The Effects of Weather on University Students' Activity-Travel Patterns: A Case Study in Batu Pahat, Johore

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Abstract. Weather conditions influencing people's activity-travel patterns, especially on students that portray more active lifestyles (e.g. conducting outdoor physical activities) than middle-age adult and elderly. However, this effects are still less explored in Malaysia, especially in Parit Raja, Johor. Therefore, this study aims to examine the effects of weather on students' activity-travel patterns by analysing the association between weather parameters (temperature and humidity) and students' activity-travel patterns in terms of travel time, number of trips, mode choice, and activity duration with regard to mandatory (e.g. study on campus) and non-mandatory (e.g. leisure and routine) activities. Initially, a total of 110 students were selected randomly among the undergraduate students of Universiti Tun Hussein Onn Malaysia (UTHM). However, only 101 students were participated in this study. A one-day of weekday and one-day of weekend activity-travel data were collected by using stated and revealed preferences approach through travel diary and questionnaire instruments. Temperature and humidity hourly data were obtained from the internet sources. The obtained data was analysed by using SPSS software version 23 that include descriptive statistics and multiple linear regression as the model for analysis method. The results show that the number of trips, activity duration and travel time are much higher in weekday compared to weekend. The students preferred to use cars as their main modes to travel. Temperature significantly affect students' activity-travel patterns in all activities. Mandatory activity-travel patterns is not affected by the weather attributes but otherwise for non-mandatory activity-travel patterns in terms of number of trips. However, all the effects are considered small, based on the adjusted R^2.

1. Introduction

Research on a travel pattern has been one of the focused area in transportation planning. Many transport planners try to understand why people travel from one place to another specific location to participate in various activities, and which transport mode that they prefer to use for that specific activity purpose. This study aims to examine the effects of weather on students' activity-travel patterns. To the author's knowledge, there are no studies being done on the effects of weather on students' activity-travel patterns

in Malaysia, especially in Parit Raja, Johore. It may be due to the difficulty in obtaining weather hourly data and daily activity-travel data on the trip level. Therefore, by conducting this study, the understanding of how the weather can affect the trip frequency, mode choice and activity duration of students can be obtained. Moreover, this study may give an insight on how weather affects students' activity-travel patterns so that the findings can be a reference for transport planners and policymakers to improve the existing transportation systems in providing better accessibility for everyone in the study areas or at local community level in various weather conditions.

2. Literature review

The attributes characterizing the commute activity-travel pattern include a number of stops, sequence of stops, activity type of each stop, activity duration of each stop, travel time deviation to each stop from previous stop relative to the direct travel time from previous stop to home and location of each stop [1]. However, the type of activity-travel pattern will be different depending on the weather especially in countries that have four seasons. Meanwhile, for countries that have a tropical climate that only have two seasons, weather also vary throughout a year although the variations are not as large as in weather in four seasons countries.

In Japan, it is found that during weekends, the number of trips made on the Tokyo Expressway is lower during rainy days [2]. In Sweden, using a survey of employees of four major companies in two Swedish cities, they found that the number of car trips is 27 per cent higher while the number of bicycle trips is 47 per cent less, during summer as compared to winter [3]. A study done in Bergen, Hordaland on the west coast of Norway shows that increases in precipitation and wind increase the likelihood of use of public transportation use as compared to walking and biking [4]. Once a trip was started, factors of weather had little impact on the duration of trips, although a statistically important relationship was present. Adverse weather would have an effect on whether or not the trip started or not instead of the duration: once a visit started, the weather conditions showed lowest impact [5]. People said that when it rains, the opportunity to get the accident will be greater and the travel time will be longer if the accident occurred, thus contribute to traffic congestion. A previous study in Sweden revealed that people also agreed that the weather does not only affect their quality of public transport services, but also can affect their travel behaviour [6]. People who receive weather information from secondary sources has a probability to vary their travel modes because they need a lot of chances to design interchange trips like origin-destination pair although the research on this issue has been proving nothing [7]. Drivers were slightly more likely to change their travel modes if they received the weather information from secondary sources, but the result was not statistically significant [8].

