Individuals’ activity space in Seri Iskandar Malaysia

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Abstract. This study examines the nature of the day-to-day variability of individual activity space in Seri Iskandar Malaysia using simple regression analysis. The results show that individuals’ time allocation to undertake in-home and out-of-home mandatory activities, household income, access to motorised mode, commute distance and perceived accessibility from home to some basic amenities significantly associate with the spread of individuals’ out-of-home activity locations. However, time spent for performing in-home and out-of-home activities, number of trips, and commute distance associate with how far individuals’ out-of-home activity locations from their home is. Longer time-use to undertake in-home and out-of-home activities negatively correlate with the spread of out-of-home activity locations, whereas commitments to undertake out-of-home discretionary activities will be conducted near a home base location. When someone is from richer household, he/she will visit out-of-home activity locations farther from his/her home and more spread out. When someone resides within an area farther from government office areas, he/she will have more spread out activity locations.

1. Introduction
Travel is a need in our daily life. We need to travel to do our daily activities such as working, eating, buying groceries and spending our time to do leisure activities. From the daily activities that human does day-to-day, it can be categorised into two, which are mandatory activities and discretionary activities. The example of mandatory activities is eating, sleeping, and working while discretionary activities are shopping, have entertainment and visiting relatives. With all type of activities, it requires a place thus made human move when they want to perform that activity. It shows that there are different types of complicated factors that influence travel since every trip has done must undergo a good judgement since it requires limited space and time.

From previous studies, there are two arguments that have been made about travel behaviour. The research stated that before human travel to another place, a person needs to choose before he acts. Thus, people will decide either they need to move to one place to do an activity or not. Meanwhile, the study stated that human travel because there are some constraints that work within the limited time and space. Those constraints are capability constraints, coupling constraints and authority constraints. Capability constraints is a constraint that limits an individual to do other activity since he restricts his time to meet his basic needs like sleep, eating and personal care.

Meanwhile, coupling constraint is a constraint that made the individual interact with another human or objects where he needs to spend his time to achieve both essential functions like making a grocery or a transaction. Another one is authority constraints which a constraint that the authority made to limit the access for the individual to be at the specific space. As an example, a bank can only be accessed during working hour and to enter another person home, and permission must be granted. From the arguments,
it is understandable that every individual’s action must be reliant on the constraints. Otherwise, the complex interaction of individual’s decision-making process will be overlooked.

Another thing to consider during the study about travel behaviour is time-space prism which must be analysed. That prism argued that human travel behaviours are influenced by other factors which are needs and resources. An individual need to satisfy his/her needs and desires such as eating, sleeping, meeting with other individuals, enjoying entertainment, and socialising with their friends. Unfortunately, due to the limited time and space, they need to realise that their needs and desires cannot be fulfilled every single time. Meanwhile, for resources, human still depends on resources like money, availability of transport networks and built environment condition [3]. As those factors mentioned in time-space prism, it shows that it provides an opportunity for individuals to perform a particular activity within a particular space and time. It also shows that human activity will be not considered as an aggregate and every human has a unique time-space prism as everyone shape their prism which influences the travel behaviour.

The concept of activity space has been part of the research for a long time, which represent by ellipses as the geometrical representation that focuses on the travel potential. However, not only ellipses can be a geometrical representation. The study used ellipses and kernel densities to represent human ability to explore space due to the limitation because of the constraints [4]. With the geometrical representations, it can cause the area to over-generalise of the activity space by its geometric rigidity. It can be shown and measure with three main approaches to represent the activity space. The approaches are confidence ellipse, kernel densities and minimum spanning tree.

Activity space is a representation of how we capture individuals’ activity-travel behaviour in the spatial dimension. It is a distribution of the visited activity locations over space in some period which is a result of an interaction among individuals’ needs, constraints and resources within time and space dimensions [3-7]. The distribution of activity space can show whether someone is within tighter or flexible time-space constraints. It does not only consider the availability of activity locations fit with individuals’ needs and desires near their pegs or anchor locations (such as home and working location) but also time allocation of individuals in undertaking various activity participation either in-home or out-of-home in the way of satisfying their needs and desires. As example, one person can have a wider activity space pattern because of the distance between one activity location with another activity location is far. With that, a suggestion to develop infrastructure or some new activity locations in a particular location can be suggested too.

