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COMMUTING IN THE GREATER JAKARTA:

Do residential household and socio-economic characteristic of workers alter their commuting behavior?

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Do residential household and socio-economic characteristic of workers alter their commuting behavior?

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Preface

The cover of this thesis depicts everyday life of commuters in one of main roads to the central business district in Jakarta. During this evening rush hour, a huge number of workers race their way to reach home as fast as possible. Impatient car drivers with their noisy car horn and overcrowded train is everyday life of workers. As a Jakartan, the author feels that this condition could create a different outcome of residential-work location relationship. It could be that due to congestion, commuters prefer to work in the proximity of their home, which mostly in the outskirt of Jakarta. Therefore, as a completion of the Master's degree program of Economic Geography at the University of Groningen, I attempt to identify the relationship by looking into the current commuting behavior.

Completing this thesis would not be possible without the help of The One Almighty, Allah SWT. Also, I want to thank my family for their unconditional love and continuous support me throughout my years of study and the process of writing this thesis. Furthermore, I want to thank dr. Samira Barzin for her helpful feedback guiding me throughout the writing process. Lastly, to all my friends that always support me, I thank you for your love and support. This accomplishment would not have been possible without them. Thank you.

Diva Almaputri

Jakarta, 30 August 2019

Summary

Theories stated that commuting behavior in urban area is influenced by two factors, which are the urban structure and socio-economic characteristic of workers. Different urban structure and socio-economic characteristic will create different commuting behavior pattern, in consideration with the location of employment center. In the Greater Jakarta, employment center is mainly located in the city of Central and South Jakarta. This means that a lot of commuters work and travel to that area every day. However, there are two main problems that might affect the commuting behavior of workers, which are highly congested road and inequalities in the provision of public transport, creating a different level of job accessibility for workers to reach certain job location. As a result, workers could have different commuting behavior from the theory mentioned before. To what extent the commuting behavior, in consideration with externalities such as congestion and inequalities in the provision of public transport, differ from the theory? Whom are people that is influenced? These questions are still missing in the literature. This thesis manages to answer these questions by incorporating the analysis of residents' commute behavior using travel time and their residential household location.

Using descriptive analysis and multiple regression analysis with the data from 2014 Commuting Survey, consists of almost 5000 household from 1312 census block in the Greater Jakarta, the results show that people mostly commute in proximity to their residential location; so it is not commute to the central city anymore. Also, it is shown that the relationship between income and travel time is positive. For every increase in income will be resulted in higher travel time. This means that people with higher income tend to have higher travel time and on contrary, people with lower income will have lower travel time.

There are several underlying reasons explaining the result of this thesis. Firstly, it could be due to the result of moving further away from central business district. As the highest congestion level is in the CBD, people tend move farther away from their workplace (city's outskirt or other districts), which relatively has lower congestion, so that they have better environment to live. Secondly, it could due to different job opportunities in the Greater Jakarta, so that the high-paid jobs tend to concentrate in CBD, therefore in consideration with their skills and job, they have to commute far from their residential location. Policy recommendation such as targeted employment or housing and employment center development could be integrated with transport planning in transport policies aiming for greater accessibility.

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GLOSSARY AND LIST OF ABBREVIATIONS

BRT	Bus Rapid Transit
CBD	Central Business District
LRT	Light Rapid Transit
MRT	Mass Rapid Transit
Province	Indonesia’s first level administrative division
Regency / City	Indonesia’s second local level administrative division beneath the provincial level. The difference lies in the size and density, in which regencies has bigger area than cities

1 INTRODUCTION

1.1 RESEARCH BACKGROUND

Cities have been characterized by their high concentration of economic activities, which resulted from the agglomeration economies. Jordaan (2000) defined an agglomeration economy as a localized economy in which a large number of firms existed in close proximity to one another. Firms are located near one another in cities because it benefits them to reduce transport costs and exchange goods, people, and ideas. As a result, cities become very attracted location for firms and industry and employment become concentrated in them. This is explained in urban economic theory, which Alonso (1964), Mills (1967), and Muth (1969) originated. The theory explains that the city has monocentric structure, so all jobs are in the city center (central business district) and the density declines radiating from the center.

