Unified and Hierarchical Model Framework of Activity and Travel Choices in Palembang Metropolitan Area

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Abstract : Activity based modelling treats travel as being derived from demand for personal activities. Given the large number of choice variables considered in the travel demand modeling process there are many approaches have chosen for a sequential framework in which activity-travel choices are modeled sequentially. These approaches usually adopt the hierarchical models where one choice process is nested within another choice process and so on. It forms a long chain of interconnected nests to complete the representation of the behavioral process. On the other hand, there are choices that one would expect to be short-term choices made contemporaneously. This paper is a preliminary study of travel behavior models in the city of Palembang. The goal of the study in this paper is to describe household travel characteristics in Palembang and the general model framework of hierarchical and unified model of activity and travel behavior models in Palembang.

Key Words : Activity, Unified, Hierarchical, Model Framework, Palembang

1. INTRODUCTION

The growing complexity in travel patterns and the need to estimate changes in travel behaviour in response to new policies *need* for a better understanding of travel behaviour. Dissatisfaction with the forecasting accuracy of trip based model as a traditional model increased during 1970's where the transport planning turned the focus from the global infrastructure developments to the travel needs of single person.Travel choices, therefore, become the part of broader scheduling process based on modelling the demand for activities rather than merely trips. Activity-based modelling treats travel as being derived from the demand for activities.

Research related to the understanding of activity-based travel behavior has a lot to do with the approach that continues to grow today. The study analyzed the relationship between the various options related to the characteristics of activities and trips. There are two basic components of conceptualizing activity-based travel demand model. The one component deals with the basic needs or self-realizations that instigate us to involve in different activities; this can be termed the activity generation component. The other component is the spatial-temporal opportunities and constraints that finally define the actual participation in different activities, which can be termed activity scheduling. More specifically the desire or need to participate in different activities indicates the activity generation, and the allocation of time and space to specific activity needs within limited action space and time limitation indicate activity scheduling. Obviously the interactions between these two components are two-way. Sometimes spatio-temporal opportunities instigate different activity needs, and sometimes different activity needs exceed the spatio-temporal opportunities and thereby people change their lifestyle. These are the basic underpinnings of the concept of activity-based travel demand analysis.

Some research on the modeling activity generation and scheduling activity that has been carried out include unified and hierarchical activity-based travel demand models:

1. Hierarchical activity-based travel demand model the characteristics of activities and travel with a hierarchical approach to the selection process of activities and travel alternatives (Ben-Akiva and Bowman 1995; Yagi and Mohammadian 2009). Results from this study is the selection type of activity affects the selection of mode and location. This study does not include the time allocation choice. Whereas in previous studies described that the allocation of time is a characteristic activity needs to be considered because of the perceived value of the benefits that an individual's use of time will affect the selection of the type of activity and travel characteristics within a certain time period (Habib 2007; Fujiwara 2010)
2. Unified activity-based travel demand model the characteristics of activities and travel inter-dependent with one another and hence inextricably linked in ways that need to be better understood to help inform the specification of activity-based travel model systems (Bhat,2010). Bhat, Eluru and Pinjari 2010 model the characteristics of the activity and travel choice with the unified selection process approaches. The results showed the influence of the decision-making process of the selection of types and the allocation of time, schedule activities and modes are used for site selection activities. However, with a unified process of decision-making method, the study did not analyze the influence of the selection of the type and time allocation activity as the result of long-term decisions related to the type of work, social status and the relationship between humans as social beings with the selection of the characteristics of the trip is a term decisions such a short time schedule trips, modes and locations for specific events. Travel options are not only affected by environmental conditions such as weather, transport characteristics and land use in the region but they are also influenced by individual socioeconomic status. Unified activity-based travel demand is a model that refutes hierarchical choice model.

The methodology in this study will develop a model of choice of activities and trips to the structure of the model in a combination of hierarchical models and the unified process of alternative choice of activities and trips. Choice alternatives that is modeled as hierarchical shows that alternative options are at a higher level determine alternative options at a lower level. In the structure of the model in this study, the alternative at the top of the hierarchical of decision-making is influenced by the choice of a long-term decisions such as residence location, family composition and school site selection. The alternative is a characteristic component of the activity, the type and the allocation of time to perform the activity. The hierarchical at the level below is the model component of travel options, including a timetable, location and mode choice activity. Activity and travel choice model is based on the theory of econometric models, namely the maximum utility combined model Multinomial Logit (MNL) and Nested Logit.

In this paper, a modeling framework of hierarchical and unified model of daily activity-travel pattern choice, activity type choice (generation), time of day choice, joint inter household choice, mode choice, destination choice, and time use allocation (duration) are described based on travel behavior characteristics in Palembang Metropolitan Area. Similar to that of other cities in the developing world, Palembang is tilted away from the private automobile towards transit, motorcycles, taxis (formal or informal) and non-motorized modes of transport.

In Palembang Metropolitan Area, a variety of urban transportation management policies are currently being examined, discussed, or implemented. For example, the introduction of a new bus rapid transit (BRT) which will replace the kind of public transportation and public transit buses. BRT, as a public transport, serves the main and long distance travel, while public transportation and public transit buses as feeder modes in local and collector transportation road network system. Based on the comparison of two unified and hierarchical modelling framework it is hoped that the proposed new models will contribute to the improvement of the methodology of travel demand forecasting and evaluation of urban transportation policy scenarios in the region.

2. ACTIVITY BASED MODELING OF TRAVEL DEMAND

Numerous approaches to activity-travel model have been developed, and it is impossible to describe a general model structure or theoretical framework in the same way. It can be described if one were describing earlier four-stage models. Numerous authors have attempted to categorize the different modeling approaches, but most of these authors have ended up with quite different categorizations and labels.

