# THE RELATIONSHIP BETWEEN STREET PATTERN AND NEIGHBOURHOOD TRAVEL CHARACTERISTICS

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# THE RELATIONSHIP BETWEEN STREET PATTERN AND NEIGHBOURHOOD TRAVEL CHARACTERISTICS

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## ABSTRACT

Recently, the dependency on private vehicles rising rapidly almost around the world. This issue arising from the rapid growth of development as well as population. The possession of a driving license easily also contributes to the increase in vehicle ownership, thus, increasing reliance on private vehicles. At the same time, the highest frequency in auto mobility related to travel demands and existing street pattern. In response to enhance sustainable mobility and active lifestyle, this research is conducted to analyse the relationship between street pattern and neighbourhood travel characteristics. This research is carried out in 13 large residential areas in Johor Bahru that have total size more than 1000 acres which are categorised by the year built of neighbourhoods. This study used Descriptive Statistics and Independent Sample T-Test in analysing the street pattern and travel characteristics. The type of street pattern, land use, street pattern measures and street network density of each neighbourhoods are identified using ArcGIS 10.2 while observation surveys are conducted to collect travel characteristics data within the study area. The results indicate that old neighbourhoods are better in street connectivity and accessibility compared to new neighbourhoods. This research also indicates that new neighbourhoods have a higher dependency on automobile trips due to highest travel time and travel expenses. There are several suggestions that can be implemented in addressing the issues includes encourage mixed-use development, enforcement of planning codes, establishing policies on private vehicle ownership and improve the existing alternative travel facilities.

# ABSTRAK

Sejak kebelakangan ini, kebergantungan terhadap kenderaan persendirian meningkat dengan pesat hampir di seluruh dunia. Isu ini berpunca dari pertumbuhan pembangunan dan penduduk yang pesat. Pemilikan lesen memandu dengan mudah juga menyumbang kepada peningkatan pemilikan kenderaan persendirian sekali gus meningkatkan kebergantungan terhadap kenderaan persendirian. Pada masa yang sama, kekerapan yang tinggi dalam perjalanan menggunakan kenderaan bermotor berkait rapat dengan permintaan perjalanan dan reka bentuk jalan yang sedia ada. Sebagai maklum balas terhadap galakan kemampanan pengangkutan, kajian ini dijalankan untuk menganalisis hubungan antara corak jalan dan ciri-ciri perjalanan di kawasan perumahan. Kajian ini dijalankan di 13 kawasan perumahan yang besar di Johor Bahru yang mempunyai jumlah keluasan melebihi 1000 ekar di mana ia dikategorikan mengikut tahun kawasan perumahan dibina. Kajian ini menggunakan Statistik Deskriptif dan *Independent Sample T-Test* dalam menganalisis corak jalan dan ciri-ciri perjalanan. Jenis corak jalan, guna tanah, ukuran bagi corak jalan dan ketumpatan rangkaian jalan bagi setiap kawasan perumahan telah dikenal pasti menggunakan ArcGIS 10.2 manakala kaji selidik pemerhatian telah dijalankan untuk mengumpul data ciri-ciri perjalanan dalam kawasan kajian. Hasil kajian menunjukkan bahawa kawasan perumahan lama lebih baik dalam kesinambungan dan kebolehcapaian jalan berbanding dengan kawasan perumahan baru. Kajian ini juga menunjukkan bahawa kawasan perumahan baru mempunyai kebergantungan yang lebih tinggi terhadap perjalanan menggunakan kenderaan bermotor ekoran masa dan kos perjalanan yang tinggi. Terdapat beberapa cadangan yang boleh dilaksanakan dalam menangani isu tersebut termasuk menggalakkan pembangunan bercampur, penguatkuasaan kod perancangan, mewujudkan dasar berkaitan pemilikan kenderaan persendirian dan meningkatkan kemudahan perjalanan alternatif yang sedia ada.