The standard model predicts that, due to the centered employment in the city, density and capital-to-land ratio decrease with distance from CBD. As Wheaton (2004) stated, cities with very high agglomerative forces, in which employment is approximately centered, will create a long commute distances. The reason for this is the rise in land rent that results from the demand for land in the city. As cities expand in population and density, the land rent gradient between the city center and urban periphery shifts upward and becomes steeper. As Brueckner, cited in Hou (2017), also explained, the marginal savings in housing costs from moving slightly further from the CBD is exactly offset by the marginal increases in commuting costs.

Gutierrez-i-Puigarnau, et al. (2016) explains that due to the different choice of residential locations, high-income and low-income households have different commuting patterns. As is typical in the economic analysis of consumer behavior, workers will maximize its utility subject to a budget constraint, which depends on their income, consumption of goods, land, and transportation. Due to the increase of housing prices, it often displace lower-income workers, limiting their residential choices to locations outside their sub regions of employment.

There are several studies that gain evidence of the differences of residential location that alter the behavior of commuter. Lima, et al (2017) discussed that in Brazil, suburbs are resided by the middle class and the downtown areas are occupied by the deprived population. It is argued that such behavior could be due to low-skilled individuals productively seek to reduce their mobility costs, eventually pursue occupations in the informal job market, generally in the vicinity of their homes, reflecting a reduced commuting time. In another side, the central areas of cities in Europe are more desired by the wealthier population, with people that is not being able to afford life in the city center, are forced to set their homes in the the peripheral areas, therefore they took longer time to commute (Lima, et al. 2017). The main reason lies in the preference, where the rich tend to idealized quality of life of the suburbs. It has been found that the structure of city is different among countries, in which even more different between developing and developed countries due to the number of ongoing development that is still took place, creating also a different commuting pattern. As Lima, et al. (2017) explains, this difference is due to the distinct urban development policies in developing and developed country, where developing countries tend to regulate urban properties through housing for poor.

In Greater Jakarta, one of the biggest mega-cities with an estimation of 10.8 million inhabitants, there are special spatial patterns of residential household locations. The inner city of Jakarta, which is the capital city of Indonesia, has many slums and squatter houses in which the lower-income population reside. This has occurred due to the face that they cannot afford the travel cost incurrent when living further away from the city, but they cannot afford to rent or buy houses formally in central city, causing the informal “slums” residential area in several location in the city. Besides that, people with high-incomes also prefer live outside the inner city, as seen in the vast development of premium residential complex in urban fringe (Woltjer, 2014). People with higher income prefer to live further away from city because they want to have better environment living condition. This difference of residential household location also affecting their commuting behavior, such as the travel time and mode of transport.

1.2 Research Problem

Having a centralized employment center, mainly in Central Jakarta, people is willing to commute across cities or regencies to work. Every day, approximately 10% of Greater Jakarta population, which counts almost 3 million people, commute across the Greater Jakarta area. This shown that commuting is a huge part of daily activities that the population of Greater Jakarta has. However, due to the huge amount of commuters using private vehicle to travel to work, congestion emerged. As stated by the Jakarta Local Government (2010), the biggest share of transport modes in Jakarta are private road vehicle, where traffic consists 98% private vehicles serving of 44% trips and 2% public transport vehicles which serve 56% of the trips undertaken. As a result, longer travel time is inevitable. Moreover, congestion is worsened by the limited provision of public transport in several cities and regencies in Greater Jakarta. For example, the intercity train does not serve Tangerang and Bekasi regions; and Mass Rapid Transit (MRT) only serves the inner city of Jakarta. As a result, many people in Greater Jakarta have to use private vehicles and experience the congestion.

Empirical evidences regarding the relationship urban structure (business district and residential household) and how it is affect commuting behavior (travel time, distance, or mode of transport) have found throughout the years (Sultana, 2002; Rickwood & Glazebrook, 2009; Duarte & Fernández, 2017). However, what is still missing in the literature is the link between residents' household location and their socio-economic characteristic on commuting, especially in such highly congested area. As Kim & Choi (2019) argued, if one introduce congestion externalities into model of monocentric city, the location of residences may influence commuting behavior. However, to what extent the commuting behavior (considering it is a high congested area) differ from the theory? Whom are people that is influenced? These questions are still missing in the literature. This thesis manages to answer these questions by incorporating the analysis of residents' commute behavior using travel time and their residential household location.

1.2.1 Research Question

Based on the research problem as discussed above, below are the main and sub question(s) of the research

Main question

How do residential-work location and socio-economic characteristic of workers influence their commuting behaviour in the Greater Jakarta?

