Transport Mode Choice by Land Transport Users in Jabodetabek (Jakarta-Bogor-Depok-Tangerang-Bekasi): An Urban Ecology Analysis

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***Abstract*—**Understanding the transport behaviour can be used to well understand a transport system. Adapting a behaviour approach, the ecological model, to analyse transport behaviour is important because the ecological factors influence individual behaviour. DKI Jakarta (the main city in Indonesia) which has a complex transportation problem should need the urban ecology analysis. The research will focus on adapting an urban ecology approach to analyse the transport behaviour of people in Jakarta and the areas nearby. The research aims to empirically evaluate individual, socio-cultural, and environmental factors, such as age, sex, job, salary/income, education level, vehicle ownership, number and structure of family members, marriage status, accessibility, connectivity, and traffic, which influence individuals' decision making to choose transport modes. The main finding is that the three-level of ecological perspective in analysing transport behaviour cannot fully be applied in Greater Jakarta as a busiest city in Indonesia. The only two-level perspective that may explain the behaviour was the individual and social factors. The environmental factors may contribute only a small proportion to someone decision to select the land transport mode in Greater Jakarta. Some factors that have greater proportion are sex, household income, and the number of vehicles owned. Meanwhile, the environment accessibility, connectivity and traffic variable had the lowest accuracy values.

***Keywords*—**urban transport, urban ecology, individual factor, social factor, environmental factor, transport mode choice.

I. Introduction

TRANSPORTATION problem in Jakarta is complicated. Based on data from reference [4], the number commuters in Indonesia have reached 7.6 million people. In Jakarta, about 78.4% employees use personal vehicles, cars or motorcycles [17], so that there are about 5 million vehicles come into and stay in Jakarta every morning [16]. The result is, more and more traffic congestion in the Greater Jakarta (Jabodetabek or Jakarta-Bogor-Depok-Tangerang-Bekasi) every day.

An improvement of transportation system has begun in Jakarta. The solution is through the development of Macro Transportation Pattern (Pola Transportasi Makro) of subway, bus-way, monorail, and Waterway [16]. However, these solutions are still relatively less effective to reduce the congestion. This is because of the preferences that are more private vehicles- oriented than public transport-oriented. Additionally, the development of an integrated transportation system in Jakarta is still not adequate to cope with the problem.

Understanding the transport behaviour can be used to well understand a transport system. Some research done in the developed countries has used the behaviour approach to encourage changes in behaviour to be more sustainable such as the use of public transport, cycling, and walking as a mode of transportation (to be described in the literature review). Adapting the ecological models approach is important because the ecological factors determine individual behaviour ([13]; [22]; [20]; [18]; [25]). Also, reference [7] uses this ecological approach to develop a model that explains the relationship between the economic status (socio-economic status / SES) with the behaviour of walking as a mode of transport.

DKI Jakarta is an urban area that requires intervention to address the problem of transportation. The analysis of urban ecology enables decision makers to make interventions that are considered to be important for the development of transportation systems. This research will focus on the application of urban ecology approach to analyse the transport behaviour of the citizens of Jakarta and its surrounding areas. This research aims to prove the factors of individual, social, cultural and environmental (details described in the literature review of factors) that influence the decision to choose the mode of transport in DKI Jakarta and surrounding areas (Greater Jakarta).

The information gaps about what factors influence the behaviour of road transport users to choose a specific transport mode will limit the understanding of the behavioural tendencies. Thus, the intervention will also be less than optimal. The research is expected to provide inputs for the manager and person in charge of transportation in DKI Jakarta and surrounding areas for the development of transportation systems in the future. Furthermore, with an improved transportation system, quality of life of people in Greater Jakarta will increase as well.