This study tries to examine the nature of individuals’ activity space in Seri Iskandar, Malaysia. Previous studies only took into account the influence of travel time and out-of-home activity participation on individuals’ activity space. This study also considers individuals’ in-home activity participation as a predictor that shapes individuals’ activity space. This study also takes in perceived accessibility of individuals’ home location to some basic amenities such as distance to government, and industrial and trade areas as neglected in previous studies [3-7]. However, this study ignores the endogeneity problems among discretionary activities, either in-home or out-of-home and between two different measures of activity space [7].

2. Problem statement

People need to visit out-of-home locations as a way of fulfilling his/her needs and desires. As an example, a person needs to go to work every day because it is essential for them since it is the way they support their life and visit a grocery shop to buy some daily groceries. The decision of whether someone can visit one or two or three out-of-home activity locations is depended on how long people undertake time allocation to a particular activity either in-home or out-of-home and travel time spent to reach all those activity locations. It means that people may have needs and desires to explore all available activity locations, but they are limited by some constraints either capability and coupling and authority constraints within 24-hour time dimension. The constraints will shape individuals’ activity-travel participation and also activity space.

In term of satisfying needs and desires, people do not only satisfy their needs to work or to undertake activities at home, such as resting, sleeping or taking care of some household activities. People also need to undertake out-of-home discretionary activities to improve their well-being [8-11]. Moreover, more
trips and longer travel time with more stops to undertake out-of-home discretionary activities is found to correlate with improving people’s well-being [12-14]. Therefore, the availability of individuals in visiting another/other activity location/s beside working locations may provide us with a picture how someone tries to satisfy his/her needs and desires in daily basis to reach particular daily well-being. The opportunity to visit another/other activity location/s. There is a possibility that someone has no opportunities to visit another/other location/s due to time and spatial constraints. Time constraints are presumably because a person has commitments to perform longer working/school time or household activities in a place.

However, spatial constraints might have occurred when there is no opportunity offered by the built environment to visit another/other activity location/s besides work locations. The opportunities offered by the built environment to perform out-of-home work/non-work activities provide a unique distribution of activity locations in which shape individuals’ spatial movement. Different built environment conditions enable individuals to have different activities participation and different activity space [3-7]. For example, locating a grocery shop near the residential areas may encourage individuals to undertake grocery shopping more often [14] than locating a grocery shop farther from residential areas. Locating basic amenities near individuals’ pegs (home and working locations) can also improve people’s well-being [10-16]. Therefore, activity space can be a representation of how individuals have opportunities to reach basic amenities or to visit other activity locations beside home and working places in a way to fulfil their daily needs and desires. Understanding the activity space can provide a hint how we are supposed to shape our built environment and to suggest time-use policies for particular group of individuals.

3. Times-space prism and activity space

3.1. Times-space prism

Based on that, prism Jones has recognised two significant aspects of understanding the prism. Those concepts are the concept of an individual or other entity having continuous existence in space-time and space has temporal expression in the time it takes to move from one location to another. Basically, from the concept, it states that there is an interaction between human, space and time. Human will be in the specific space as long he stays in that area. However, there will be trade-off between humans’ time and space if he moves from one location to different location. As human can manipulate the space and time prism. There are also constraints limiting human freedom to move.

The constraints that the study suggests which can restrict human to move and occupy certain time and space locations are capability, coupling and authority. Capability constraint is a constraint that limits human activities that they can join by spending the time to meet human needs such as sleep and eating. Other than that, the distance to travel also is limited due to the given period affected by the mode of transportation use. Meanwhile, coupling constraints require human to interact with other people or objects at specific places, for a certain period to complete the essential purpose like make a transaction or consumption. Finally, authority constraint is the permission to access to a specific place at a certain period like to do grocery shopping must be on operating hours and to enter another human house, and permission must be granted.

With regards the prism, the study has introduced a time budget to understand human travel behaviour according to the relationship between time and space. The time budget is a systematic record of a person’s use of time over a given period. From that system, it shows that time budget is always constant but how people allocate it can be manipulative as different people spend their time cannot refer to an aggregate model. With the presence of time budgets and its relationship between time-space prism, it has made a positive contribution to the study of time, location, frequency, sequence and duration of human activities.