Sub question

- How does travel behaviour of commuters in cities and regencies in the Greater Jakarta?
- To what extent does income influence the travel time of workers in the Greater Jakarta?

1.2.2 Hypothesis

The hypotheses that is tested here are as follows:

- The Greater Jakarta still has monocentric urban pattern (most employment is in Jakarta area), therefore commuting behavior follow the urban pattern accordingly

- Workers that have higher income tend to have longer commuting travel time

1.3 RELEVANCY

1.3.1 Societal relevance

A high number of commuters could stem from possibilities: there is substantially environment deteriorate in the city therefore people want to live outside the city; or the land price/house rent in the city is very high therefore people cannot afford to live inside the city. Considering the increasing traffic in the Greater Jakarta, both of the cases, can affect directly to the travel cost and possible reduction of accessibility the city to certain groups of income level.

Accessibility of the city which might arise due to the high cost of land and transportation could have different meanings. For example, Lima, et al. (2017) stated that a high relative transport cost leads to physically isolating the poor from job opportunities, further diminishing their chances of social mobility. Social mobility is a term in which people have barrier to do activities in the city that leads to exclusion. There is also job accessibility, which are the number of job opportunities available depending on given travel costs such as travel distance and time (Kawabata & Shen, 2007). It can be said that road congestion in an area will cause a person that travels through the area more cost and therefore lowers their job accessibility. Based on that, this thesis will give insight of the effect of income on travel time, especially in such highly congested area.

1.3.2 Scientific relevance

For scientific purposes, one of the topic that will be addressed is the distribution of workers in a mega-cities in developing country. By identifying the current commuting behavior, this thesis identify the main employment center of Greater Jakarta and how congestion could create a different commuting behavior from the theory. Moreover, the link between commuting behavior and their socio-economic characteristic is also assessed. Using income as variable that explains socio-economic characteristic, this thesis will analyze in which direction is the socio-economic characteristic of workers influence commuting behavior.

1.4 METHODOLOGY

To answer the research question above, this study will use quantitative method to analyze the influence of income to travel time using STATA software. The data that is going to be used was obtained from the 2014 Commuting Survey that was designed by Indonesian Central Bureau of Statistic (BPS). Conducted in

May 2014, the sample consists of 13.120 household from 1312 census block in the Greater Jakarta, which are Jakarta city, Bogor Regency, Bogor City, Depok City, Tangerang City, Tangerang Region, Tangerang Selatan City, Bekasi Region, and Bekasi City. Further explanation on the methodology will be discussed in chapter 3.

1.5 THESIS STRUCTURE

The structure of this thesis will be as follows: in chapter 2, theoretical review about commuting and travel time will be discussed to generate an understanding of commuting behavior. Chapter 3 provides the methodology that is going to be used in the study. In chapter 4, the description of area that is being identified and also the data that is used in this research. The discussion of the result and finding will be discussed in chapter 5 and the reflection upon the result also concluding remarks will be explained in chapter 6.

2 THEORETICAL FRAMEWORK

In order to answer the research question, a theoretical framework is needed to understand the fundamental theory and earlier studies about the topic that will be researched. This chapter will be consist of the main theory of urban spatial patterns and commuting behavior.

2.1 URBAN THEORY

2.1.1 Agglomeration economies and urban areas

In explaining why certain groups of people or certain industrial activities occupy land at particular location within the city economy, one must understand the basic location theory of urban areas. The main central theory that explains the mechanism of city development is essentially derived from von Thunen's theory (1826). In the model it is explained that there is a specific market point located at M, at which all agricultural goods are traded and we assume that all land is owned by absentee landlords. Land is treated as simply a factor input in firm's production process and land payments are viewed as being residual. The assumption means that rental payments to land are distributed only after all other non-land factors and transport costs have been paid (Mccann, 2013). Also land is allocated according to its most profitable use, or alternatively to the highest bidder, at that point M. Therefore, this leads to a spatial structure of an increase in high price of land by the proximity to the point M.

The theory is then extended to an urban context by Alonso (1964). It is discussed if there are different sectors (not only agricultural) compete for land. He assumes that there are service, retail and distribution, and manufacturing sectors, in which has different priority in their production function. For example, service sector prioritize market accessibility, therefore it tends to locate closer to the center of economic activity and on contrary, retail and distribution sector need large floorspace input, therefore it tends to locate farther away from the city. This theory is not only applicable for industries, but one can simplify the analysis by treating groups of different activities as though they were part of a homogeneous individual group.