The literature is therefore at times quite confusing to anyone for whom mathematical modeling is not their core field of interest. For the purposes of this paper, the following broad categorizations offered by Timmermans H *et al* (2002) are adopted:

1. Constraints-based approaches

These models typically examine whether particular activity patterns can be realized within a specified time-space environment. These models are required as input activity programmes, which describe a set of activities of certain duration that can be performed at certain times. The space-time environment is defined in terms of locations, their attributes, available transport modes and travel times between locations per transport mode. Geographers have played a dominant role in developing such models. The theoretical origins of constraint-based approaches to activity schedule model are rooted directly in time geography, with the PESASP. PESASP (*Program for Evaluating the Set of Alternative Sample Paths*) is an early computer model constructed using the time geography theoretical framework which was developed by Bo Lenntorp (1978). The inputs to this model were a synthetic population's postulated daily activity agendas, a spatial configuration of activity stations, and a transportation system connecting these stations. The outputs of the model were a quantification of the number of possible ways, given capability, coupling and authority constraints, the given activity agendas could be scheduled in time and space.

2. Utility-Based Approaches

The theoretical origins of utility-based approaches to activity schedule model lie in microeconomics and its principles of utility-maximization behavior. Utility-based models extend constraints-based models by adding an actual choice prediction to the generation of feasible activity schedules. The prediction of actual scheduling choices made it possible to link these models, and their associated aggregated trip patterns, to models that assign trips to a network.

The utility-based models uses disaggregate modeling procedures, originally developed in the context of a discrete trip and choice-based framework, to predict activity schedules. Thus multinomial logit models are used to predict an *individual's* choice from a set of possible complete daily activity schedules, or alternatively, nested logit models are used to predict choices at various stages in the activity scheduling process. In both instances, the choice of an activity schedule is predicted on the basis of that option from which the individual is likely to derive maximum utility although, typically, predictions are made within a satisfying, as opposed to optimizing, framework. The models thus assume that an individual's search for a better option, in response to some environmental change, is abandoned once a satisfactory (as opposed to optimal) option is found.

3. Rule-based approaches

The assumption of utility-maximizing behavior, characteristic has been criticized by some scholars, arguing that individuals do not necessarily arrive at 'optimal' choices but rather use context dependent heuristics. Computational process models constitute a powerful theoretical approach that conceptualizes choices as outcomes of such heuristics. The theoretical origins of rule-based approaches to activity schedule modeling lie in psychology. Rule-based models focus on the process of decision making, and the heuristics that this involves, rather than assuming an overriding behavioral theory such as utility maximization. Individuals, within a household context, are assumed to make choices on the basis of their opinions and imperfect cognitions of their environment. These opinions and cognitions are understood to be constantly collected and updated through their interactions and experiences. The models use a set of empirically derived rules, or 'condition-action pairs', to simulate the formulation and execution of activity schedules. The rules attempt to capture the decision-making process of individuals by specifying the execution of a particular action when, or if, a particular condition is encountered.

4. Hybrid Approaches

Hybrid approaches to activity schedule modeling are drawn from the theoretical frameworks and *modelling* techniques of various other approaches. An example is SMASH (*Simulation Model of Activity Scheduling Heuristics*), a model developed at the University of Technology, Eindhoven, which combines heuristic rule-based approaches and utility-based approaches in activity scheduling. Another example is AMOS (*Activity-Mobility Simulator*), a component of the SAMS model developed by Research Decision Consultants Inc. in San Francisco, which uses neural networks to derive the condition-action rules that drive the simulation of activity schedules. AMOS has been applied in the Washington (DC) area to assess the potential short-term response of commuters to 'transportation control measures' measures implemented in terms of federal clean air legislation.

Hierarchical and unified activity-based travel demand model are based on the theory of econometric models, namely the maximum utility combined model Multinomial Logit (MNL) and Nested Logit. The advantages of maximum utility model are :

1. Based on the theory economics and statistical science that has been continuing to grow until now.
2. Research with empirical data and simulation continue to grow until now (Bhat, 2010; 2011)
3. The validity of the model has been tested in developing countries (Yagi and Mohammadian 2009)
4. Data processing can use statistical and econometric software: SPSS, STATA, LIMDEP, R, GAUSS.

3.DATA DESCRIPTION

The data set used in this paper is derived from the 2010 Cities Development Initiatives (CDIA) Palembang Urban Transport Study. The data includes information on: (1) Individual and household socio-demographics (2) Household and individual travel survey records were augmented extensively with several secondary data items, including land-use characteristics, transportation network level-of-service data, and cencus population and housing data.

3.1. Demography and Land Uses

Palembang is the capital city of Indonesia's Sumatera Selatan (South Sumatera) Province. Geographically, it is situated on either side of the Musi River, about 80 kms from the open sea. The majority of the city is located north of the river, where the old City Centre is also located. The area to the south of the river is less developed, although a second commercial centre is being promoted, the city's parliament is already located there, and there are plans to relocate provincial government offices. The current population of Palembang city is estimated to be about 1.5 million. In recent years this population has been growing steadily at around 2% per annum. If this trend continues, the population in 2015 will be around 1.63 million and in 2030 will be around 2.20 million. The total area covered by the city at the present time is 400.61 Km^2. However, large areas of the city are still undeveloped (17% is agricultural land, for example). The highest average population densities are to be found in Ilir Timur I (13,400 per Km^2), Ilir Barat II (11,200 per Km^2) and Kemuning (10,200 per Km^2). These subdistricts cover the area surrounding the city centre and extending northwards on either side of Jl. Jenderal Sudirman. The city centre itself is not so densely populated, largely because of the presence of offices, shops and other commercial and government buildings.

3.2. Road Network

Palembang's road network is based on radial routes, supported by a series of ring roads. The main radial road runs from the Ampera Bridge, which crosses the Musi River north-westwards towards Alang-Alang Lebar and on wards to Jambi Province. Four on the radial routes lead to other gateways to the city – to the new international port complex at Tanjung Api- Api, 80 kms to the north, and to Bengkulu and Bandar Lampung to the south. The ring roads include an Inner Ring Road and a Middle Ring Road. Neither of these roads is complete, since they do not link to bridges over the Musi River – and intervening development and land acquisition issues would now make their completion quite difficult.