Time-space prism is a powerful and elegant perspective to analyse human participation in activities. This prism can be defined as framework that recognises the activity participation involves both spatial and temporal dimensions [2]. Activities occur at specific locations for limited periods. Therefore, a transportation mode allows human to trade time for space to travel and participate in activities at dispersed locations. It also shows that human travel anchored by certain activities that are relatively
fixed in space and time. As example, going to work since the time cannot be rescheduled, and the place of working place is fixed. This prism also views that human in space and time as the centre of social and economic phenomena. It means that everything happens and change in the society and economy because there is someone that does and change the environment since human consume time and space to do the activity.

Also has referred to the prism and suggest that three time-space related concepts can be used to transform the general theoretical approach into a complicated and accurate prism which are travel choice options are constrained in space and time, trip generation is an outcome of activity choices and time budget are constant. Based on that suggestion, it shows that travel can be constraints by choices depend on our decision as it will never change the time budget. Furthermore, according to Chapin [2], the belief that human activity patterns represent the means of human needs and want. Human will first be motivated to act, then make a choice and finally act. His belief later identifies two groups of human. One group acts according to the basic needs like to sleep, have a portion of food and find shelter while another group acts according to their social needs like to do leisure and recreational activities.

3.2. Activity space
The research, activity space is an approach to describe individual perceptions, knowledge and actual usage of space as it represents the space which contains the places frequented by an individual over some time [18]. It works as an indicator to observed daily travel pattern [4-5]. It is because an individual chooses routes through time and space to meet their obligations, needs and desires. Human will choose the routes optimally to travel, but they still are constrained by their knowledge, their reasoning abilities and by the time and concentration, which enable them to construct and select a route. In a wider sense, the activity space contains both those locations where human has personal experience, as well as second-hand experiences which come from family, friends, books or other media [19].

The confidence ellipse concept picks up existing approaches to visualise distributions used for example in biological habitat research. It can show dispersion of visited locations and can be used to compare the dispersion between human on different days of the weeks. Meanwhile for the kernel densities, it considers activity space as the area with non-zero probability of activity performance. It also allows exploring the combined effects of locational choice and the frequency of visit. The basic process behind the estimation of kernel densities is a transformation of a point pattern into a continuous representation of density in wider area [4].

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Unfortunately, the geometrical representation above has different kind of weakness that can make the result of the research can bring uncertainty. As an example, all the geometrical representation can over-generalise the activity space size by its geometric rigidity [5]. The methods also are not proper because only measure the visited action space rather than individual’s potential action space. Kernel densities are only able to represent the most visited activity locations on the given days to reduce the generalisation of the area to support the statement. It ignores the connections between activity locations and the spread measurement. Minimum spanning trees also only pointing out directly the precise locations by measuring the distance between exact visited activity location and the individual’s home location but ignores the spread of the out of home activity locations.

Therefore, as an alternative to measuring the distribution of the individual’s activity space, [3] has used the second moments of activity location where two indices are known as Ic and Ih. Ic describes the spread of the activity around the centre while Ih shows the total squared distance of an individual’s out of home activity location to home. The two indices are complemented to each other to describe the spatial orientation [6, 7]. This method also is better than geometrical representation because it measures the exact visited activity space and the connections between the visited locations. Furthermore, it is easy to calculate and can be applied through standard statistical methods to measure how the individual activity space indices change for different given circumstances. By using this method, a transaction between the degrees of an individual’s activity location spread out (Ic) and how far the activity centroid
location from home (Ih) can be known. As in travel time budget, travel time to reach the activity location may shape a certain distance of the activity location from home. The travel time needed for the first trips will influence the remaining travel time available thus shape the degree of spread out of the activity location.

4. Methodology

4.1. Activity space

This project focuses mainly on travel behaviour and how it shapes human activity space. The research has been done by surveying about 143 respondents that living and working around Seri Iskandar, Perak, Malaysia. The survey was included with a set of question-based on the travel behaviour and the travel diary to know the destination for every trip made by the respondents. In the travel diary also, respondents need to mention their activities time to time and the location of the activity that has been done. In the survey also, they need to fill in their personal information about their characteristics such as age, salary and number of households to determine the socio-demographic and transportation owned. From the survey, an analysis of data can be processed to provide statistical data by using multivariate analysis. With that analysis, a model between the travel location and the activity made can be constructed to show the activity pattern and the distribution of the visited locations over space in some period. The data measured can be demonstrated in activity space indices.