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II. Research Methodology

This study used primary data by using a research instrument of questionnaires *(travel survey)* with a design that adapts the KONTIV-design [6] with a participant from the Greater Jakarta area. For the primary data, the sampling method was *stratified-cluster sampling*. Each city/municipality in the Greater Jakarta area, namely North Jakarta, South Jakarta, East Jakarta, West Jakarta, Central Jakarta, Tangerang, Bekasi, Depok, and Bogor, sampled as many as 14 individuals/samples per location. Samples were also stratified according to economic status [7], the middle class and lower-upper. In accordance with KONTIV design [6], surveys conducted for 1 person (mostly often travel in the household) per travel day. The travel day was randomly selected for each person. So the *sample size* was 126 (or 126 days for the time of the survey.)

The survey form designed to be consisted of 1 form a travel diary and 1 form of household information. The factors studied are shown in Table 1.

TABLE 1
THE FACTORS IN URBAN ECOLOGY MODEL PROPOSED

Factor	References
Individual Factors	
Age	[8]; [21]; [24]
Sex	[8]; [21]; [24]
Job	[8]; [2]; [24]
Income / Salary	[2]; [7]
Level of education	[8]; [21]; [2]; [24]; [23]; [7]
Social factors	
Number of vehicles owned	[24]; [7]
The number of persons in a household	[7]
Marital status	[26]; [2]
Environmental factors	
Environmental Accessibility	[19]; [21]; [24]; [12]; [3]; [7]
Connectivity road	[19]; [21]; [24]; [12]; [3]; [7]
Traffic (road density levels in the environment)	[19]; [21]; [24];[12]; [3]; [7]

Thus, here are the hypotheses to be tested through this research:

Hypothesis 1 (H1): Age influence the decision to select the mode of land transport

Hypothesis 2 (H2): Gender influence the decision to select the mode of land transport

Hypothesis 3 (H3): Job/employment influence the decision to select the mode of land transport

Hypothesis 4 (H4): Income/salary influence the decision to select the mode of land transport

Hypothesis 5 (H5): The level of education influence the decision to select the mode of land transport

Hypothesis 6 (H6): Number of vehicles owned effect on decision-making to select the mode of land transport

Hypothesis 7 (H7): The number of person in a household influence the decision to select the mode of land transport

Hypothesis 8 (H8): Marital status influence the decision to select the mode of land transport

Hypothesis 9 (H9): Environment accessibility influence the decision to select modes of land transport

Hypothesis 10 (H10): Connectivity influence the decision to select the mode of land transport

Hypothesis 11 (H11): Traffic influence the decision to select the mode of land transport

Meanwhile, this research used the *revealed preferences* diary system because it lets users record the actual events on the determined travel day. From 126 respondents gathered, it was found 475 trips data. However, there are 95 travel data that can not be used because of incompleteness. Thus, the completed travel data in the study was only 380 data. With 380 trips and 13 data variables to be studied, the ratio of variable-data was 1: 29.23. This ratio is considered to be adequate to conduct the research.

To analyse the relationship between the variables with the mode choice, this study used two methods, namely Neural Networks (NN) [10] and Support Vector Machine (SVM) [11]. Both methods use the n-fold cross validation to eliminate the dependency of data with the other data. In addition, testing for repeated NN for 10 times was to eliminate the influence of no randomisation in the calculation and see the average of each method performance.

Factors that were considered to have an influence on the selection of land transport modes were treated as *feature vectors*. Meanwhile, the types of land transport mode represent the type of cluster. The accuracy of the model indicated by how much the ANN or SVM distinguish the feature vectors into groups accordingly. This is commonly called as the level of accuracy *(accuracy rate).* The accuracy is the point of measuring how well the above factors have an influence on the participant selection over the land transport modes.

Then, because of only few amount of data (126 sample) used in the study, this study used cross validation techniques *(cross validation technique)* and techniques of randomization *(randomization technique)* [9]. The cross validation technique involves a couple of times training and testing with training data and testing data in exchange-rates. Both of these

techniques help to overcome the possibility of abnormal data. In addition, these techniques will also help in *over fitting* the ANN/SVM model to keep suit to the real situation..