3.3. Public Transportation

Motorized public transport in Palembang is provided by buses, angkots (mini-vans), ojegs (motorcycle taxis) and taxis. The city buses generally stop on demand, rather than at fixed stops, and do not run to fixed time tables. Driver behavior is also sometimes erratic. The flat fare is currently Rp 3,000 for each boarding. In 2010, there were 448 city buses operating on 8 routes. However, 320 (or about 71%) of these will need to be retired by the end of 2012, because they will have reached the 10-year age limit stipulated by city regulations. In February 2010, a new

Trans-Musi bus service commenced on two corridors, using a fleet of 25 high-floor, air conditioned buses. Three more corridors are due to be implemented by early 2011, and the remaining three corridors are expected to be operated before 2013. However, funding difficulties are currently being experienced in implementing the associated stop infrastructure. In 2008, there were also 2,690 angkots operating on 18 routes. Although some routes will need to be re-orientated to avoid competition with bus services, it is anticipated that these vehicles will continue to be required to provide feeder services to the Trans-Musi network. Ojegs operate as an independent, opportunistic and informal mode of transport, and also provide feeder services to other transport modes in areas where larger vehicles cannot penetrate. Transport on the Musi River is available on an informal basis, with many small boats offering their services. However, this does not provide a very large proportion of the urban transport needs of the city.

3.4. Non-Motorised Transport

Non-motorised modes, including becaks (traditional tricycles with seats for two people), bicycles, and walking, play a very important part in the city's transport system. Becaks operate informally, providing transport services for short trips within residential areas, and also provides valuable feeder services to the bus network. Except for a very few areas where special projects have been implemented, conditions for pedestrians in the city are generally poor. The situation is particularly serious where access is required to public transport stops, in areas where modal interchange takes place, and in other areas, such as commercial and recreational areas, where people congregate. Of the 98 kms of roadway that constitutes the proposed network of Trans-Musi bus corridors, less than 40% currently have sidewalks, and where sidewalks do exist they are generally in need of maintenance and rehabilitation.

3.5. The Rapidly Increasing Use Of Private Transport Modes

With increased economic prosperity, the ownership of private cars and motorcycles in the city has risen rapidly in recent years, with annual increases often exceeding 10%. This has resulted in a continuing rise in the use of private vehicles, leading to increased road congestion, increasing emissions of greenhouse gases, an increased incidence of traffic accidents, stagnation (or slow decline) of the public transport system, and a dramatic reduction in walking and the use of non-motorised modes for travel within the city. The increasing number of parked cars and motorcycles has also led to deterioration in environmental conditions in some parts of the city (notably the city centre). For all these reasons, the current trends in private vehicle use are considered to be unsustainable.

3.6. External Transport Facilities

External transport facilities include an international airport and a railway station. There are also active port facilities providing passenger and freight transport services to nearby provinces.

3.7. Household Information

This survey component covers the socio-economic background of the household including number of household members, age structure, household composition and employment status obtained from a survey conducted by BPPS Palembang, while travel characteristic and related items data obtained from 2010 Cities Development Initiatives (CDIA) Palembang Urban Transport Study. The data was collected from 400 residents in the city of Palembang.

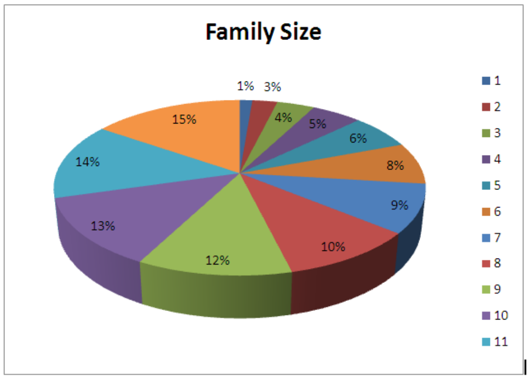


Figure 1. Number of Household Member

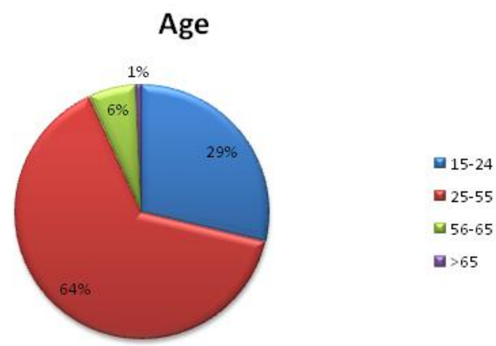


Figure 2. Age Structure

Like in other cities in developing countries, Palembang has a relative great number of household members. Based on household survey, the average number is 6 consist of father, mother and children. 64% population in Palembang is a productive age between 25 to 55 and this may affect the number of trips at the same time as hours commuting to and from work. If this is not supported by adequate public transport services, people will prefer using private transport to meet the needs of their tours, this can lead to the problem of congestion at peak hours.