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| | | |
|---|---|---|
| CBD | - | Central Business District |
| CfIT | - | Commission for Integrated Transport |
| CMHC | - | Canada Mortgage and Housing Corporation |
| CO | - | Carbon Monoxide |
| CVLB | - | Commercial Vehicle Licensing Board |
| EWA | - | Effective Walking Area |
| GIS | - | Geographical Information System |
| HC | - | Hydrocarbon |
| JBCC | - | Johor Bahru City Centre |
| km | - | kilometre |
| LNR | - | Link to Node Ratio |
| MIT | - | Massachusetts Institute of Technology |
| $NO_2$ | - | Nitrogen Dioxide |
| Pb | - | Lead |
| PRD | - | Pedestrian Route Directness |
| SPSS | - | Statistical Package for the Social Sciences |
| UniKL | - | Universiti Kuala Lumpur |
| US | - | United States |
| UTM | - | Universiti Teknologi Malaysia |
| VHT | - | Vehicle Hours Travelled |
| VKT | - | Vehicular Kilometres Travelled |
| VMT | - | Vehicle Miles Travelled |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

In promoting sustainable mobility, dependence on private vehicle must be minimized and convert to use public transport or active transport such as walking and cycling as main mode. Urban designers and planners should give priority to the interests of vulnerable and public transport users. Recently, there are several studies related to street pattern and travel characteristics. Nevertheless, it is insufficient to encourage people to walk and cycle as well as reduce dependency on motorized vehicles especially private vehicles. The results obtained from previous studies involving street pattern indicators are still questionable because their study is based on data obtained in the selected neighbourhood or country. Data are changing according to the selected neighbourhood which is compatible with the analysis carried out in the area. Thus, the impact of street pattern on travel characteristics in other neighbourhood or country is still problematic. Due to a limited range of street pattern indicators on previous studies, there is a requirement to identify the relationship between street pattern and neighbourhood travel characteristics. This study seeks to design a better street pattern in order to enhance sustainable mobility and active lifestyle.

There is a requirement to understand the street pattern indicators as street pattern is a key element that influence travel behaviours such as socio-demographic, built environment and travel factors (Chan *et al*, 2016). An understanding of the street pattern indicators will lead to an understanding of connectivity, safety and accessibility. Street pattern indicators used in this study are housing density, point of

intersection, shape of block or size of block, nodes per blocks and length of road which is street density. These indicators are main factors that influence sustainable mobility. The travel characteristics that present in this research are vehicle ownership, main mode of transportation, travel expenses, time travel and level satisfaction of public transportation, walking facilities and cycling facilities. In order to make this research more interesting, perspective of land use characteristics such as land use type, layout of development and year built of neighbourhood also included. This research presents street pattern indicators based on current literature that consider sustainable travel.

Mixed use built form and high connectivity of street network design should be planned in all neighbourhoods to create sustainable commuting trips. This also helps to change the transport-related physical activity of inhabitants in Johor Bahru neighbourhood into an active lifestyle which is more depending on the active transportation. Noraini Anor *et al*, (2012) stated that travel behaviour is very important before implementing and enforcing new planning codes or new policy in order to achieve sustainable development whereas it can affect the life of residents. Norhafizah *et al*, (2015) add that street pattern, availability of walking facilities and type of land use may affect the travel distance as well as travel behaviour. This research indicates that street pattern indicators associated with the travel characteristics produced by residents in different residential areas in Johor Bahru. There are some measures that not included in previous studies to evaluate neighbourhood street patterns on a detailed scale. Therefore, this research use a better statistical method which is a measure to evaluate street connectivity and travel patterns at neighbourhood streets. In order to analyse the evolution of travel characteristics and street pattern, Independent Sample T-tests is used.