The first approach to facilitate this study is to know the set of data input that needs to be collected to conduct this research. The data that need to be collected for the research can be in different varieties such as activity done in specific space and time, mode of transportation. Time spent on travel, the destination of the trip and the road use to travel. These types of variables are very useful to understand travel behaviour and human activity space.

After the data has been determined, we need to determine how to collect it. In this research, a survey needs to be designed to collect the data from the respondent. The survey can be designed based on the variables stated and the period for the survey to be conducted. For this research, five days of the survey is allocated for the target person who is three days on weekdays and two days of weekend. It is because we can investigate and compare what the type of activity done is and how long a person spends their time to do their mandatory and discretionary activities on weekdays and weekend. After the variable and the period has been set, the survey is designed into two different parts which are individual characteristic questions and time-use and activity diary questions. Individual characteristic question is the preliminary stage and as a warm-up before the time-use activity diary question is spread to the respondent [4]. It collected basic information about the individual such as age, gender, occupation, accommodation type, monthly income, access to a motorised travel mode and the travel distance from their house to the location of the daily routine’s activities. With that information, it can help us to determine the personality of the respondent and the constraint that they need to face to travel.

Meanwhile, for the time-use and activity diary questions, it is used because it offers richer information to capture human travel behaviour and the participation of human in the activity space [20]. This survey can help to record in-home and out-home activity participation, travel behaviour, trips and activity locations. The diary survey is designed at 15 minutes interval because it is fewer biases in estimate the time allocated for the activities. Meanwhile the activities are classified into twenty-one activity classifications which classified of mandatory, maintenance and leisure activities.

When the survey was designed, it must be implemented. Personal relationships between the respondent and the surveyors must be established as it can determine the success of the survey. The surveyors need to interact with the potential respondent and ask them to sign a commitment letter agreeing not to withdraw from the survey until it has completed. After that, the surveyors need to distribute the questionnaires to the respondents. During the period, the surveyors need to arrange a face to face meeting every day to see the progress of the surveys and to ensure the respondents completed the surveys correctly [20].

As the surveys have completed, the result of the survey can be recorded in a computer and ready to be analysed by transfer the hard copy information to the soft copy information in statistical analysis software like IBM SPSS and Microsoft Excel. To analyse the data, the computer software that can work
multivariate analysis such as RStudio can be used to interpret more than one statistical outcome. Multivariate analysis is different than univariate and bivariate analysis since it can process a lot of variables. Therefore, this software can help to reduce a large number of variables to a smaller factor of data modelling and select a subset of variables from a larger set, based on which original variables have the highest correlations with some other factors. Therefore, statistical data can be show and can be examined to show the travel behaviour and the relationship between human activity spaces.

4.2. Survey results

As the data input has been set and the survey has been designed, it has been implemented to the people of Seri Iskandar. The survey has been done on 30th August 2017 until 3rd September 2017. It has been filled by 143 respondents that do their daily activity around Seri Iskandar. Commonly, the respondent is either live at Seri Iskandar or work around the location. The survey is done at Seri Iskandar because this location is developing fast. In 5 years, there are a lot of facilities that have been built to support the community here since the majority of the people here consists of students from Universiti Teknologi PETRONAS and Universiti Teknologi MARA. Seri Iskandar located at Perak Tengah and has been a capital city for the district. It is surrounded with a former site of a tin mining.

Compare to Ipoh which is the capital city of Perak, Seri Iskandar is very developing and become the centre of the activity to the people of Perak Tengah since most of the government office is located at the city. It has an uncongested road network since there is a two-lane for each side of the highway from Ipoh to Lumut. Mostly, people at Seri Iskandar travel using their car and motorcycle since the public transport system is not very good.

During the survey period, people of Seri Iskandar need to answer and fill the activity diary and personal information that consists of the data of activity done in a day, physical activity and household info. The survey involved 143 respondents and conducted for five consecutive days, and it was prepared in English as some of the respondents are not a citizen of Malaysia thus, they cannot understand if the survey conducted using Bahasa Malaysia.

The survey consists of two parts which are the information of the household and the activity diary. For the household data, the respondents need to fill their information about household composition, travel behaviour, the distance to accommodate to specific location, internet access, household income, physical activities, social and communication activities, lifestyle habits and healthy lifestyle. Meanwhile for the activity diary, respondents need to fill 24 hours of activity diary that has been divided into 15 minutes for each cell.