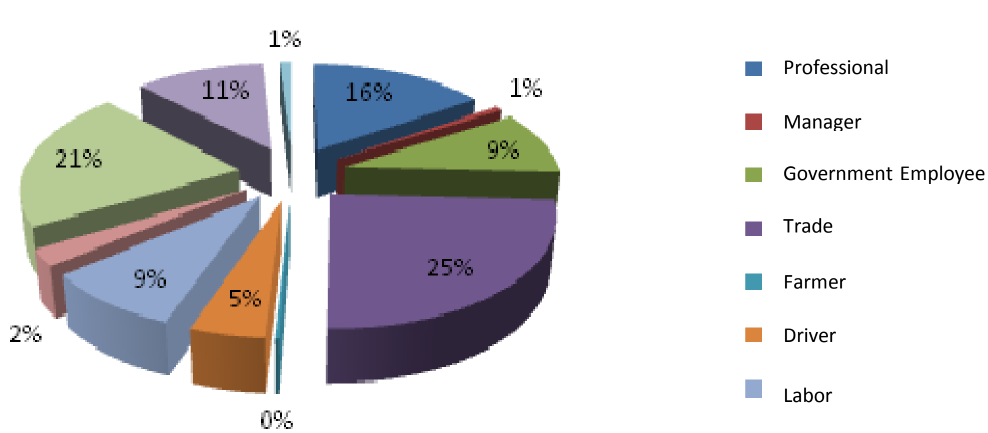
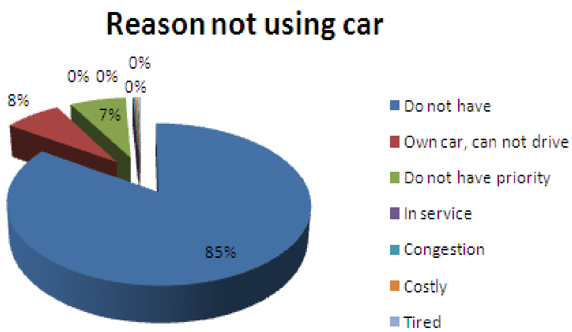


Figure 3. Percentage Of Employment Status

According to a survey conducted by BPPS Palembang, 25% population in Palembang has an employment status as an entrepreneur. This means activities undertaken to work less bound by time and this also affects the time of day choice for mandatory, maintenance and discretionary activities.



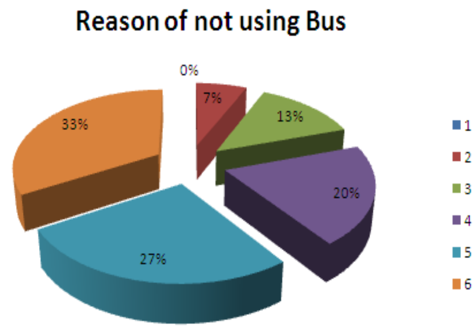


Figure 4. Percentage of Reason not using carFigure 5. Percentage Of Reason of not using Bus

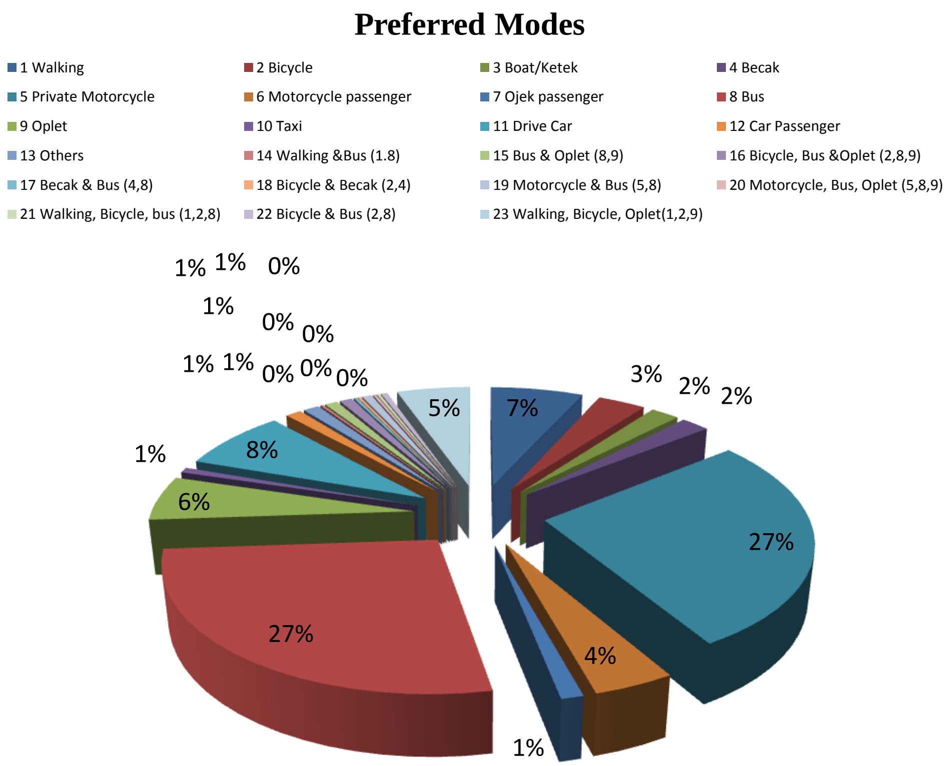


Figure 6. Percentage Of Preferred Modes

Figure 4,5 dan 6 show travel characteristic and related items data obtained from 2010 Cities Development Initiatives (CDIA) Palembang Urban Transport Study. The data was collected from 400 residents in the city of Palembang. The data show that rich diversity of modes in Palembang, bus and private motorcycle being a major mode in Palembang.

The data, which was collected from 400 residents in the city of Palembang, shows the diversity of using modes in Palembang. Bus and private motorcycle become major modes in Palembang.

4.MODELLING METHODOLOGY

4.1.Definitions

A "trip" is defined as a travel between two activities representing the trip purpose (Home (H) to Work (W), Home to School, etc.). The term "purpose" in this study is used to present the activity performed at the end of a trip. Furthermore, each trip record is coded with travel mode (auto, motorcycle, transit, etc.). A "tour", on the other hand, is defined as a chain of trips which starts from a base and returns to the same base. One or more activities (i.e.purposes) are involved in the course of a tour. Based on data for out-of-home activities, they are often grouped into the following three, commonly categorized as types of activity (Vovsha *et al.* 2004):

1. Mandatory activities (e.g. work, university, or school),
2. Maintenance activities (M) (e.g. shopping, banking, visiting doctor, etc.), and
3. Discretionary activities (D) (e.g. social and recreational activities, eating out, etc.).

