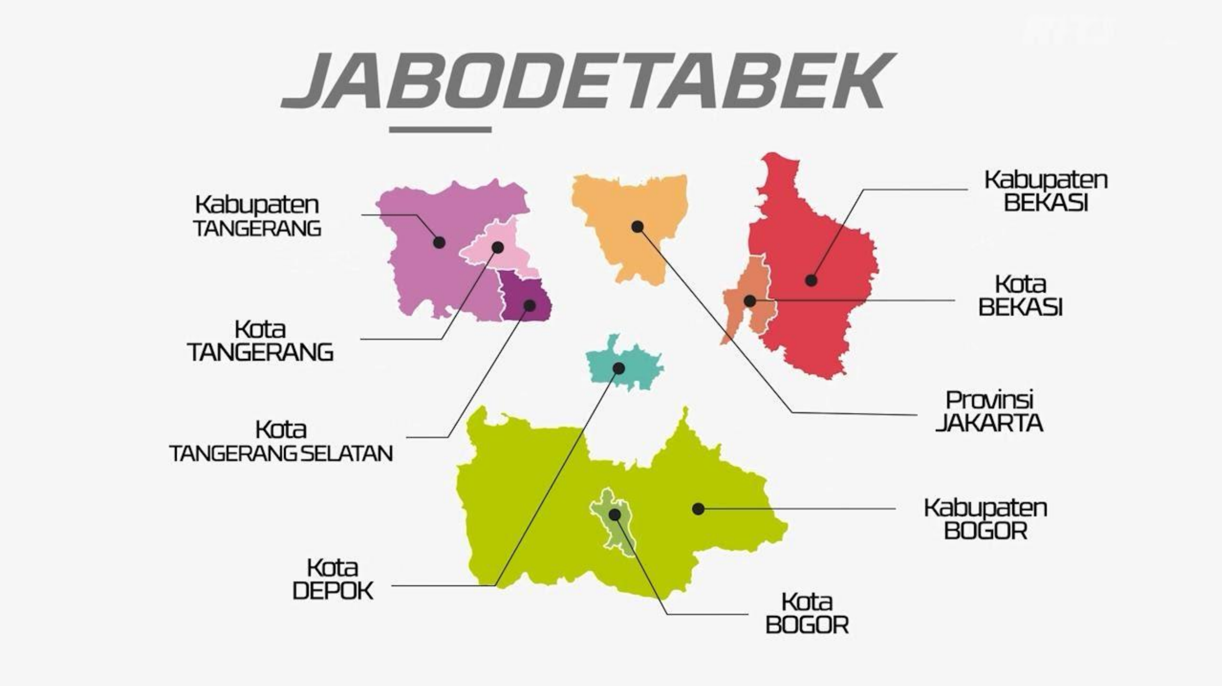

Measuring accessibility using an activity based model approach in Jabodetabek

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Abstract

This research will capture individual travel behaviour characteristics and estimate the accessibility level using an Activity Based Model (ABM). This method has become popular for many researchers with its ability to capture individual travel characteristics. It can accurately measure accessibility, however not many researchers do utilize it for that purpose yet.

The case study of this research is the Jakarta agglomeration (Jabodetabek: Jakarta-Bogor-Depok-Tangerang-Bekasi), which has a population of approximately 29 million inhabitants. It is the 2nd biggest agglomeration worldwide after greater Tokyo. The majority of people who live in the area surrounding Jakarta perform their primary activities (working, studying, shopping, etc.) in Jakarta. Therefore, measuring accessibility is very important to understand how the current transport infrastructures support commuting in this area.

The data that for this study is obtained from JICA who conducted a study named Japtrapis (JABODETABEK Public Transport Policy Implementation Strategy). The data that we use for this study are the Household Travel Survey (HTS) and the Activity Diary Survey (ADS) with in total 178.954 households.

Keywords

Activity Based Model (ABM), MATSim, Accessibility, Jakarta.

1. Introduction

Accessibility is an interesting issue to be discussed for the Jakarta agglomeration (Jabodetabek: Jakarta-Bogor-Depok-Tangerang-Bekasi). The urban public transport infrastructures, which can not serve the demands of all persons, lead to low accessibility. It causes individuals to rely on a car, motorcycle, and even on taxi app based transportation (i.e. Uber, Grab, and Gojek). It is clearly understandable why people in low accessibility areas tend to have a higher number of private vehicles to support their daily activities. By knowing the level of accessibility, we will know which location should be prioritized to make urban transport more accessible, and as Loder and Axhausen (2016) found that the probability of car ownership decreases, while accessibility increases.