Most of the researcher compares the street patterns with the density of their study area. Only a few of them compare with year built of neighbourhoods. Rafee *et al* (2012) indicates that travel trips and vehicular kilometre travelled (VKT) will increase with the increase of age of the neighbourhoods. Therefore, this study compared the street connectivity with year built of neighbourhoods within different residential areas to identify the street pattern. Five types of street patterns are used in

measuring the road network in Johor Bahru neighborhood in order to compare with travel patterns of residents in Johor Bahru which are grid-iron (Dillon Consulting Limited 2010), warped parallel, loops and lollipops (Moeinaddini *et al*, 2014), fragmented parallel, and lollipops on a stick (Grammenos *et al*, 2002; Goix and Huet 2012). This types can identify the quality of existing street network and can be used to propose improvements to existing urban streets in Johor Bahru as well as promoting sustainable transportation. Besides, different types of street pattern have different number of intersection points. Street pattern with many distributor or cul-de-sac may cause difficulty to pedestrian arrive their destination with a short time due to low linkages (Nor Haslina *et al*, 2014). Since this study tries to serve the requirements of pedestrians, cyclists, and public transport users specifically vulnerable users whether old, young or disabled, designers have room to implement a high standard of urban streets for active users at neighbourhood level.

## 1.2 Problem Statement

Transport Statistics of Malaysia 2010 stated that there are 20,188,565 total of motor vehicles ownership in Malaysia include motorcycle, motorcar, bus, taxi, hire and drive car, goods vehicle and others (Ministry of Transport Malaysia, 2010). This number increases by 4,912,627 in five years from 2010 until 2014 as shown in **Table 1.1**. There is a correlation between the motor vehicles ownership with the rapid growth of development as well as population (Guerra, 2014; Schafer and Victor ,2000; Sperling and Claussen, 2004; Sperling and Claussen, 2002; Leibling 2008). Malaysia is no exception. High rate of motor vehicles ownership is arising from the possession of a driving licence (Leibling, 2008), and economic development (Sharma *et al*, 2011; Dargay *et al*, 2007). A higher private vehicle ownership will lead to a higher travel trips as well as VKT (Rafee *et al*, 2012).

**Table 1.2** shows that about 1,281,936 new registered of motor vehicles has been issued in 2014 compared to 1,158,072 in 2010 by Commercial Vehicle Licensing Board (CVLB) from 2010 until 2014 (Road Transport Department 2010-2014). Having a driving license at a young age is very important in order to travel to

work place, institutional and market but is it necessary to have a driving license while there are many public transports? This case is related to travel demands and existing street pattern. Moeinaddini *et al*. (2012) found that street pattern indicators affecting the travel characteristics such as travel mode choice.

**Table 1.1 :** Total motor vehicles by type and year in Malaysia

| Year | Motorcycle | Car | Bus | Taxi | Hire & Drive Car | Goods Vehicle | Others | Total |
|---|---|---|---|---|---|---|---|---|
| **2010** | 9,441,907 | 9,114,920 | 69,149 | 84,661 | 18,300 | 966,177 | 493,451 | 20,188,565 |
| **2011** | 9,985,308 | 9,721,447 | 71,784 | 90,020 | 19,194 | 997,649 | 515,867 | 21,401,269 |
| **2012** | 10,589,818 | 10,354,678 | 73,536 | 93,040 | 19,296 | 1,032,004 | 539,849 | 22,702,221 |
| **2013** | 11,087,878 | 10,535,575 | 62,784 | 99,921 | 53,954 | 1,116,167 | 862,977 | 23,819,256 |
| **2014** | 11,629,265 | 11,199,910 | 65,044 | 105,689 | 58,945 | 1,159,872 | 882,467 | 25,101,192 |

Source : Road Transport Department, as cited from Ministry of Transport (2010-2014)

**Table 1.2** : New registered motor vehicles by type and year, Malaysia

| Year | Motorcycle | Car | Bus | Taxi | Hire & Drive Car | Goods Vehicle | Others | Total |
|---|---|---|---|---|---|---|---|---|
| **2010** | 498,041 | 585,304 | 2,067 | 5,026 | 3,277 | 40,887 | 23,470 | 1,158,072 |
| **2011** | 542,308 | 594,610, | 2,405 | 4,947 | 3,568 | 39,718 | 24,443 | 1,211,999 |
| **2012** | 609,596 | 628,239 | 1,440 | 4,187 | 2,127 | 40,742 | 25,418 | 1,311,749 |
| **2013** | 528,608 | 583,060 | 1,833 | 3,861 | 3,904 | 40,765 | 40,743 | 1,202,674 |
| **2014** | 541,387 | 664,335 | - | - | - | 43,705 | 19,490 | 1,281,936 |