For this study, mandatory activities are further divided into *work* and *school* purposes because there is essentially a difference between *work* and *school* as to by whom and when such activities are carried out. The last two activity types, *maintenance* and *discretionary* activities, are often treated as one type of activity, that is, non-mandatory pattern (Bradley and Vovsha 2005) that can be distinguished from mandatory primary activities such as *work* and *school* patterns. Activities are prioritized based on the purpose of the activity, with work activities having the higher priority, followed by other purpose. In this study this classification has been applied to deal with intra-household interaction in the activity-based travel demand model.

The period of time in a day is divided by modeling framework used by Bath and Singh's research Comprehensive Daily Activity-Travel Generation Model System for Workers, 2000. Time for workers are divided into five time periods: the period of time before work (before-work period/BW), time from home to office (home-to-work commute period/HW), time for work (work-based period/WB), time from work time to home (work-to-home commute period/WH), after I got home (post-home-arrival period/PW).

4.2. Model Framework

The hierarchical activity based model assuming a hierarchical of model components with three types of major models, namely, choices of daily activity-travel patterns, time of day, and mode and destination in the hirarchy. While the unified activity based model system combines activity type choice, activity time of day choice, mode choice, destination choice and activity duration in a holistic unifying utility-maximization framework.

4.2.1. Hierarchical Model Framework Of Activity-Travel

For this study, the fundamental hierarchical modeling approach is a discrete choice model based on the random utility maximizing principles. It has been shown that the multinomial logit model is the most popular form of discrete choice model in practical applications (Mohammadian and Doherty 2005). Nested logit models are very commonly used for modeling mode choice, permitting covariance in random components among the nests of alternatives. Modlling fram based on household characteristics and travel in the city of Palembang, which include:

The modeling system in this study primarily adopts a modified version of the frameworks proposed for Jakarta (Yagi,S. and Mohammadian, A.,2006) to develop a credible model which can replicate the patterns of activity and travel in Palembang City. It has a similar tour-based structure in which the tour is used as the unit of modeling travel instead of the trip, preserving a consistency in destination, mode, and time of day across trips. The overall modeling structure based on household and travel characteristics is depicted in Figure 1.

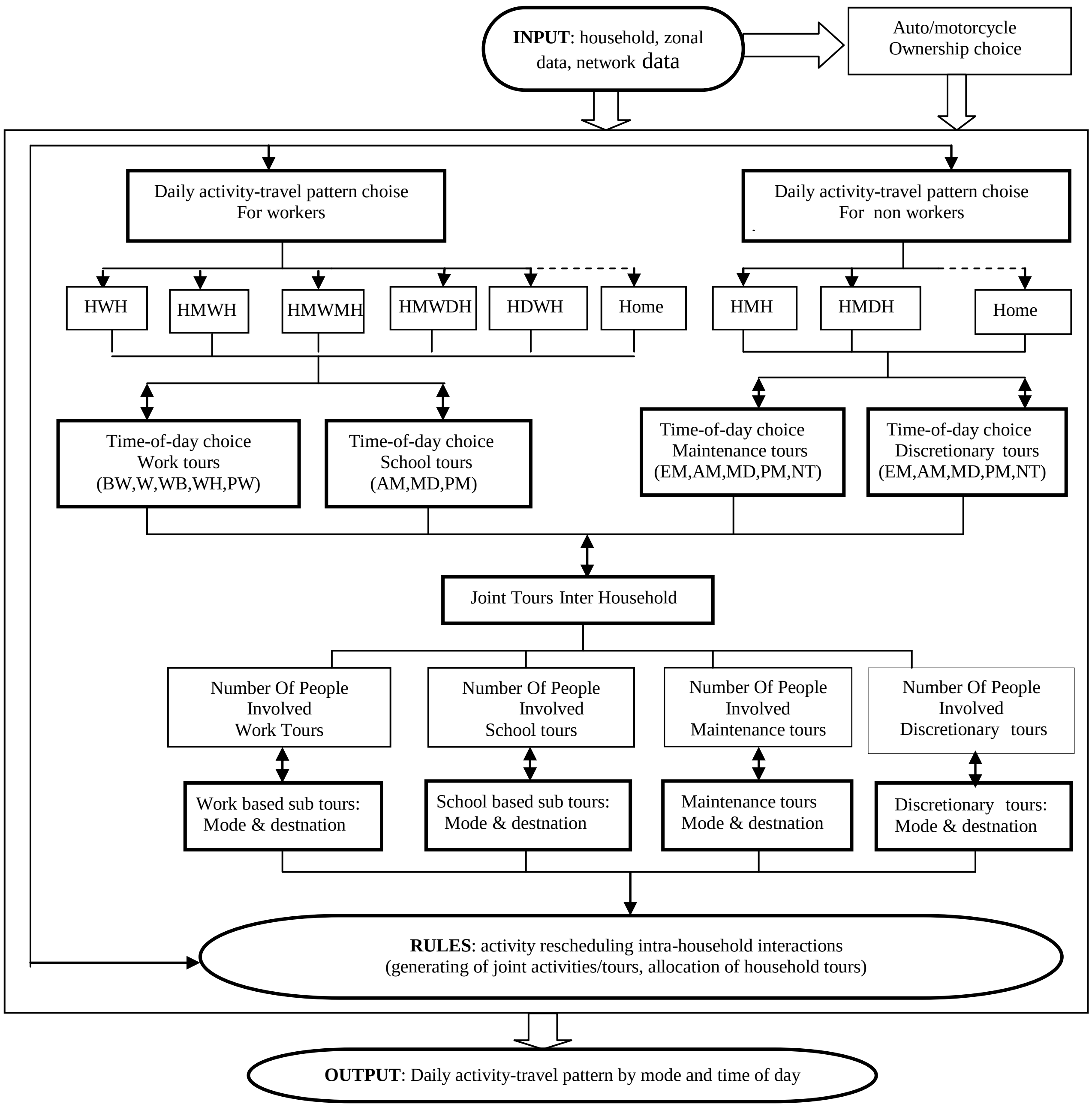


Figure 7. Hierarchical Modeling Framework of
Daily Activity-Travel Pattern By Mode And Time Of Day