Accessibility can be defined as the availability of means of urban transport to support the travel of individuals from their homes to their destination locations (Dalvi and Martin, 1976) and can also be measured based on several assumptions on travel behavior and transport supply (Pirie, 1979). The method to measure accessibility needs improvement, especially to capture activity patterns using activity-based models. As Geurs and Van Wee (2004) explained, there are four common methodologies to measure accessibility that such as infrastructure-based, location-based, person-based, and utility-based, which different methodologies have different strengths and weaknesses.

In this paper, we will measure accessibility using the dynamic transport simulation system MATSim. The locations of home and office, sociodemographic characteristics such as income, the number of household members, and vehicle ownership, have an influence on each individual decision, such as where to travel and which mode of transport to take. Those factors will be our concern for the further investigation of accessibility levels.

2. Accessibility

There is a rich literature that tries to measures accessibility. Paez et al. (2012) reviewed several measures of accessibility with the focus on normative (i.e. prescriptive), and positive aspects (i.e. descriptive) in the city of Montreal, Canada, and they identify the gap between desired (as normatively defined) and actual levels (as revealed). Chen et al. (2013) developed a reliable space-time prism model to analyze service areas with travel time uncertainty and continued their research to evaluate accessibility under travel time uncertainty for large-scale urban areas. This research was inspired by a placed-based framework (Chen et al, 2016).

Hallgrimsdottir et al. (2016) have examined accessibility policy for older people and wheelchair user in Sweden between 2004 and 2014 for the outdoor environment. Pyrialakou et al. (2016)

have measured, identified, evaluated, and quantified transport disadvantages in the U.S with measure accessibility, mobility, and travel behavior. Maroto and Zofio (2016) have measured accessibility infrastructure in different regions using the non-parametric frontier approach (DEA) with a dynamic scope (Malmquis indices). Lättman et al. (2016) have developed a Perceived Accessibility Scale (PAC) that measured people perception when they travel with a specific mode of transport.

Furthermore, Dong et al. (2005) have used ABA (activity-based accessibility) to measure all individual activities, to integrate scheduling and travel characteristic, and to examine all trips and activities throughout the day. Dubernet and Axhausen (2016) have measured accessibility using a joint destination-mode choice model and MATSim. There are three basic models that should be calculated to measure accessibility, i.e. destination choice, mode choice, route choice.

2.1 Accessibility measurement

The measurement of accessibility in this study is following MATSim accessibility extension seen as potential accessibility (Ziemke, 2016). Hansen (1959) defines the potential accessibility and calculates it for the whole scope of activities facilities (e.g. shopping, leisure, etc.). In our case, the accessibility is calculated based on a primary tour of home-to-work-to-home and home-to-school-to-home. The mathematical form is as follows:

$$A_l = g\left(\sum_j a_j f\left(c_{lj}\right)\right) \quad (1)$$

where,

j : All possible destinations (opportunities),

a_j : Opportunities attracting the traveller,

c_{lj} : The generalized travel cost between origin i and destination j,

$f(c)$: An impedance distance function which (typically) decreases with increasing costs,

$g(.)$: An arbitrary, but usually monotonically increasing function.

3. Activity-based model

Activity-based models became popular for many researchers with their ability to capture individual travel characteristics based on sociodemographic variables using discrete choice models (see, for example, Axhausen and Gärling, 1992; Bowman and Ben-Akiva, 2000; Dubernet and Axhausen, 2016). These models enable us to estimate the impact of accessibility in every situation and for every profile of respondents, with each individual having a different utility.

4. Data Collection and Sample

The data for this study was obtained from the 2010 JICA study that designed the JABODETABEK Public Transport Policy Implementation Strategy (JAPTRAPIS) with the Household Travel Survey (HTS) and Activity Diary Survey (ADS). The HTS sample consists of 178,954 households which is equal to three percent of all households. Those household members who had work or study activities were further surveyed. The total number of respondents is equal to 334’973. The ADS for three working days has 600 respondents with 300 respondents for the urban area (i.e. DKI Jakarta, Depok, Tangerang, Bekasi, Tangerang Selatan) and 300 for the suburban areas (Bogor Regency, Tangerang Regency, Bekasi Regency, and Bogor City).

The HTS data contains information on:

1. Home location and office location.
2. Population group (worker, student, non-worker).
3. Mobility tools (car, motorcycle, public transport).
4. Age.
5. Sex.
6. Household income.

The summary statistics of the sample data are presented in Table 1.

