V_{j}) \] .......................... (11)

3.3.1. Maximum utility for mode choice [7]:
\[ U_s = V_s + \varepsilon_s = \sum \theta z + \varepsilon_s \] .......................... (12)
\[ U_{Alloc} = V_{Alloc} + \varepsilon_{Alloc} = \sum \gamma y + \varepsilon_{Alloc} \] .......................... (13)
\[ U_{m-a} = V_{m-a} + \varepsilon_{m-a} = \sum (\beta x)_{m-a} + \varepsilon_{m-a} \] .......................... (14)
\[ U_{m-b} = V_{m-b} + \varepsilon_{m-b} = \sum (\beta x)_{m-b} + \varepsilon_{m-b} \] .......................... (15)

with
\[ P_{m-a} = \frac{\exp(\mu_m V_{m-a})}{\sum_{M \in C} \exp(\mu_M V_M)} \] \quad (16) \\
\[ P_{m-b} = \frac{\exp(\mu_m V_{m-b})}{\sum_{M \in C} \exp(\mu_M V_M)} \] \quad (17)

3.3.2. Maximum utility for each activity by need-based model:

\[ U_a(s,d) = V_{1a,d-s} + V_{2a,d} + \varepsilon_{1as} + \varepsilon_{2ad} \] \quad (18)

with Probability Approach

\[ P_a(d|s) = \frac{\exp[Z_a(s,d)]}{1 + \exp[Z_a(s,d)]} - \frac{\exp[\max_{k=\beta+1}^{d-1}[Z_{ak}(s,k)]]}{1 + \exp[\max_{k=\beta+1}^{d-1}[Z_{ak}(s,k)]]} \] \quad (19)

4. Data

4.1. The great metropolitan Bandung

Based on West Java Province Metropolitan Development Management (WJP-MDM, 2012) data, the Bandung Metropolitan Area (BMA), known as the Metropolitan Bandung Raya (MBR), is a fast-growing metropolitan. Urban characteristics that make up the metropolitan are seen from various aspects, including population, economic activity, and the size of the developed area. With the agglomeration of these aspects, the intensity of activities in Metropolitan Bandung Raya is very high which will continue to cause rapid development.

The development of Metropolitan Bandung Raya began with the development of the City of Bandung as the capital of West Java Province. Furthermore, the development of areas around the city of Bandung occurs along with the expansion of urban characteristics from the city of Bandung to the surrounding area.

In 2010, there were 56 districts that had urban characteristics in Bandung City, Cimahi City, part of Bandung Regency, part of West Bandung Regency, and part of Sumedang Regency. The 56 sub-districts are included in the delineation of Metropolitan Bandung Raya with a population of 5,813,269 people and an area of 106,015 Ha. Meanwhile, in 2010 the total area of the developed area reached 26,142 Ha or around 25 percent of the total area. The 2015 projection covers 61 sub-districts in Bandung City, Cimahi City, Bandung Regency, West Bandung Regency, and Sumedang Regency with a population of 9.9 million. The Greater Bandung Metropolitan Area based on the 2020 projection includes 68 sub-districts in the City of Bandung, Cimahi City, Bandung Regency, West Bandung Regency, and Sumedang Regency with a population of 11.4 million.
The large population in the Greater Bandung Metropolitan is not only caused by natural population growth (the difference between the number of births and deaths), also caused by urbanization or the presence of migrants who live permanently or temporarily. With the agglomeration of economic activities, the employment is increasingly broad so as to make Metropolitan Bandung Raya a destination for migrants to work. Other economic advantages such as in terms of public facilities also lead to an increase in the number of migrants in Metropolitan Bandung Raya, for example an increase in the number of students studying at universities in Metropolitan Bandung Raya.

The large population has resulted in infrastructure and public facilities in Metropolitan Bandung Raya continue to be developed to the maximum to serve the population. One of the most needed infrastructure is housing. Currently there have been many formal housing developments, especially in suburban areas. There is also the development of apartments both in the city center and in suburban areas.

In addition to housing infrastructure, commercial activities are also growing rapidly in Metropolitan Bandung Raya. This is indicated by the development of shopping centers, shops, cafes, and so on. This development is supported by good access to other big cities, namely DKI Jakarta, making Metropolitan Bandung Raya an urban tourism destination. In addition, nature tourism also develops in the area around Metropolitan Bandung Raya.

However, developments in the Greater Bandung Metropolitan were also accompanied by problems, such as high levels of congestion, slums, infrastructure quality, clean water quality, flooding, and other problems. For this reason, conceptual development is needed to further guide the development of Metropolitan Bandung Raya and provide benefits both for Metropolitan Bandung Raya and for West Java, so that it becomes an accelerator of the acceleration of development for all of West Java.

4.2. Transportation problems of the great metropolitan Bandung

One of the issues and transportation problems that occur in The Great Metropolitan Bandung is the problem of traffic congestion. There are at least 32 points of traffic jams in the city of Bandung caused by economic activities (markets, street vendors, shopping centers, etc.), narrow roads, and intersections (Transportation Masterplan of Bandung, 2009). The points of congestion will increase at peak times and on holidays. Congestion also occurs in the area around the city of Bandung, especially in areas directly adjacent to the city of Bandung.

Other issues and problems include the convenience and safety of traffic, both for passengers who use public transport and private vehicles. In addition, transportation also causes problems in the form of air pollution.
pollution. Issues and problems are also caused by the availability and quality of transportation infrastructure, such as highways, toll roads, railroads, public transport terminals, airports, railway stations, and so on.

4.3. Data summary of social, economic and geographic
Percentage (%) of Socioeconomic Household Characteristics for Non-Working Urban Women (N=466)*

Figure 3. Percentage of socioeconomic household characteristics.