The hierarchical activity based model assumes a hierarchical of model components with four types of major models, namely, choices of daily activity-travel patterns, time of day, Joint Tours Inter Household, mode and destination in the hirarchy. Hierarchical model framework of activity-travel in Palembang based on:

1. Although the ownership of cars and motorcycles in Palembang has risen rapidly in recent years, public transit and ojeg still in great demand by the people who do not have captive private vehicles (Figure 6)
2. The numbers of family members are relatively large but the number of vehicle ownership is limited so it tends to make a joint tour inter household (Figure 1).
3. Time of day choice for workers and non workers are more flexible because the distance of the location of the activity is relatively close.

Based on that situation, model framework of activity-travel in Palembang in figure 1 for home based tour, with four types of major models, namely choices of daily activity-travel patterns, times of day, joint tour inter household and mode-destination choices in the hierarchical. Lower level choices depend on the decisions at the higher level. The decisions, which are linked to the lower level choices through the logsum variables, reflect expected maximum composite utility of lower-level choices. Daily activity-travel patterns (DAPs) except for *home*, which means staying at home all day, are defined by primary activity, primary tour type, and number and type of secondary tours. Primary activities or purposes are classified as *home* (H), *work* (W), *school* (S), *maintenance* (M), and *discretionary* (D) for the sake of modeling. As shown in the example of Figure 1, each classification is represented as a string of letters indicating a sequence of activities. Note that ‘H’ is included at the beginning and the end of each string to show that it is a home-based tour. On the other hand, secondary tour type is defined by activity purpose, and it is classified into *maintenance* and *discretionary* activities. According to (Yagi, S. and Mohammadian, A., 2006) there may be 121 DAP alternatives combination including 1 *home* pattern, 60 primary *work* tour patterns, 20 primary *school* tour patterns, 20 primary *maintenance* tour patterns and 20 primary *discretionary* tour patterns.

In order to model the time-of-day (TOD) choice, a day is divided into five time periods, namely, early morning (“EM”, 3:00 – 6:29), a.m. peak (“AM”, 6:30 – 9:59), midday (“MD”, 10:00 – 15:59), p.m. peak (“PM”, 16:00 – 18:59), and night (“NT”, 19:00 – 2:59). These five time periods are distinguished by considering characteristic hourly traffic volume in Palembang. Time for workers are divided into five time periods: the period of time before work (before-work period/BW : 3:00 – 6:29), time from home to office (home-to-work commute period/HW: 6:30 – 9:59), time for work (work-based period/WB : 10:00 – 15:59), time from work time to home (work-to-home commute period/WH: 6:30 – 9:59), after I got home (post-home-arrival period/PW: 10:00 – 15:59).

Choice number of people get involved in work, school, *maintenance* and *discretionary* activities can be 0,1,2,3,….,.Mode and destination choice are placed at the “bottom” of the hierarchical consisting of the three major models, and are conditional on decisions at the higher levels, those are, choices of DAPs and TODs by purpose and Joint Inter Household. Eight of the most commonly used combinations of travel modes observed in the region are considered. These include auto drive alone (ATD), auto shared ride (ATS), motorcycle (MTC), taxi (TXA), motorcycle taxi (TXM), transit with motorized access (TRM), transit with non-motorized access (TRN), and non-motorized transport (NMT). For the destination choice, some representative destinations are considered for each tour in order to reduce the complexity computational process.

Conditional probability that daily activity-travel pattern will be chosen:

$$\mathrm{Prob}_{\mathrm{DAP_i}} = \mathrm{Prob}[\mathrm{U}_{\mathrm{DAP_i}} + \max(\mathrm{U}_{\mathrm{time\ j}|\ \mathrm{DAP_i}}) > \mathrm{Prob}[\mathrm{U}_{\mathrm{DAP_k}} + \max(\mathrm{U}_{\mathrm{time\ j}|\ \mathrm{DAP_i}}) \qquad (1)$$

Where $i \neq k$

$\mathrm{Prob}_{\mathrm{DAP_i}}$: Probability that daily activity-travel pattern i will be chosen

$\mathrm{U}_{\mathrm{DAP_i}}$: Utility of daily activity-travel pattern i

$\mathrm{U}_{\mathrm{time\ j}}$: Utility of time of day j

Probability expression for each level can be computed using the following standard multinomial logit formula :

$$P_{ni} = \frac{e^{V_{ni}/\lambda_k} \left(\sum_{j \in B_k} e^{V_{ni}/\lambda_k} \right)^{\lambda_k - 1}}{\sum_{l=1}^{K} \left(\sum_{j \in B_l} e^{V_{ni}/\lambda_l} \right)^{\lambda_l}} \qquad (2)$$

$$\lambda_{ij} = \log \left\{ \sum_{i=1}^{n} \exp v_{ij} \right\} \qquad (3)$$

Where:

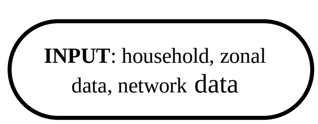
P_{ni} : Probability that alternative *n* will be chosen for individu *i*

V_{ij} : Deterministic function of alternatif *j* for individu *i*

λ_{ij} : Logsum variables

4.2.2. Unified Model Framework of Activity-Travel

The unified activity based model system combines activity and travel characteristics choices in a holistic unifying utility-maximization framework. As mentioned in the previous section, the unified activity based model system in this paper covers activity type choice, activity time of day choice, travel mode choice, joint tour inter household choice, activity location (destination) choice, and activity time use allocation (duration). In the current study, individual time budget is required in the unified activity based model system model is specified as (24 hours – individual's sleep activity duration) (Bhat, 2010). The establishment of a model based on the assumption is expected to be short-term choices made contemporaneously. The overall modeling structure based on household and travel characteristics is depicted in Figure 2.