The respondents also need to know the type of activities that they have done, as mentioned in the guidelines where it has 21 types of activities to help it easier for them to input it. After five days, the surveyor needs to collect the questionnaire and the activity diary and input it in Microsoft Excel for a record. To summarise the survey that has been done, the profile of the sample used has been illustrated in Table 1. After the survey has been recorded in Microsoft Excel, the activity diary needs to be analysed so the 21 types of activities can be classified of mandatory and discretionary activities. Mandatory activities are classified as activities that are difficult to be re-scheduled with relative higher temporal and spatial fixity such as work, school and pick up/drop activities [21]. Therefore, it shows that the individual’s ability to perform discretionary activities.

Meanwhile, discretionary activities are activities that are easy to be re-scheduled within time and space limitations with relative higher temporal and spatial flexibility, such as shopping and leisure activities. As for the mandatory activities, it contained in-home and out-of-home mandatory activities while for the discretionary activities, it has maintenance and leisure that can also be divided into two parts which are in-home and out-of-home activities. To know which activities, belong to which categories, Table 2 illustrates the activity classification.

After the activity has been classified, the activity space indices need to be calculated using the coordinates for every place that the respondents have gone. To calculate the activity space indices, it needs to use the formula of the second moment of activity locations.

It will give a value of \( Ic \), the total squared distance of an individual’s out-of-home activity locations to the centroid of activity locations, and \( Ih \) which is the value of total squared distance of an individual’s out-of-home activity locations to home [7]. Figure 1 shows how to calculate the activity space indices.
Table 1. Profile of the samples used.

| Variables                                      | Percentages or Mean |
|-----------------------------------------------|---------------------|
| Socio-demographic characteristic at individual level |                     |
| • Male                                         | 60.1%               |
| • Worken and non-worker                        | 57.3% and 11.2%     |
| • Age (Continuous) (Years Old)                 | 23-45               |
| • Low income, Medium Income and High Income (RM) | >4000               |
| Household Characteristics                      |                     |
| • Number of household members                  | 3.76                |
| • Number of dependent children per house       | 0.82                |
| • Number of cars per household                 | 1.19                |
| • Number of motorcycles per household          | 0.42                |
| Trips engagement and travel spent on weekdays (weekends) |                     |
| • Number of trips                              | 2.1818 (2.1294)     |
| • Percentage of using motorised mode           | 70.86 (85.59)       |
| • Percentage of using public transport         | 27.39 (0.78)        |
| • Percentage of using non-motorised mode       | 1.75 (13.63)        |
| • Total Travel Time (min)                      | 64.335 (89.59)      |
| • Time Spent on in-home mandatory activities (min) | 571.4685 (611.748)  |
| • Time Spent on in-home leisure and maintenance (min) | 126.3465 (153.2775)  |
| • Time spent on out-home family activities (min) | 109.755 (151.0485)   |
| • Time spent on out-home sports activity (min)  | 12.9375 (20.088)    |

Table 2. Activity Classification

| In-home activities | Mandatory | Discretionary |
|--------------------|-----------|---------------|
| Sleep              | Personal Care: |
|                    | Taking a bath, eating and drinking |
| Household Activities| Babysitting |
| Online shopping    | Socialising |
| Entertainment      | Window shopping |
|                   | NGO activities |
|                   | Sports |
|                   | Vacation |

| Out-of-home |
|-------------|-----------|
| Mandatory   | Discretionary |
| Work at the office place | Social and family activities |
| Work out-of-office         | Eating outside |
| Study at school            | Window shopping |
| Study out-of-school        | NGO activities |
| Drop/pick up child/children | Sports |
| Grocery shopping           | Vacation |
| Personal care: going to the bank, post office etc | |


5. Relationship between individuals’ activities space and time use to various activity participation

Based on the calculations of activity space indices and the relationship between the variables, there is a lot of descriptive analyses that can be done. In Figure 2 and 3, the graph consists of the relationship between the time duration of different type of activity participation and individuals’ Ic and Ih, respectively. The activities categorise into in-home mandatory activities, in-home maintenance activities, in-home leisure activities, out-of-home mandatory activities, out-of-home maintenance activities and out-of-home leisure activities. To summarise it, the activities have been simplified as in-home activities and out-of-home activities. There is also the time used for the respondents to travel.