Table 1. Sample summary statistics

Categorical variable	N	Share (%)
Person is male**	234'181	69.91
Employed**	202'924	60.58
University degree***	96'542	47.58
Age categories**		
Less than 6 years old	9'212	2.75
6 - 12 years old	62'086	18.53
12 - 18 years old	53'286	15.91
18 - 24 years old	34'627	10.34
24 -32 years old	51'435	15.35
32 - 42 years old	61'023	18.22
42 - 60 years old	57'565	17.18
More than 60 years old	5'739	1.71
Household income (in IDR per month*)		
No answer	1'445	0.81
Less than IDR 1 M	28'024	15.66
IDR 1 M - 3 M	116'461	65.08
IDR 3 M - 5 M	23'369	13.06
IDR 5 M - 8 M	6'746	3.77
IDR 8 M - 15 M	2'216	1.24
More than 15 M	692	0.39
Total expenditures (in IDR per month*)		
No answer	1'818	1.02
Less than IDR 1 M	69'646	38.92
IDR 1 M - 3 M	96'849	54.12
IDR 3 M - 5 M	8'204	4.58
IDR 5 M - 8 M	1'825	1.02
IDR 8 M - 15 M	506	0.28
More than 15 M	105	0.06
Transport expenditures (in IDR per month*)		
No answer	16'798	9.39
Less than IDR 1 M	150'430	84.06
IDR 1 M - 3 M	11'229	6.27
More than 3 M	496	0.28
Spatial household location		
DKI Jakarta	53'084	28.72
Agglomeration Jakarta	131'781	71.28

Categorical variable	N	Share (%)
Car ownership		
No car	164'364	82.95
1	12'703	7.10
2	1'486	0.83
3	270	0.15
More than 4	130	0.07
Motorcycle ownership		
No Motorcycle	53'009	29.62
1	92'668	51.78
2	26'274	14.68
3	5'635	3.15
More than 3	1'367	0.76
NMT ownership		
No NMT	146'724	81.99
1	24'786	13.85
2	5'722	3.20
3	1'192	0.67
More than 3	529	0.30
Driving license**		
Motorcycle license	98'854	29.56
Private car license	7'410	2.22
Passenger vehicle license	2'512	0.75
Motorcycle & car license	13'195	3.95
Motorcycle & pasanger vehicle license	1'385	0.41
No license	211'087	63.12
Most frequently used mode of transport		
No answer	4'795	2.68
Comuter rail	7'554	4.22
BRT	7'264	4.06
Feeder	46'090	25.76
Taxi	171	0.10
Motorcycle taxi	6'524	3.65
Car	7'225	4.04
Motorcycle	94'507	52.81
NMT	3'383	1.89
Others	1'440	0.80

*At time the survey was conducted, 7,470; IDR was equivalent to 1 US Dollars

** The calculation is based on member of household who had work or study

*** The calculation is based on working member of household

Table 2 shows the distribution of the most frequent mode of transport by mobility tool ownership. There are 4.02% of a car owners, who use rail-based, 3.92% using BRT, and 8.07% are using feeders. For motorcycle owners, there are 3.92% using rail-based, 4.09% are using BRT, and 13.41% are using feeders.

Table 2. Distribution of the most frequent mode of transport with mobility tool owned

Mobility tool		Rail based		BRT		Feeders		Car		Motorcycle		Non-motorized	
		Most frequent mode of transport											
		N	%	N	%	N	%	N	%	N	%	N	%
Car	No	6484	4.48	6146	4.24	47995	33.13	731	0.50	80611	55.64	2905	2.01
	Yes	576	4.02	561	3.92	1156	8.07	6408	44.75	5559	38.82	60	0.42
Motorcycle	No	2520	5.62	1977	4.41	33708	75.14	1522	3.39	2929	6.53	2206	4.92
	Yes	4862	3.92	5067	4.09	16615	13.41	5523	4.46	90985	73.43	849	0.69

5. Analysis

In this study, the activities of agents are simulated using MATSim based on geocoded locations of home and work or school location. There are around 600,000 homes and workplaces that were geocoded. The network is developed based on OSM for the Jakarta agglomeration consisting of 450,000 links. The activities that will be modeled are a primary tour of home-to-work-to-home and home-to-school-to-home.