Alonso (1964), Muth (1969), and Mills (1972) also attempt to explain the theory in context of residential household location. The assumption is the same as von Thunen (1826), except the consideration of choosing the land location is based on how to maximize utility and minimize cost. As the incomes of people tend to differ markedly according to the different types of employment activities in which people are engaged, the overall budget constraint faced by individual person also differs. The authors assume society is composed by three income groups, namely, low-income, middle-income, and high-income. It is assumed that low-income people are to be constrainted in terms of their location possibilities, because their limited budget limit their ability to incur transport costs. Therefore, they relatively reside close to economic activities. Middle- and high- income groups earn sufficiently high wage income to allow them to incur transport costs, if they so choose, therefore they have greater preference for space outside the city.

In more recent studies, it is found that there are three determinants in choosing residential location (Jordaan, et al., 2004), namely accessibility, environmental characteristics (topographical features, landscape, or weather), and house rent. Accessibility, as he argues, is the proximity to amenities in which they commonly travels. It is stated that there is a trade-off of accessibility and environmental characteristics against rent. As Joordan, et al, (2004) argues:

"In a monocentric city, where all employment opportunities and shopping facilities are located in the Central Business District (CBD), it is also easy to determine accessibility; however, dynamic changes within cities that establish employment opportunities, shopping centers, and commercial uses in suburban areas complicate the establishment of an individual accessibility curve for every household, which basically leaves the price of land as the one factor that can easily be estimated" (p. 534)

In spite of that, there are many studies that gain evidence of the residential household choice in urban areas. As Lima, et al (2017) discussed that in America, suburbs are resided by the middle class and the downtown areas are occupied by the deprived population. In another side, the central areas of cities in Europe are more desired by the wealthier population, with people that is not being able to afford life in the city center, are forced to set their homes in the the peripheral areas, therefore they took longer time to commute (Lima, et al., 2017). Glaeser, et al. (2000) found that "old cities" and "new cities" in the US also have different patterns. For old cities, income falls with distance from the CBD; however for the new cities, income rises with distance from the CBD. The authors use the term old and new cities to compare the behavior of both groups, considering there is a difference in urban development; old cities have more established downtown and centralized employment before 1900 and new cities after 1900. It is found that in older cities, with established downtowns and centralized employment, the rich often live closest to the city center. In newer cities, with decentralized employment and with a physical infrastructure built for vehicle use rather than walking, income rises monotonically with distance from the central business district. In developing countries, Woltjer (2014) stated that middle-to high-income residential is emerging in the peri-urban areas in Africa, as large scale land and property development in peri-urban areas are becoming more emphasized. In the city of Solo in Indonesia, Roychansyah & Diwangkari (2009) found that very low-income people reside in informal housing. These phenomenon is common in developing countries, as the urban areas are increasing towards outskirt of the city, with relatively low house/land price, people could access urban amenities without needing to live in the central of the city.

2.1.2 Mega city (urban) patterns

Veneri (2018) explained that there is an emerging expansion of people and economic activities out from the existing major centers, which has changed the concept of city into a more "regional" phenomenon. The reason is that there is an urban expansion across cities, which emerged to a mega-city, metropolitan area, or greater area. Lüthi, et al. (2010) explained that mega-city regions consists of 'a number of smaller, specialized, closely-related centers', which has evolved to a single metropolitan center. Lin, et al. (2012) discuss that this phenomenon emerged in the mid to latter half of the 20th century. Employment began to disperse, with the proportion of jobs in the center decreasing over time and most new growth in employment being located outside of the CBD of mega cities (Lin et al., 2012). Therefore, many daily trips also expanded over a wide area outside the original CBD.

Due to its multi-centers, mega city is considered as polycentric city. As defined by Liu and Wang (2016) cited in Cai, et al. (2017), polycentric city usually covers more than one urban areas, as well as satellite cities, towns and intervening rural areas that are socio-economically tied to the urban core. Therefore, besides the main center (e.g CBD), there are also subcenters with greater density of people, unlike monocentric city that only has one main center.