Figure 1. Example Calculations of Activity Space Indices

\[ X_e = \frac{5+10+3}{3} = 6, \quad Y_e = \frac{12+10+1}{3} = 7. \]

Home-to-Centroid Distance, \( L_h \):
\[ L_h = \sqrt{(X_e - X)^2 + (Y_e - Y)^2} = \sqrt{(6-3)^2 + (7-7)^2} = \sqrt{9} = 3. \]

Elements of the Second Moment, \( I_x \) and \( I_y \):
\[ I_x = 2^2 + 5^2 = 29 \quad \text{and} \quad I_y = \left|\frac{3}{2}\right| + \left|\frac{5}{3}\right| + \left|\frac{1}{4}\right| = 90. \]

Figure 2. The relationship between individuals’ Ic and their time allocation to various activity participation
In Figure 2, respondents that have high Ic spend more time to do in-home activities on the weekend compared to the respondents that have low Ic. It is because, during weekdays, they already spend a lot of times to do the out-of-home activities; thus, they want to spend their time on weekend to do in-home activities. The graph shows that time used for respondents with high Ic is high to do in-home mandatory to support it, in-home maintenance and in-home leisure activities during weekend compare on the weekdays. Compare to the respondents with low Ic, and the graph shows that there is not a lot of drastic changes on time used for every activity either on weekdays or weekend as they tend to spend more time to do in-home activities during weekdays and weekend. Other than that, respondents that have high Ic spend more time to travel compared to the respondents that have low Ic. It is because respondents that have high Ic need to travel to do the out-of-home activities.

Meanwhile, in Figure 3, it shows the relationship between Ih and time allocation to various activity participation. Based on the figure, respondents that have high Ih spend more time to do in-home activities on the weekend than on weekdays compare to the respondents that have low Ih. It is because, during weekdays, they already spend a lot of times to travel further from their home to do the out-of-home activities. It is shown by the graph that the respondents with high Ih use more time on out-of-home mandatory activities during weekdays compare on weekend. However, respondents with high Ih spend more time to do out-of-home leisure activities during weekend compare on weekdays as that is the only time that they are free to do such activities. Meanwhile for the respondents with low Ih, there are not a lot of drastic changes in the time used to do every activity on weekdays or weekend. It is because they tend to spend more time at home to do in-home activities rather than to travel from their home to perform any out-of-home activities. Other than that, based on the graph, the respondents with high Ih spend more time to travel compared to the respondents that have low Ih. It is because respondents that have high Ih need to travel further from their home to do the out-of-home activities.

Figure 3. The relationship between individuals’ Ih and their time allocation to various activity participation.
6. Estimation result

To better understand the relationships between the influences of activity-travel behaviour towards activity space, the interaction between activity-travel behaviour and activity space indices, \( Ic \) and \( Ih \) are modelled in this study. It is assumed that each activity and travel time spent to reach the locations and the different on socio-demographic can directly influence an individual’s activity space. The further from home, the activity location is located, the less available time there is to make the activity locations more spread out across space and vice versa.

The activity spaces of individuals either \( Ic \) or \( Ih \) are influenced by in-home and out-of-home activities, the socio-demographic, built environment and also the activity space indices. It shows that activity space indices are influenced by time allocation to various activity participation, socio-demographic, built environment and activity space indices. All of the complex interaction can be explored using simple regression analysis.

From Table 3, the results illustrate the time spent for different type of activity participation, socio-demographic and built environment variables explain the variations of the individuals’ activity space indices. For \( Ic \), the significant variable that affects the indices is time duration to undertake all activities except out-of-home leisure activities, \( Ih \), income, access to the motorcycle, commute distance from home to work location and distance between home and government offices. Meanwhile for \( Ih \), the significant variables that affect the indices are number of trips, all types of activity, \( Ic \), gender, income, commute distance from home to work locations and percentage of using public transport mode.

**Figure 4.** The proposed model structures

For \( Ic \) model, individuals’ time spent for various activities particularly in-home activities and out-of-home mandatory activities negatively correlate with \( Ic \), whereas household income, commute distance from home to work, and distance between home and government offices positively correlate with individuals’ \( Ic \). Out-of-home mandatory activity is only out-of-home activities that significantly shape \( Ic \). On the other hand, almost all time-use variable to participate in in-home activities (except in-home leisure) is found to shape \( Ic \).