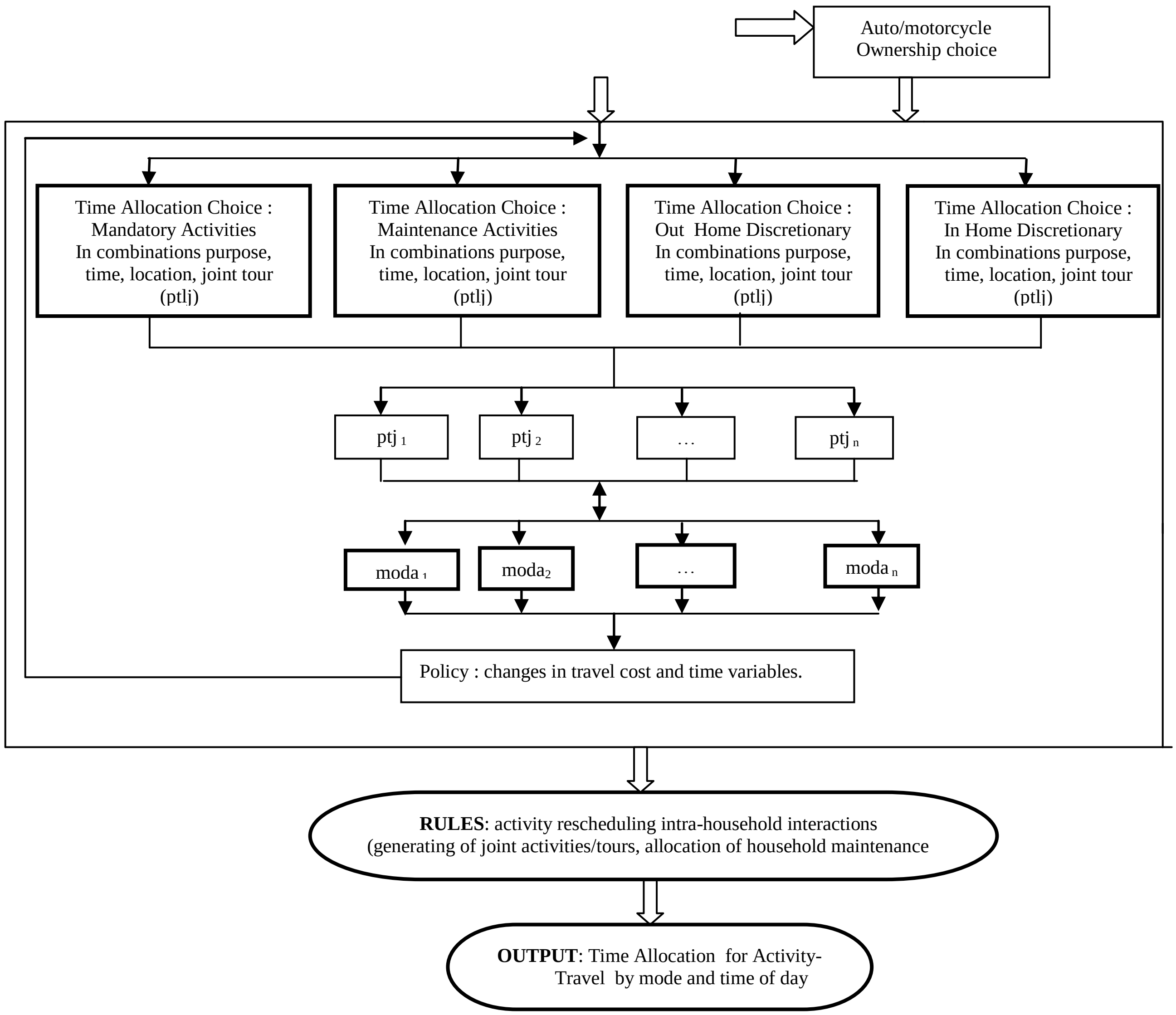


Figure 8. Unified Modeling Framework of
Daily Activity-Travel Pattern By Mode And Time Of Day

The probability that the individual chooses activity time use allocation (duration) $x_1^*, x_2^*, ..., x_Q^*$, activity type, activity time of day, joint tour inter household and activity location (destination).

$$P(x_1^*, x_2^*, ..., x_Q^* 0, 0, ..., 0) = \left[\prod_{k=1}^{Q} r_k\right]\left[\sum_{k=1}^{Q} \frac{1}{r_k}\right]\left[\frac{\prod_{k=1}^{Q} e^{V_k}}{\left(\sum_{h=1}^{K} e^{V_h}\right)^Q}\right] \tag{4}$$

Where : $r_1 = \left(\frac{1}{x_k^*}\right)$ and $r_k = \left(\frac{1}{x_k^* + \gamma_k}\right) \forall k > 1$ (5)

$$V_1 = \beta' z_1 - \ln(x_1), \tag{6}$$

$$V_2 = \beta' z_2 - \ln\left(\frac{x_2}{\gamma_2} + 1\right), \text{ and} \tag{7}$$

$$V_k = \beta' z_k + \theta_k \ln \sum_{l \in N_k} \left(\frac{\phi' w_{lk}}{\theta_k}\right) - \ln\left(\frac{x_k}{\gamma_k} + 1\right); \forall k > 2 \tag{8}$$

$\beta' z_1$ dan $\beta' z_2$: Basic utility component from *maintenance* and *discretionary* activities in and out of home

ε_1 dan ε_2 : Unobserved components assumed to be independent and identically Gumbel distributed