In terms of the housing of workers, Hakim & Parolin (2008) stated that large scale housing projects also have been developed in distance from the metropolitan center, creating a more dispersed residential household – workplace location. This phenomenon is evident in growing mega cities, for example, in peri-urban areas in Jakarta Metropolitan Area (JMA), there is a spurts of growth in housing for medium and high income classes, inducing a rapid population growth in the peri-urban areas of Bodetabek (Bogor, Depok, Tangerang, Bekasi) and a low population growth in Jakarta city. Woltjer (2014) explains that the main reason of the spurts of housing growth in suburbs is due to urban expansion. As urban areas expand, they induce clusters of businesses, shops, and entertainment facilities beyond conventional urban area, which become this residential suburbs or semi-rural communities.

2.2 COMMUTING BEHAVIOUR

2.2.1 Commuting in developing countries

As discussed above, there are differences of spatial structures in urban context. Lin, et al. (2013) explain that spatial structure will translate to different commuting behavior. It is stated that there are four types of spatial structures, namely monocentric model, “urban village” model, polycentric model, and composite model, which differ by their employment center location and the “pull” strength. In monocentric model, employment center is very centralized in one city or districts, therefore people are mainly still commute to one CBD and the commuting movement will follow a radial pattern, where people commute from periphery toward center. In urban vilage model, there are more than one employment center and people live next to the place of employment. Therefore, they have shorter commuting time. Finally, in polycentric and composite form, commuting behavior patterns in a non-uniform distribution structure, with composite model differ in the presence of a dominant center.

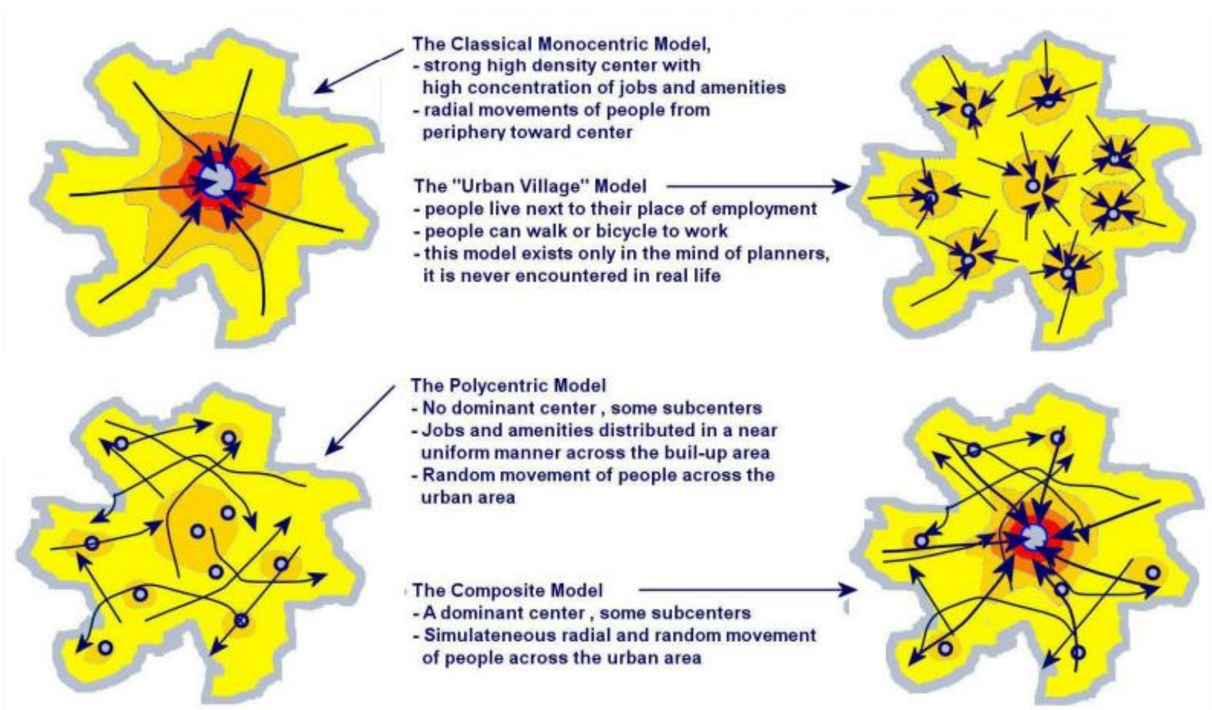

Figure 1 Type of Urban Spatial Structures in Mega-cities (Lin, et al., 2013)

There are several explanation in why people commute. Firstly, it could be that people can’t afford to live in central cities, due to the high price of land and house in the area. Also as explained in the urban spatial theory that is already discussed above, due to the high economic concentration in the city, it increases the demand of land in the city, and having the area is very dense, the land price is inevitably increasing