Source : Road Transport Department, as cited by Ministry of Transport Malaysia (2010-2014)

Dependence in private motor vehicles become a threat for many cities especially cities in developing countries. It causes substantial detrimental impact on the environment, economic, social and health (Sperling and Claussen, 2002;

Massachusetts Institute of Technology (MIT) and Charles River Associates Incorporated, 2001). The concentration of motor vehicle growth rate in India contaminate the environment by emission of CO, unburned HC, Pb, $NO_2$ and suspended particulate matter from automobile exhaust (Sharma *et al* 2011). Chuen *et al* (2014) stated that the growing demand for mobility in accordance with the rapid growth of the country's development led to congestion and consequently increases the carbon emission. The reduction of traffic congestion indirectly reducing the hazardous gas emission from motor vehicles and thus minimizing the air pollution which is the root cause of health problems such as asthma (Bugliarello *et al* 1996; Gakenheimer *et al* 1996).

Nowadays, most countries are experiencing process of urbanization and urban growth which caused by several factors includes migration and increasing of natural population (Cohen, 2006). The expansion of land use in urban area led to a crisis of urban sprawl and thus contribute to many problems (Bekele, 2005) especially on street pattern and travel characteristics. Due to the separation of residential area from the urban centre, private car ownership grow rapidly (European Environment Agency, 2006). Bekele (2005) analyse that there is high correlation between travel by automobiles and living outside city centres as shown in **Figure 1.1**. This figure shows that how private motor vehicles compliment with living at the edge of cities. Most people prefer to living in suburb because of high density of population and excessive land consumption in the city centre. As private car ownership increasing, more roads are needed to accommodate the volume of motor vehicles on the road. Eventually, the roads itself become a threat to the city and community particularly for example the roads are built to serve the automobiles.