Conditional probability that mode (*m*) will be chosen for an activity episode purpose (*p*), time of day (*t*), joint tour inter household (*j*) and activity location (*l*) or *ptlj* combination *k*, given that x_k^*>0, is given by :

$$P\,(m \mid x_k^* > 0\,; m \in N_k) = P\,[\ \varphi' w_{mk} + \eta_{mk} > \phi' w_{mk} + \eta_{mk}\ \forall\ l' \neq l] \tag{9}$$

η_{mk} : Unobserved components assumed to be independent and identically Gumbel distributed across different activity episode

$\phi' w_{mk}$: Observed components assumed to be independent and identically Gumbel distributed across different activity episode

Unified model framework of activity-travel in Palembang based on:

1. Palembang urban population who mostly work as self-employed (Figure 3) have led to uncertainty to their daily activity schedule, so the choice of generating activity more prioritized alternative combinations of time-duration, not on the agenda of alternative combinations of activities carried out in one day like in hierarchical activity based model .
2. Destination, mode, activity type, activity duration and joint tour choices that is expected to be short-term choices made contemporaneously. Those decisions are made at one time spontaneously and not gradually
3. Although the ownership of cars and motorcycles in Palembang has risen rapidly in recent years, public transit and ojeg still in great demand by the people who do not have private vehicles
4. The numbers of family members are relatively large but the number of vehicle ownership is limited. So it tends to make a joint tour inter household.

The unified activity based model system is formed as a combination of activity type, time of day, and travel mode while the duration of each activity constitutes the continuous dependent variable.

4.3. Comparison of the Unified and the Hierarchical Model Framework

The major objective of this paper is to describe household travel characteristics in Palembang and the general modeling framework of hierarchical and unified model of activity type choice (generation), time of day choice, mode choice, destination choice, and time use allocation (duration). This study is a first step in modeling activity based travel behavior in a city in a developing country. Although the data presented is very limited, but hopefully this study can form the basis for further study of the activity data and a more complete way. The unified and hierarchical activity based models system are based on random utility logit and nested logit models. The calibration and validation of the model need Household Travel Survey (HTS) and Activity Diary Survey (ADS).

Some important things of the data collected, as in section 4.3. can be used as input data for the model to form a hierarchical structure and unity of activity-based travel demand model are :

1. Palembang has a relative great number of household members. Based on household survey, the average number is 6 persons, consist of father, mother and children so that joint tour inter household should be considered in the model structure.
2. According to a survey conducted by BPPS Palembang, 25% population in Palembang has an employment status as entrepreneurs. This means activities undertaken to work less bound by time and this also affects the time of day choice for mandatory, maintenance and discretionary activities.
3. The data, which was collected from 400 residents in the city of Palembang, shows the rich diversity of modes in Palembang. Bus and private motorcycle become major modes in Palembang, so that the competition of the transportation modes should be considered in the random utility model.

The other things that can be analyzed from the comparison between modeling framework of hierarchical and unified model of activity-travel choices are :

1. A hierarchical of activity based travel demand model in Palembang assumes one choice process is nested within another choice process and so on, forming a long chain of inter-connected nests to complete the representation of the behavioral process. Mode and destination for work and school based subtour depend on joint tour inter household. Joint tour inter household depends on time of day choice for doing activities.
2. The unified activity based model system is relatively simpler because the model combines the fifth choice in the maximum utility model framework. (Bhat, 2010) found that the unified activity and tour- based model systems universally strive to mimic and replicate activity-travel choice processes of individuals.
3. The unified approach assumes time allocation, activity type, location and inter-household joint tour choices which influence people for selecting modes.
4. For the hierarchical model, each policy can change activity patterns in a day. It can be seen also how they affect people for selecting location and mode to do their activities.

5. CONCLUSIONS

This paper describes household travel characteristics in Palembang and the general modeling framework of hierarchical and unified model of activity type (generation), time of day, mode, destination and time use allocation (duration) choices. The unified and hierarchical activity based models system are based on random utility logit and nested logit models. The hierarchical activity based model assuming model components with four types of major models, namely, choices of daily activity-travel patterns, time of day, joint tour inter household, mode and destination in the hirarchy. While the unified activity based model system combines activity type choice, activity time of day choice, mode choice, destination choice and activity duration in a holistic unifying utility-maximization framework.

The modeling system in this study primarily adopts a modified version of the frameworks proposed for Jakarta (Yagi, S. and Mohammadian, A., 2006) and for San Francisco (Bath, 2010). Options-choice of activities and trips are organized within the framework of a model adopted to the conditions activities and travel characteristic in Palembang, such as :

1. Public transit and ojeg still in great demand by the people who do not have private vehicles
2. The numbers of family members are relatively large but the number of vehicle ownership is limited so it tends to make a joint tour inter household.
3. Time of day choice for workers and non workers are more flexible because the distance between the location of the activity is relatively close.
4. Urban population who mostly work as self-employed have led to uncertainty to their daily activity schedule

In this study, the hierarchical model assumes there is a structured alternative to higher levels than other alternatives. Decision making process for the higher level alternatives in the hierarchical has a longer period of time than the decision-making process for alternatives that exist at the bottom level. On the other hand, the unified model is based on the assumption which is expected to be short-term choices made contemporaneously.

Although the data presented in this paper is very limited and the data analysis has not done in-depth, but hopefully this study can form the basis for further study of travel behavior models in Palembang. The unified and hierarchical activity based models system are based on random utility logit and nested logit models. Calibration and validation process of the models need Household Travel Survey (HTS) and Activity Diary Survey (ADS). Once the HTS and DAS data are collected, the next study will continue to test the validity of the unified and hierarchical activity based travel models for the city of Palembang. Based on this study, it is hoped that we can understand the factors better that must be considered from the study area before making travel behavior activity based model. So the models can be used to mimic and replicate activity and travel choices process of individuals in developing countries.

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