(Miles, 2012). This then leads people to reside outside the city and commute to their jobs in the city. Other explanation is a job and housing imbalance, as argued by Sultana (2002), people commute due to the imbalance between job that are available in the area where they are residing. This is also relates to search theory, which explains that workers are willing to accept any job that pays a higher wage than their reservation wage, assuming that wage is the only one attribute of the decision to accept a job (Ruppert, et al., 2009)

In developing countries, spatial mismatch hypothesis could be the explanation of the outcomes of labor and land market (Bunel & Tovar, 2014). They argue that there is a different availability of job across space, therefore people have to travel in distance to be able to work. Cheng & Bertolini (2013) also stated that the increasing distance due to spatial mismatch became a spatial barrier for workers, which represents the degree of spatial separation between the residential locations of workers and of employers. This degree of spatial separation can be represented as distance, time or cost, usually called generalized cost, in a physical space. He also further argues that increasing distance between their inner-city residential location and poor accessibility to jobs leading to high unemployment.

As in an urbanized area, the degree of transport accessibility also plays a big role in understanding the outcome of labour outcomes. Cheng & Bertolini (2013) explain this in a term of 'job accessibility', which is potential of job opportunities for interaction' or the 'ease of reaching work places'. Cheng & Bertolini (2013) stated that transportation system is the most important aspect to connect workers to jobs.

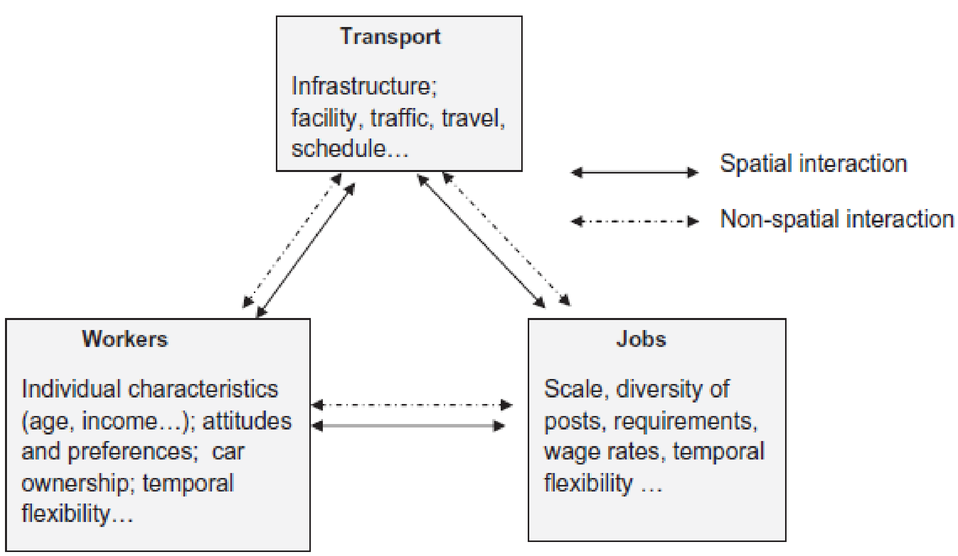

Figure 2 Conceptual framework of job accessibility (Cheng & Bertolini, 2013)

In explaining job accessibility, Cheng & Bertolini (2013) use a conceptual framework that discuss the spatial and non-spatial interaction of transport, workers, and jobs. Transport elements, consist of the spatial distribution, such as facilities, and services that ensures the connection between places of residence and work; in another hand, non-spatial aspect of transport, such as service schedules, traffic management, and planning policy, ensures the variation of mobility provision. On the side of the worker sub system, the individual characteristics (age, income, family structure), attitudes and preferences, car ownership, and flexibility in working hours, influence the demands of the transport itself (mode of transport, travel frequency, and timing. On top of that, job sub system, also influence the demand for workers and provision of transport services to the work place.

2.2.2 Socio-economic characteristic of commuters

Many empirical studies has found commuting behavior such as distance, travel time, and travel mode is influenced by worker's socio-economic characteristics. As argued by Lin, et al. (2016), there is a strong link between transportation and socio-economic characteristic of commuters, which may be more significant than the factors of urban spatial patterns. It is argued when individual socio-demographic factors (e.g., income, education and occupation) are considered, the impacts of urban structure on travel behavior appear to be much reduced in importance. The reason of this is that "soft" factors such as socio-economic characteristic has bigger influence on how much they need to commute.