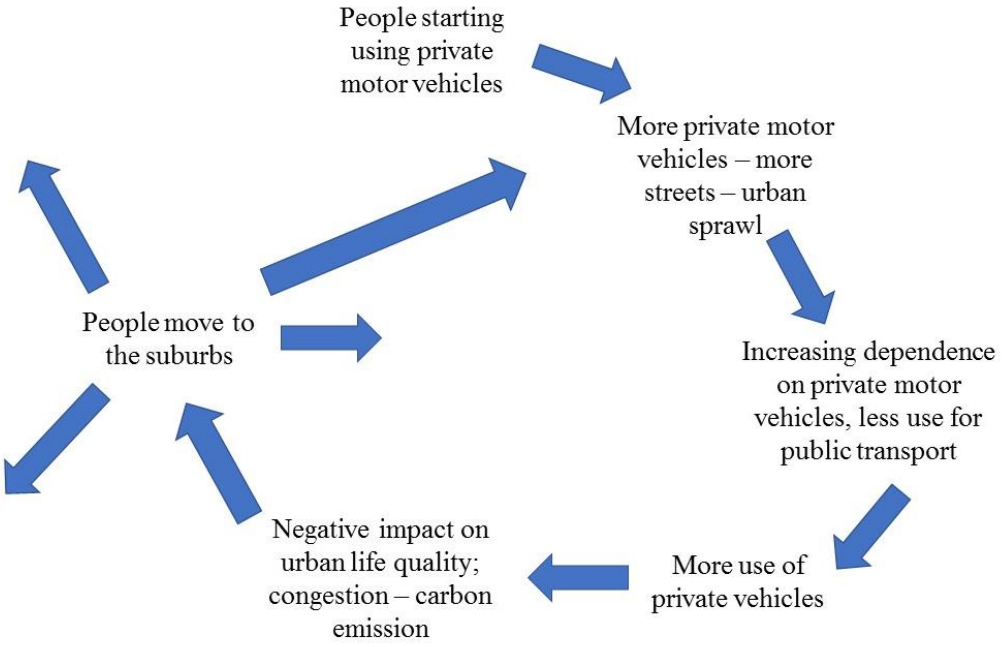


**Figure 1.1** Relationship between private vehicles and sprawl (Bekele, 2005)

People desire automobiles to enable them travel from their homes to work place, shop, hospital, school or visit friends and relatives. Business also requires automobile to access them to their sources of raw materials, markets and employees (Massachusetts Institute of Technology (MIT) and Charles River Associates Incorporated, 2001). Distance have separates them to their destination which have change their travel behaviour. Although new public transport technologies grew rapidly during this Twentieth Century (Litman, 2015) including rapid bus, bullet train and others, but trend of choosing public transport as main mode is still low because of some factors that affect travel demands. According to study by Litman (2015), there are four aspects of factors affecting travel demands such as economic factors of productivity, incomes and prices, quality of available transport options, land use factors and emerging social patterns and preferences. Therefore, land-use planning and sustainable travel may resolve the problems related to dependence on private motor vehicles.

In terms of land-use planning for sustainable mobility, street connectivity and accessibility between housing area and other destinations must be improved as well as deliver advantages to human well-being (Massachusetts Institute of Technology

(MIT) and Charles River Associates Incorporated 2001). Street patterns play an important role in terms of accessibility and connectivity. According to studies done by Sapawi and Said (2012), accessibility includes pattern of street network, variety and proximity of activities, connectivity between uses, mix land use, physical barrier, walking related infrastructure, distance to destination, clustered development pattern, and sufficient width of sidewalk. There are four categories of street patterns which are grid-iron, warped parallel, loops and lollipops and mixed patterns (Moeinaddini *et al*, 2014).

## 1.3 Research Questions

This research is seeking answers to the following questions:

i. How can the street pattern indicators in Johor Bahru neighbourhoods be analysed?
ii. What are the travel characteristics in Johor Bahru neighbourhoods?
iii. What is the significant differences between street pattern indicators in old and new neighbourhoods?
iv. What is the significant differences between travel characteristics in old and new neighbourhoods?

## 1.4 Research Objectives

The objectives of this research are:

i. To analyse the street pattern indicators in different neighbourhoods.
ii. To identify travel characteristics in different neighbourhoods.
iii. To find the significant differences between street pattern indicators in old and new neighbourhood.

iv. To find the significant differences between travel characteristics in old and new neighbourhood.

## 1.5 Scope of the Research

The scopes of the research are:

**i. To evaluate the neighbourhoods' street connectivity in different year built of neighbourhoods.**

The first phase in this research is to create evaluation on street connectivity. This research includes evaluation of accessibility and street network design. The things that encompass the evaluation of street connectivity including the street pattern indicators, land use composition, acreages of residential and year built of neighbourhood. These aspects will be analysing according to different year built of neighbourhood which are old neighbourhoods and new neighbourhoods. This research influence the sustainable mobility at neighbourhood level.

**ii. To study the mobility pattern of residents in different neighbourhoods.**

This research is identified the travel characteristics that influence the mobility of respondents. There are thirteen neighbourhoods in Johor Bahru that observed in this study. The selected neighbourhoods are elected by area that have more than 1000 acres. Face-to-face interviewed were conducted among 1300 respondents in the neighbourhoods which are 100 respondents per neighbourhood to identify the travel characteristics. It takes about one year to complete the survey questionnaire. These respondents are categorized according to ratio of gender which are 689 males and 611 females and ethnic ratio which are 585 Malay, 442 Chinese, 117 Indians and 156 others. This ratio was calculated from the total population of Johor Bahru. Both gender

and ethnic groups were taken into consideration in order to identify the relationship with movement patterns. Besides, this research focused on respondents between young and middle-age adults which is from 15 until 69 years old. This age group are chosen because most of them afford to walk, cycle and use public transport as transportation to workplace and leisure. Thus, this group is very suitable to serve as respondents to fulfil the requirements of the study.

iii. **To identify the relationship between street pattern and neighbourhood travel characteristics.**

The street pattern indicators and travel characteristics are analysed using Independent Samples T-Test to find the relationship in thirteen neighbourhoods.