Temperature also affects mode choice, people tend to use vehicles aside from motorcycles throughout weather condition than once the weather is cold. People do not like using motorcycles during windy conditions. It may because of the wind that may affect the infrastructure of the urban transport or inter-city highways and rail due to falling trees or overturning vehicles [9]. Furthermore, it is prone to get accidents during windy conditions. However, the people of Yogyakarta will choose to use public transport if public transport facilities improved beforehand. The current public transport facilities costs them more time to travel and more difficult to move from one place to another in various weather conditions [9]. Thus, Yogyakarta community tend to use private vehicles, especially private car, even during heavy rain compared with propensity to use public transport. In Brussels, travellers' behaviour during normal and adverse weather conditions found that unfavourable weather (e.g. rain, snow, fog, dust) causes route choice and changes in mode as well as departure time of automobile commuters [8].

3. Materials and method

Quantitative method has been chosen because a large amount of data is gathered was use and then analysed statistically rather than qualitative that are normally use small amount of data. A pilot study was conducted on a small sample size consisting of respondents of about 10 people. Referring to piloting an instrument, a pilot study involved 10 subjects should be an affordable range for a project with 100 individuals because of the sample size [10]. This small sample size of students should consist of both males and females so that the data collected would not be so biased towards one gender. The questionnaires are to be distributed to respondents among university students. The design of the travel

diary in this study is similar with Ahmad Termida *et al*. [11].The data was collected for 2 days (1 day in weekday and 1 day in weekend). The study was done at one of the public university in Malaysia namely Universiti Tun Hussein Onn Malaysia (UTHM) which is located in sub-urban areas of Parit Raja in Batu Pahat, Johore. According to UTHM corporate profile, the student population is approximately 12,832 undergraduate students of UTHM. Thus, the sample size representative of the community of UTHM in this research is 99 respondents by using sample size precision of ±10% [12]. Initially, self-reported questionnaires and travel diaries instruments were distributed to 110 respondents who are among undergraduate students of UTHM. Note that the questionnaire was designed in two sections: Section A and Section B. Respondents' background information such as gender, age, education status, employment status, marital status, income, number of household members, owned children, and residential information was obtained in Section A. In Section B, respondents' travel diary about their activity-travel patterns was asked. Meanwhile, the travel diaries were provided to the respondents to record their each trip and the corresponding trip details such as date, start time, finish time, origin and destination addresses or crossroads, transport mode, trip purpose, estimated travel distance, travel costs, travel companion, and the use of weather forecast in each trip. Finally, only 101 respondents have respond and answer both instruments, thus, the data of these 101 respondents are used in the analysis. Therefore, the response rate of this study is considered high with 91.8% response. The data collected through the questionnaire was analyzed using the Statistical Package for Social Sciences (SPSS) Version 23. The data were then analyzed by using descriptive statistics and multiple linear regression model. For this study, weather data act as a secondary data since it is obtained from the weather websites in the internet.

3.1. Respondent profiles

Most respondents are male (60.4%), at the age of 25 years old (32.7%), single (98%) and comes from Malay race (66.3%). Most of the respondents for this study was from Faculty of civil and environmental engineering (FKAAS) (45.5%), and staying at the rental house (61.4%), with at least 3 household members (27.8%). However, 36.6% are living with 7 to 9 persons in a household on average. The respondents in this study were making 1 to 5 trips per week more than others (e.g. none or more than 5 trips per week) for both mandatory (e.g. work and study) (77.2%) and non-mandatory (e.g. leisure and maintenance activities) (70.3%) activities.

3.2. Travel characteristics and weather data

The descriptive statistics of travel characteristics (N = 101) and weather data are shown in Table 1. As expected, the respondents made more trips on weekday compared to in weekend. On average, the students made approximately 2 trips per person per day for mandatory and non-mandatory activities respectively in weekday. As expected, the number of mandatory trips per person per day on weekend is lower than during weekday since many lectures are done during weekdays than weekend. This is also supported by the number of trips per person per day made for conducting non-mandatory activity that is much higher in weekend compared to mandatory activity done in weekend. However, the number of trips per person per day made in weekend and weekday for conducting non-mandatory activities are similar in which about 2 trips per person per day. The total travel time spend by a student is similar during weekday and weekend with 50 minutes per person per day. However, the students spend more time to travel when conducting non-mandatory trips on weekend. As for the activity duration, the students spend more time on weekday compared on weekend. The activity duration for mandatory activities are much higher in weekday than in weekend, and otherwise for the time spend to participating in non-mandatory activities. In terms of mode choice, mostly the students making their trips by using car as the main mode choice to travel in both days (weekday and weekend). The lowest of percentage for mode choice of the students is non-motorized modes. The trend is also similar for conducting mandatory activities in which the students preferred to use car than other modes, and least preferred to use non-motorized modes. However, the students least preferred to use public transport in both weekday (7.6%) and weekend (0.9%) to conduct non-mandatory activities.