4.4. Data summary of trip-activities pattern

Figure 4. Percentage of non-working urban women trip chaining.
5. Regression results from the models and analysis

5.1. Regression results another

|                       | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|-----------------------|---------|---------|---------|---------|---------|---------|---------|
| R²                    | 0.11†   | 0.08†   | 0.02†   | 0.04†   | 0.16†   | 0.13†   | 0.05†   |
| F_stat                | 2.509***| 2.884***| 2.137***| 0.892   | 3.660***| 3.671***| 1.410   |
| (Constant)            | -0.255  | -0.014  | 3.005***| 609.071†| 313.875†| -34.279 | 962.099†|
| Age (Yr)              | 0.016   | 0.016   | 6.982   | 1.949   | 1.430   | 6.658   |         |
| Eduv (Yr)             | 0.041   | 0.063   | 25.029  | 5.262   | 4.542   | 39.251†|         |
| No. of Children (Pr)  | -0.117  | -0.137† | -49.117 | -18.776 | -1.340  | 23.400  |         |
| No. of Family (Pr)    | 0.023   | 0.006   | -37.041 | 4.641   | 5.627   | 13.250  |         |
| Housing (Ym)          | 0.235   | 0.369   | -11.432 | 36.479  | 31.714  | 80.080  |         |
| Electricity (Wh)      | 0.032***| 0.062***| -291    | -0.812  | -0.017  | 0.243† |         |
| Motorcycle (Vkm)      | 0.482   | 0.707   | 21.658  | 67.626  | 34.165  | 156.470 |         |
| Business (Vkm)        | -0.219  | -0.145† | 111.265 | -105.425†| 52.205† | 51.269  |         |
| Time of M Act (Min)   | 0.004†  | 0.001†  | 0.007   | 0.007   | -0.004  |         |         |
| Time of D Act (Min)   | 0.013†  | 0.033†  | 0.051   | 0.197†  |         |         |         |
| Time of Journey (Min) | 0.003†  | 0.001†  | -0.80†  | 0.383†  | 0.0001† |         |         |
| Income (M Rp)         | DV      | DV      | 4.096   | 2.660   | 6.019†  | 19.045  |         |

Figure 5. Regression result for Cluster 1 (The City of Bandung).

Figure 6. Regression result from Cluster 2 (Outer region of Bandung City).

5.2. Analysis

From the results of the Regression with the Seemingly Unrelated Regression Model approach processed with SPSS and Eviews, the results are obtained, namely: There are 7 possible models based on each of Dependent Variables (DV), these are: Income and Time. This method can produce a simultaneous model, but not in accordance with the initial purpose of this research, we only find the impact of trip-chain variables. For income model, there are several significant independent variables consistency, namely: Education, Housing, Electricity and Business. For Time model, there are two significant variables consistency, namely: Business and Time of Journey. In Cluster 1, the best models are: Model 1 as Income Model, and Model 4 as Time of Mandatory Activity Model. This means that respondents in Cluster 1 supported to education variables, home status, the amount of electricity consumption and business have significant effects on household income which leads to Maximum Utility (Model 1). On the other hand, Motor Mode use, Business activities, Free Activity time, and travel time have significant effects on the time of women daily routine activities which in the end also affects the Max Utility of the family (Model 4). In Cluster 2, the best models are: Model 1 as Income Model, and Model 6 as Time of Journey Model. This means that respondents in Cluster 2, the variable magnitude of electricity...
consumption and travel time have significant effects on household income which leads to Maximum Utility (Model 1). On the other hand Business activity variable, Discretion Activity time, and income have significant effects on daily travel times that are in the end also impacts to the Max Utility of the family (Model 6).

6. Conclusion
We can conclude for this paper to estimate the trip-chain patterns activities based that the housewives in The Great Metropolitan Bandung did everyday as: Women in the Great Metropolitan Bandung are increasingly confident to make daily trips according to their needs in terms of family, household and themselves, including non-working women. The daily journey carried out aims to meet the needs of themselves and their families, both for the needs of goods and services. Socioeconomic and demographic factors will influence the trip-chain activity-based that undertaken by housewives in the Great Metropolitan Bandung. These socio-economic and demographic factors will also determine the time and number of activities undertaken, while travel time cannot be predicted further given the increasing traffic congestion in the Great Metropolitan Bandung.

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References
[1] MacQueen J 1967 Some methods for classification and analysis of multivariate observations In Proceedings of the fifth Berkeley symposium on mathematical statistics and probability 1(14) 281-297
[2] M Ben-Akiva and M Bierlaire 1985 Discrete Choice Methods and their Applications to Short Term Travel Decisions in Handbook of Transportation Science 1985, 1999 5–33
[3] Prasetyo I, Fukuda D, Yoshino H and Yai T 2003 Analysis of Travel Time Saving Benefit by Understanding Individual Needs and Value of Activity Time: Case Study of Tokyo and Jakarta Transp. Res. Rec. 1854(1) 12–21
[4] Leirdal S and Ettema G 2009 Freely chosen pedal rate during free cycling on a roller and ergometer cycling European journal of applied physiology 106(6) 799-805
[5] Ben-Akiva M E, Lerman S R and Lerman S R 1985 Discrete choice analysis: theory and application to travel demand 9 MIT press
[6] Srinivasan S and Bhat C R 2005 Companionship for Leisure Activities : An Empirical Analysis Using The American Time Use Survey Present. Innov. Travel Demand Model. Conf. 1–19
[7] Akbari S and Habib K N 2015 An econometric investigation on the relationship between modal accessibility and the home–work spatial configuration of two-commuter households Transp. A Transp. Sci. 11(10) 897–917