## 1.6 Limitation of Research

This research has some limitation on two aspects which are the size of study area and the selected neighbourhoods. The targeted area in this research only focused on large geographic area which is exceeding 1000 acres because of higher travel trip, variety of land uses, higher housing density, multi-modal transportation and diversity of economic, social, ethnic and demographic. There are about 22 large neighbourhoods in Johor Bahru but 9 of them are excluded in this research includes industrial area, institutional area and private residential area. Industrial area is excluded from this research because this research needs to conduct a survey on population living in that area. On the contrary, industrial area does not have permanent residents who carry out various activities such as social, economic and education. They only commute to the area to perform their jobs. Next, institutional area excluded from this research because majority of the population have similar ages. In addition, they do not livings in the area for a long term. The aspects of employment status, monthly income and travel characteristics also taken into consideration in this research.

Most of the areas that excluded from this research are private residential area. The reasons of exemption are because of the difficulty in obtaining data from the residents. Majority of them did not cooperate to be interviewed for this research. Besides, one of the excluded residential area has large vacant area compared to their housing area. They have a very low housing density. Therefore, this research was not conducted due to lack of population as well as they do not have diversity of ethnic groups. At the same time, this area does not have diversity of social and economic activities and variety of land uses.

## 1.7 Significance of the Research

This research has identified the street pattern indicators that influence the travel pattern of inhabitants in Johor Bahru towards sustainable mobility. The indicators should be taken into consideration when designing neighbourhoods' street pattern to serve all requirements of pedestrian and cyclists whether od or disable. This research indicates that by produce a well-designed walking and cycling environments enable safety and comfortable movement around residential area. The major outcome of this research is the sustainable mobility through a better street pattern in the results of significance differences between street pattern indicators and travel characteristics in old and new neighbourhoods. It is hoped that all the outcome gathered from the research will spark an awareness in planners, urban designers and residents about the importance of sustainable mobility and active lifestyle.

This research is important to identify travel pattern of inhabitants in Johor Bahru in order to encourage them to support sustainable mobility. Thus, a better street pattern can attract people to choose walking, cycling and public transport as their mode choice instead of travel by private vehicle. A better street pattern must have a good accessibility, pleasant environment, good connectivity such as connected of residential blocks, less driving, reducing trip length and facilitating pedestrian, cyclist and transit areas. The shape or morphology of the street pattern play a key role to connect between land use and trip behaviour of residents. If more people exposed to public transport access, the more likely they drive less. Land use

policies play an important role to reducing driving. So, land use policy should be designed to meet lower carbon-based travel along with measures to promote active travel. Furthermore, the higher the number of walkers and cyclists contribute to congestion reduction and provide a better air quality. Therefore, less dependence on non-renewable energy gives a better environment to the society. Neighbourhood streets with more pedestrian and cyclist-oriented, appropriate infrastructure and facilities play an important role to serve all requirements of pedestrians and cyclists especially vulnerable users whether old or disable.

This research indicates that the problem on neighbourhood street can be minimized by make a good connection among the residents to reach the utilitarian destinations such as grocery stores, have access to green and open spaces and to transit stop. It affects the level of walking and cycling within a neighbourhood area. Other than that, a well-designed walking and cycling environments encourage safety and comfortably movement around the neighbourhood. In addition, the existing guideline for pedestrian and cyclist can be reviewed to achieve a high standard on pedestrian street as well as attract more people to choose walking and cycling as their transportation. A high standard of walking environment also helps to reduce the crashes among walkers and cyclist. Thus, this study shows that travel characteristics is associated with street pattern at neighbourhood level.

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