Table 1. Travel characteristics (N = 101) and weather data.

Variables	Weekday + weekend (2 days)	Weekday (1 day)	Weekend (1 day)
Total trips			
Number of trips (N)	664	411	253
Trips per person	6.57	4.07	2.50
Trips per person per day	3.29	4.07	2.50
Mandatory activity			
Number of trips	233	192	41
Trips per person	2.31	1.90	0.41
Trips per person per day	1.15	1.90	0.41
Trips per total trips	0.35	0.47	0.16
Non-mandatory activity			
Number of trips	431	219	212
Trips per person	4.27	2.17	2.10
Trips per person per day	2.13	2.17	2.10
Trips per total trips	0.65	0.53	0.84
Total travel time (in minutes)			
All activities	10,069	5,101	4,968
Travel time per total trip	15.16	12.41	19.64
Travel time per person	99.69	50.50	49.19
Travel time per person per day	49.85	50.50	49.19
Mandatory activity	3,014	2,442	572
Travel time per total trip	4.54	5.94	2.26
Travel time per person	29.84	24.18	5.66
Travel time per person per day	14.92	24.18	5.66
Non-mandatory activity	7,139	2,728	4,411
Travel time per total trip	10.75	6.64	17.43
Travel time per person	70.68	27.01	43.67
Travel time per person per day	35.34	27.01	43.67
Activity duration (in minutes)			
All activities	52,720	33,462	19,258
Activity duration per total trip	79.40	81.42	76.12
Activity duration per person	521.98	331.31	190.67
Activity duration per person per day	260.99	331.31	190.67
Mandatory activity	31,952	27,349	4,603
Activity duration per total trip	48.12	66.54	18.19
Activity duration per person	316.36	270.78	45.57
Activity duration per person per day	158.18	270.78	45.57
Non-mandatory activity	22,153	7,276	14,877
Activity duration per total trip	33.36	17.70	58.80
Activity duration per person	219.34	72.04	147.30
Activity duration per person per day	109.67	72.04	147.30

Table 1. Travel characteristics (N = 101) and weather data *(cont.)*

Variables	Weekday + weekend (2 days)	Weekday (1 day)	Weekend (1 day)
Mode choice per total trips (percentage)			
All activities			
Motorcycle	35.4	39.4	28.9
Car	47.1	43.8	52.6
Public transport	7.5	10.0	3.6
Non-motorised mode	8.3	5.6	12.6
Mandatory activity			
Motorcycle	37.8	38.5	34.1
Car	41.2	43.2	31.7
Public transport	14.6	13.5	19.5
Non-motorised mode	2.1	2.1	2.4
Non-mandatory activity			
Motorcycle	34.0	40.0	27.7
Car	50.0	44.0	56.3
Public transport	4.3	7.6	0.9
Non-motorised mode	11.4	8.4	14.6
Weather attributes			
Temperature (in Degree Celsius)			
Mean	30.16	29.84	30.67
Standard deviation	3.31	3.2	3.42
Humidity (in percentage)			
Mean	77.15	81.01	70.85
Standard deviation	31.11	36.69	17.02
Precipitation (in milimetre)			
Mean	0	0	0
Standard deviation	0	0	0

As for the weather, the precipitation values are zero in both weekday and weekend, meaning that there is no raining condition during data collection period. The temperature, however, slightly higher in weekend compared to weekday. As for the humidity, it is slightly humid in weekday than in weekend. Note that the t-test has been conducted for temperature and humidity attributes in weekday and weekend. The result indicates that there is difference in mean for temperature $(t = 3.107, df = 507.11, p = .002, two - tailed)$ and humidity $(t = -4.13, df = 661, p < .001, two - tailed)$ during weekday and weekend. Thus, it is assumed that both temperature and humidity may affecting students' activity-travel patterns since both days have statistically different weather condition in terms of temperature and humidity.