Gutierrez-i-Puigarnau, et al. (2016) explained that wage is one of the factor that drives commuting behavior. The effect of which is usually assumed to be a linear effect, so it either income increases or decreases the travel time (Lima, et al., 2017). Various empirical evidence has been found in regards of the relationship between commuting patterns and income. Murillo (2018) found that in Santiago, Chile, low income people have the longest and farthest commutes; and the city's wealthiest neighborhoods have the shortest and quickest commute time. It is argued that the location of jobs are located in proximity with the richer residential household, therefore higher income workers tend the have the shortest commute time. In contradictory with previous study, Sandow & Westin (2010) found that incentives to commute longer distance are greater with higher wages. This can explained by high income workers' preference to live farther away from the city, due to the lower land price and better environmental surrounding. Conversely, (Lima, et al., 2017) found evident that the income groups of both lowest and highest income are the one who have smallest commuting time. It is argued that this finding is because low-income people cannot afford to use public transportation, restricting their activities to places that can be reached by foot or bicycles.

Workers’ skills and occupations are also factors that influence commuting behavior. Skills is often measured by their level of education. It is stated that workers with higher education tend to be more mobile than others, presumably because their job opportunities are bigger in scope and they can possibly gather and process information more efficiently (Eliasson, et al., 2003). As a higher level of education often is a proxy for a more skilled and better-paid job, this can compensate for higher commuting costs. Therefore, it is argued that the higher the level education is, the longer the commuting time is. In regards of occupations, previous studies found that people that work in informal jobs tend to reduce their mobility cost (Lima, et al., 2017), however, people that work in formal jobs tend to do commuting activities (Warsida, et al., 2013).

There are two possibilities in the relationship between travel time and income. As discuss by Sandow & Westin (2010), one of the possibility is the motivation of the workers. For example, if commuting is chosen as a means to promote individual achievement, it can be said that the relationship to income should be a positive. However, commuting is also time consuming and long absences from home may have negative impacts on the commuters’ relationships and interactions with their families, neighbourhoods, communities, and workplaces. If one choose the latter, the commuting time will lower than the former. Therefore, it is argued that motivation is also important in assessing commuting behavior.

3 METHODOLOGY

In this chapter, the methodology used in this research is being presented. In the first sub-chapter, conceptual framework are explained, which are derived based on both chapter 1 and 2, consisting of variables that are being identified in the research. After that, methodological approach and method of analysis are described.

3.1 RESEARCH FRAMEWORK

In this sub-section, research framework which is derived from the theoretical framework (Chapter II) is explained. Research framework is crucial in research because it summarizes the concept of theory and hypothesis about the study that will be conducted.