III. Result And Discussion

A. Result

For the neural network method, the prediction of accuracy was only 26.56%. The accuracy was very low because it was only able to correctly predict 26.56% of the mode choice of the users. In addition, to see the influence of each variable, it was predicted by using one variable executed at a time. The accuracy results were as follows:

TABLE 2
THE ACCURACY RESULT FOR EACH VARIABLE USING NN METHOD

No	Variable	Accuracy
1	Sex	31.58%
2	Number of Cars	29.47%
3	Number of Motorbike	27.73%
4	Total Household Income	27.20%
5	Traffic	25.91%
6	Education Level	25.74%
7	Accessibility	23.49%
8	Marital status	23.40%
9	Age	23.16%
10	Connectivity	22.80%
11	Number of Persons in household	20.07%
12	Job/employment	18.73%
13	Income / Salary	17.75%

The highest accuracy obtained with the NN method was Sex, 31.58%. If we look at a recap summary of data on sex and mode of transportation below, there was such pattern. 43.75% of men travelled using motorbikes, while 24.47% percent of women used public buses/Transjakarta. In addition, the result of the overall accuracy which was only 26.56% was lower than the accuracy of the variable 'sex'. This is because the NN method always tries to accommodate all variable so that there is an interaction between variables which decreased the accuracy of the variable.

In addition, the number of vehicles (number of car ownership and total ownership of the motor) also explained the behaviour of the mode choice of Greater Jakarta (Jabodetabek). Also, comparing the variables 'Total household income' and 'individual income', it was obvious that the 'total household income' variable was more accurate to predict household mode choice than the 'individual income' variable.

TABLE 3
THE SUMMARY OF MODE CHOICE FOR EACH SEX

No.	Type of Transport Modes	Men		Women	
1	Office-owned car	9	4.69%	4	2.13%
2	Private car	34	17.71%	24	12.77%
3	Motorbike	84	43.75%	21	11.17%
4	On foot	22	11.46%	32	17.02%
5	Bicycle	6	3.13%	0	0.00%
6	Taxi	3	1.56%	10	5.32%
7	School/shuttle bus	0	0.00%	8	4.26%
8	Public bus / Transjakarta	19	9.90%	46	24.47%
9	Angkot (public transport)	9	4.69%	31	16.49%
10	KRL (Railway mode)	1	0.52%	5	2.66%
11	Others	5	2.60%	7	3.72%
	Total	192	100.00%	188	100.00%

Meanwhile, using the second approach, Support Vector Machine (SVM), the accuracy of predicting the transport mode choice was 57.11%. This accuracy results provided a more satisfactory results than the former method. This accuracy of 57.11% can be achieved by SVM using convex optimization exact method by separating one class mode of transportation with other transportation modes. The accuracy of each variable using the SVM method is presented in the following table:

TABLE 4
THE ACCURACY RESULT FOR EACH VARIABLE USING SVM METHOD

No	Variable	Accuracy
1	Total Household Income	42.36%
2	Income / Salary	34.73%
3	Sex	34.21%
4	Number of Cars	33.42%
5	Age	32.36%
6	Number of Motorbike	28.94%
7	Number of Persons in household	27.63%
8	Marital status	27.63%
9	Job/employment	27.63%
10	Education Level	27.63%
11	Accessibility	27.63%
12	Connectivity	27.63%
13	Traffic	27.63%

It can be seen from the table above, the variable that had the highest level of accuracy was 'Total household income'. The result was similar to the previous result using NN. However, the variable 'income individuals' had a higher accuracy result than using the NN. This was caused by the nonlinear methods using by SVM that was more able to differentiate between groups compared to the linear

summation method using by NN. This also applied to other variables. The accuracy for each variable obtained from SVM was always higher than the accuracy result obtained from NN.

Besides, using VSM method, the accessibility, connectivity and traffic variable had the lowest accuracy values. This can be caused by the Greater Jakarta was too populated and the daily habits of transport users that mostly ignore the environmental factors, in this case: accessibility, connectivity and traffic variable.