3.3. Model selection

In this study, multiple regression was used to analyse the data to achieve the study objectives. One of the mostly used statistical procedures for both scholarly and applied marketing research is multiple regression analysis [13]. The independent variable, x, is weather variables (e.g. x_1 = temperature, and x_2 = humidity). The dependent variable, y, is activity-travel pattern variables (e.g. number of trip, travel

time, and activity duration). The multiple linear regression formula applied in this study is shown in equation (1). ε is error or unobserved factors.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon \quad (1)$$

4. Results

Note that only significant result are discussed in this section. All the results are shown in Table 2. Note that the significant results ($\boldsymbol{\rho < .1}$) are shown in bold with $\boldsymbol{B}$ is unstandardized value, $\boldsymbol{\beta}$ is standardized value and $\boldsymbol{\rho}$ is a probability that the results from the sample data occurred by chance.

Table 2. Regression results for the effects of weather on students' activity-travel patterns.

Dependent variable	Activity type	Independent Variable	*B*	Standard error of *B*	*β*	*ρ*
Number of trips	All	**Temperature**	**0.039**	**0.020**	**0.075**	**0.050**
		Humidity	**0.012**	**0.004**	**0.130**	**0.001**
Activity duration	All	**Temperature**	**-4.837**	**0.754**	**-0.240**	**0.000**
		Humidity	0.057	0.135	0.016	0.675
Total travel time	All	**Temperature**	**0.252**	**0.112**	**0.087**	**0.024**
		Humidity	0.023	0.020	0.045	0.246
Activity duration	Mandatory	Temperature	-3.474	3.776	-0.106	0.359
		Humidity	0.936	0.890	0.121	0.294
Number of trips	Non-mandatory	**Temperature**	**0.180**	**0.092**	**0.195**	**0.050**
		Humidity	**0.093**	**0.020**	**0.471**	**0.000**

4.1. The association between weather and students' activity-travel patterns in all activities

A significant model emerged for the effects of weather on students' number of trips: $\boldsymbol{F(2,680) = 8.556, p < .005}$. The model explains 2.2% of the variance in students' number of trips for participating in all activities (adjusted $\boldsymbol{R^2 = .022}$). Thus, the relationship is considered small [14]. The regression model shows that all variables are statistically significant in predicting the number of trips made by the students. Therefore, the association between weather and students' number of trips does exists. As for the effects of weather on students' activity duration, a significant model emerged: $\boldsymbol{F(2,680) = 20.618, p < .005}$. The model explains 5.4% of the variance in students' activity duration (adjusted $\boldsymbol{R^2 = .054}$). Thus, the relationship is considered small [14]. The regression model results show that only temperature variable is significantly affect the students' activity duration. When the temperature is increased, the students' activity duration will be decreased. Next is the association between weather (temperature and humidity) and students' activity-travel patterns in terms of total travel time. A significant model emerged: $\boldsymbol{F(2,679) = 3.508, p < .05}$. The model explains only 0.7% of the variance in students' total travel time (adjusted $\boldsymbol{R^2 = .007}$). Thus, the effects of weather on students' travel time are considered very weak in association [14]. The regression model results show that only temperature variable is statistically significant in predicting students' total travel time. Based on the model results, students total travel time will be longer when the temperature is increased.

4.2. The effects of weather on students' mandatory activity participation

For the effects of weather on number of trips, an insignificant model emerged: $F(2,230) = 2.538, p = .081 > .05$. Meaning that the model is not fit for the data, thus no further analysis being conducted. As for the effects of weather on students' mandatory activity duration, a significant model emerged: $F(2,230) = 5.669, p < .005$. The model explains 3.9% of the variance in students' activity duration for mandatory activities (adjusted $R^2 = .039$). The relationship is considered small [14]. However, the

multiple linear regression results show that temperature and humidity are not statistically significant affecting students' mandatory activity duration. Thus, the activity duration for participating in mandatory activities such as attending lectures are not depending on weather conditions, but other possible factors such as timetable. As for the weather effects on students' total time travel in conducting mandatory activities, an insignificant model emerged: $F(2, 230) = 1.302, p = .274 > .05$. Meaning that the model is not fit for the data. Thus, no further analysis being conducted.