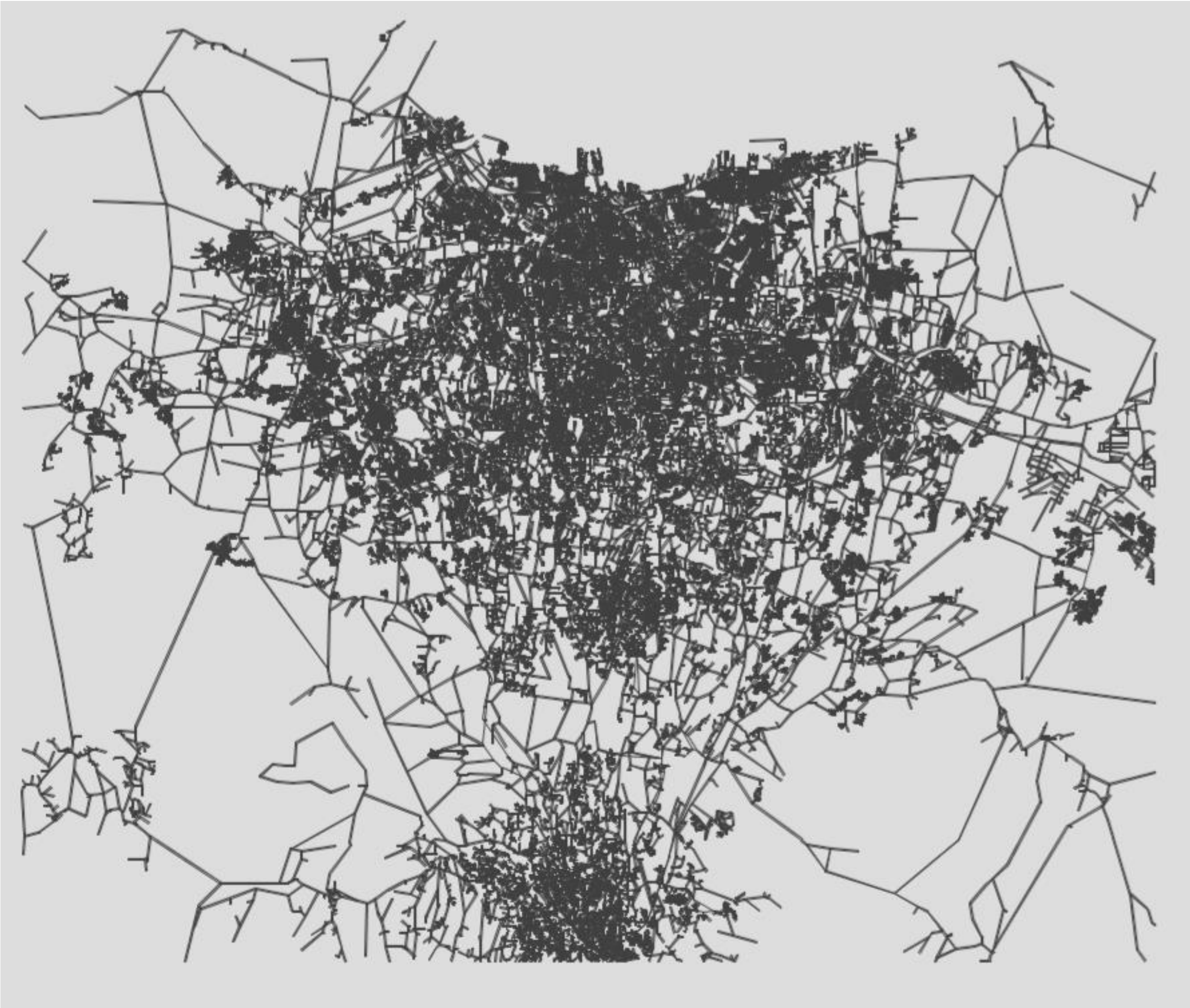
There are several file several files with XML format will be included in the model.

1. The activities of each agent or event file (see. Figure 1).
2. The network file of Jakarta based on OSM (see. Figure 2).
3. Public transport network and schedule.

Figure 1. Example of the events XML

```
<person id="1" age="25">
    <plan selected="yes">
        <act type="home" x="106.705478" y="-6.174926" end_time="05:48:18" />
        <leg mode="car">
        </leg>
        <act type="work" x="106.689964" y="-6.117689" end_time="16:48:18" />
        <leg mode="car">
        </leg>
        <act type="home" x="106.705478" y="-6.174926" />
    </plan>
</person>
```

Figure 2. Jakarta agglomeration area's OSM network



6. Further Work

Estimation of accessibility is important to support the further development urban transportation in Jabodetabek. The lack of accessibility tends to reduce the utility of public transportation, and people tend to use a private vehicle to support their activities as their mobility tools.

Further development is strongly needed to increase the accuracy of measurement. There are several issues should be addressed in future model development.

1. Motorcycle should be included. Motorcycle is the main mode transport that provides low cost and high mobility but less safety for people. It is important to address because of the huge number of motorcycle in Jakarta but also in other Asian cities.

2. Public transport, there several public transportation modes that will be included in the model such BRT, MRT, LRT, and feeder buses.
3. Public transport schedule for each mode of transport (e.g. fixed schedule, real-time GPS data).
4. Office building locations.
5. Development of a synthetic population.
6. Development of a further type of activities such as leisure, shopping, etc.

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