B. Discussion

From the result provided above, it can be seen that the three-level of ecological perspective in analysing transport behaviour cannot fully be applied in Greater Jakarta as a busiest city in Indonesia. The only two-level that may explain more about the behaviour was the individual and social factors.

The highest accuracy obtained with the NN method was sex. 43.75% of men travelled using motorbike, while 24.47% percent of women used public bus/Transjakarta. It was somehow in line with the greater household transport survey conducted in 2002, called SITRAMP (Study On Integrated Transportation Master Plan for Jabodetabek), that found that women mostly used public bus for their motorised transport mode [1]. However, although men also used public used mostly, the second choice was motorbike. The change is due to the fact that the growth in motorbike users was predicted higher (1.7) than public bus users (1.6) [1]. Reference [5] also reports that the highest number registered motor vehicles in Jakarta are motorbike, and in the year 2009 it already reached the number of 8,000,000.

The gender difference in the mode choice reason can be explained by [14] that argue that men spend more travelling time than women. In addition, [15] find that women make more trips than men. It is significantly important that there is a different attitude and approach towards different gender in transportation issue. Several resources have been provided by DKI Jakarta government to meet this different gender attitude, for example the availability for two women-only train carriages in each Express and AC-economy train.

Meanwhile, in the social factors, the 'number of vehicles' variable (number of car ownership and total ownership of the motor) can also influence more the mode choice of Greater Jakarta (Jabodetabek). SITRAMP has shown that cars and motorcycles were used by more people with more cars and motorcycle owned [1].

In addition, comparing the variables 'Total household income' and 'individual income', the 'total household income' variable was more accurate to predict household mode choice than the 'individual income' variable. Although income/salary is in the group of individual factor, the household income is a factor in another level, social factors. Explaining the factor of the household income, [7] use household income to define individual level SES (Socio-Economic Status) that influence walking for transport.

On the other hand, using SVM method, the accessibility, connectivity and traffic variable had the lowest accuracy values. This can be caused by the Greater Jakarta was too populated and the daily habits of transport users that mostly ignore the environmental factors, in this case: accessibility, connectivity and traffic variable. These findings do not fully supported the previous research, such as [7] that identify those environmental factors as mediators for walking for transport and [3] identify the environmental factors that influence cycling behaviour. Discussing these factors further, it seems that the environmental factors may apply to the countries and/or cities that have sustainable development focus for its urban transport development.

IV. Conclusion And Future Work

The three-level of ecological perspective in analysing transport behaviour cannot fully be applied in Greater Jakarta as a busiest city in Indonesia. The only two-level that may explain more about the behaviour was the individual and social factors. In the individual factors, the highest accuracy obtained with the NN method was sex, and there is difference between men and women mode choice. Men mostly travelled using motorbike, while women mostly used public bus/Transjakarta. Meanwhile, in the social factors, the 'number of vehicles' and 'total household income' can also influence more the mode choice of Greater Jakarta (Jabodetabek).

On the other hand, using SVM method, the accessibility, connectivity and traffic variable had the lowest accuracy values. The environmental factors may contribute only a small proportion to someone decision to select the land transport mode in Greater Jakarta. Although in some developed countries, the environmental factors considered to be one of important factor influencing mode choice behaviour, it is not fully applicable in Greater Jakarta. The environmental condition, such as accessibility, connectivity, and traffic would not fully influence people in Greater Jakarta to select a transport mode. Furthermore, individual and social factors, such as sex, vehicles ownership, and household income, are more accurate to predict the transport behaviour in Greater Jakarta. Therefore, the transportation policy makers in Greater Jakarta should develop such interventions that consider these factors to overcome the transportation problem.

Although the research findings do not fully supported the whole ecological model proposed that covers individual, social, and environmental factors, the research model that needs to be expanded to be more specific explaining how the factors and levels really interact each other. Then, it can be used to identify appropriate levels of detail and the mechanism for the model. Positive-negative relationship of the factors needs to be undertaken to explain the details more fully.

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