4.3. The effects of weather on students' non-mandatory activity participation

The effects of weather on students' number of trips made for conducting non-mandatory activities has produced a significant model: $F(2, 435) = 23.00, p < .005$. The model explains 9.7% of the variance in students' number of trips for non-mandatory activities (adjusted $R^2 = .097$). Thus, the relationship is considered small [14]. The model results show that both temperature (marginally) and humidity are statistically significant predicted the number of trips made by the students to conduct non-mandatory activities. It might be due majority of students conduct their non-mandatory activities in outdoor activities. It is worth noting that previous study has observed that higher temperatures were positively associated with outdoor activities in various cities including San Francisco and Chicago [5]. As for the effects of weather on students' non-mandatory activity duration, an insignificant model emerged: $F(2, 435) = 2.654, p = .072 > .05$. Meaning that the model is not fit for the data. Thus, no further analysis being done for this effect. The insignificant model also emerged for the effects of weather on students' travel time for conducting non-mandatory activities: $F(2, 435) = 1.814, p = .164 > .05$. Therefore, the model is not fit for the data and no further analysis being done for this effect.

5. Discussions and conclusions

This study aims to analyse the weather effects on university students' activity-travel. The study has been conducted in UTHM with 101 respondents that are among undergraduate students. The data has been collected on one day during weekday and one day during weekend, thus producing a total of 664 number of observations on trip level. The descriptive statistics show that, most of the students preferred to use cars for travel compared to other modes, regardless of weather (e.g. temperature, humidity and precipitation) and when the travels took place (e.g. weekday or weekend). Based on this, the mode choice of the students may not really depends on the weather condition. However, it is worth noting that there is no raining during data observation period, thus producing very small or to none precipitation values. It is expected that rainy condition may have a larger effect on students' mode choice as found in previous studies [e.g. 4,8]. The students least preferred to use non-motorised modes (e.g. walking and cycling) for conducting mandatory activities during weekday and weekend. Meanwhile, for conducting non-mandatory activities, the students least preferred to use public transport in both weekday and weekend. These analyses concern the most since both non-motorised and public transport modes are more sustainable compared to other modes. Actions should be done by university top management and policy makers in order to encourage students to use sustainable modes to travel. As for the regression model results, it is found that the adjusted $\boldsymbol{R^2}$ values are very low in almost all significant models. This could be due to the fact that very few independent variables (only 2: temperature and humidity) entered the model, thus producing less power in explaining the dependent variable with regard to its variance. In general, temperature plays an important role to shape students' activity-travel patterns with regard to number of trips, activity duration and total travel time. Humidity only affects students' number of trips for conducting all activities. As for the effects of weather on mandatory activities (e.g. study and work), only the effects of weather on activity duration for mandatory activities producing significant model, however, the temperature and humidity effects are all insignificant ($\boldsymbol{p > .05}$). Meaning that the weather has no effect on students' activity-travel patterns for conducting mandatory activities. This is accepted since mandatory activities are hardly to be avoided unless there is an emergency situation (e.g. family death, accident, sick, etc.) experienced by the students that prevent them to travel to participating in mandatory activities. Moreover, the weather condition during observation day is not much different (e.g. no adverse weather condition occurred). As for the effects of weather on non-mandatory activities (e.g. leisure and maintenance activities), only the effects of weather on number of trips made by the students to participating in non-mandatory activities producing significant model. It is found that both

temperature (marginally) and humidity do affect students' trips to participating in non-mandatory activities. The higher the temperature and humidity values, the more trips made by the students to conduct non-mandatory activities. This result in-line with previous studies done in San Francisco and Chicago where higher temperature is positively associated with outdoor activities that generate travels [e.g. 5]. As a conclusion, weather do affect students' activity-travel patterns in general, but less effect on students' mandatory and non-mandatory activity-travel patterns, at least in this study.

6. References

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