Moreover, how far is individuals’ commute distance and how far is individuals’ home from government offices are a representation of spatial dimension in shaping \( Ic \). In Seri Iskandar, Malaysia, basic amenities are more likely located near government offices. It means that when an individual resides farther from government office areas, he/she will have more spread-out activity locations than the ones who reside near government office areas. Another activity space index, \( Ih \), is found to shape \( Ic \) insignificantly.

Different from \( Ic \) model, in \( Ih \) model, time allocation to out-of-home activity participation and in-home leisure are found to shape \( Ih \) significantly. The magnitude of undertaking in-home and out-of-home mandatory activity participation shows higher than out-of-home discretionary activities such as out-of-home maintenance and leisure activities. Moreover, different from \( Ic \) model, having more spread activity location positively associate with having activity location far from the city centre. When an individual takes more trips, male, has higher percentage of using public transport and lengthier commute distance to working location, he/she more likely visits activity locations near his/her home. However, when an
individual has higher household income, he/she more likely manage to visit activity locations farther from his/her home.

Table 3. Model Estimation Result for Activity Space Indices

| Variables                           | Ic  | Coeff | T-stat | Ih  | Coeff | T-stat |
|-------------------------------------|-----|-------|--------|-----|-------|--------|
| Intercept                           | 0.378 | 1.996 |        | 5.539 | 11.368 |
| Number of trips                     | -0.083 | -3.882 |        | -0.058 | -11.663 |
| IH mandatory                        | -0.005 | -2.353 |        | -0.057 | -9.508 |
| IH maintenance                      | -0.005 | -2.441 |        | -0.057 | -11.003 |
| IH leisure                          | -0.005 | -1.906 |        | -0.057 | -12.049 |
| OH mandatory                        | -0.005 | -1.906 |        | -0.057 | -12.049 |
| OH maintenance                      | -0.005 | -1.906 |        | -0.057 | -12.049 |
| OH leisure                          | -0.005 | -1.906 |        | -0.057 | -12.049 |
| Ih                                  | 0.172 | 2.800 |        | -0.172 | -2.800 |
| Mean of the dependent variables     | 6682.43 | 109552.8 |        | 6682.43 | 109552.8 |
| Standard deviation                  | 3312.65 | 27111.5 |        | 3312.65 | 27111.5 |
| cit                                 | 0.69 x 10^{5} | 0.69 x 10^{5} |        | 0.69 x 10^{5} | 0.69 x 10^{5} |
| R^2                                 | 0.203 | 0.313 |        | 0.203 | 0.313 |
| Log likelihood                      | -221269.31 | -243385.93 |        | -221269.31 | -243385.93 |

7. Conclusion

This study examines the interaction of time-use and activity participation, trip parameters, socio-demographic and perceived accessibility of individuals’ home location to some basic amenities on individuals’ activity space indices, Ic and Ih. Ic represents how spread individuals’ activity location, whereas Ih illustrates how far individuals’ activity location from their home location. Interaction or trade-off between time-use and activity participation, trip parameters, socio-demographic and perceived accessibility shows the interaction or trade-off between individuals’ constraints and resources within time and space limitation perspective. How spread and how far from home the activity locations is a result of interaction among time duration of various activity participation, travel time spent to reach all out-of-home activity locations, number of trips and the opportunities offered by space dimension.

It shows that undertaking longer in-home activities and out-of-home mandatory is found to significantly shape Ic and negatively associate with Ih in higher magnitude. It means that ignoring time duration of undertaking activities in the home base will reduce the accuracy of activity space analysis as also noted in previous research [7]. Moreover, people in Seri Iskandar, Malaysia tends to choose to undertake out-of-home discretionary activities or to visit more activity locations near their home base. The increasing of distance from home to government officials make the activity location more spread out. Seri Iskandar is located in the middle between two metropolitan areas in Perak state in which are Ipoh and Lumut. The travel time to reach those two metropolitan areas is around 45 minutes. It means that when people in Seri Iskandar tries to undertake out-of-home discretionary activities, the more likely visit the discretionary activity locations near their home base rather than travel to Ipoh and Lumut.
However, when an individual comes from richer household, he/she tends to reach Ipoh and Lumut to undertake out-of-home discretionary activity locations.

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