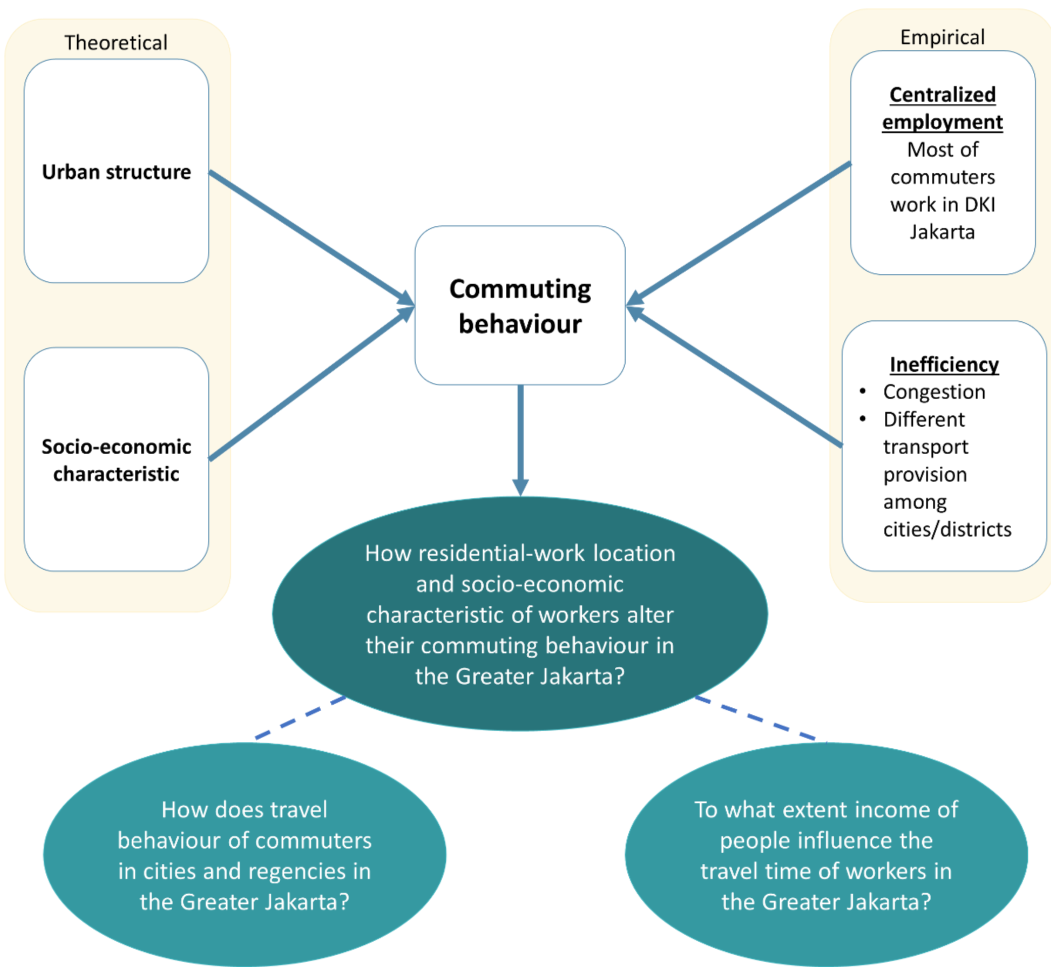

Figure 3 Conceptual framework

As discussed in earlier chapters, in theory, commuting behavior in urban area is influenced by two factors, which are the urban structure and socio-economic characteristic of workers. As stated by Lin, et al., (2013), different urban structure will create different commuting behavior, in consideration with the location of employment center. In terms of socio-economic characteristic, it is stated that in a larger metropolitan area there is a differences in commuting patterns between income groups; in which higher income groups tend to commute farther away from work. This theory is derived from urban economic theory, which explains that the reason of this phenomenon is happened is due to the differences in land price and preferences of each groups. Therefore, in the figure above, these two factors are the main theoretical foundation of the research.

In the Greater Jakarta, employment center is mainly located in the city of Central and South Jakarta. This means that a lot of commuters work and travel to that area every day. However, there are two main problems that might affect the commuting behavior of workers. Firstly, the highly congested road is creating a longer travel time for workers to get them to reach to their workplace. Workers could then alter their commuting behavior, for example, having a job that in proximity with their residential location. Secondly, across the cities and regencies in the Greater Jakarta, the (public) transportation provision is not well distributed, creating a different level of job accessibility for workers to reach certain job location. As a result, workers could have different commuting behavior from the theory mentioned before.

3.2 Methodological Approach

Methodological approach that is used in this research is quantitative research, which focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon (University of Southern California, 2019). As this thesis want to identify current residential-work location across the Greater Jakarta, using numerical data such as number of commuters that is embedded with origin-destination location will help to identify how many and where the employment centers are. Moreover, as the spatial scale that is going to be identified is in such large scale (mega-cities), it needs large sample size in order to generalize the concept. This thesis also attempt to see a correlation relationship between income and travel time, which could be seen using numerical data by analyzing it using regression analysis.

However, in quantitative research, one also need to acknowledge the limitation or weakness of the methodology. As stated by Queirós, et al. (2017), it may be that the related data is not available in such extent to represent the phenomenon. Also, the result is also dependent to the data that is used, so if there is an error in the data, it will impact the quality of the result.

3.2.1 Regression Analysis

In analyzing the data, this research will use regression analysis technique, which examine the relationship between dependent variable and independent variable(s). Regression analysis is used to provide quantitative evidence about a relationship between a set of variables measuring different phenomena in a population based upon a random sample of data drawn from population (Mehmetoglu & Jakobsen, 2017). This technique could show the strength of the relationship between two variables and also the significance of the coefficient.

The estimation method that used in this research is Ordinary Least Squares (OLS), that is based on the least-squares principle. The estimation method is try to minimize the squared residual and identify the strength of the relationship between variables.

The model that is used in this research is based on Dargay & Ommeren (2005); which found that there is a log-log relationship between travel time and income, so that the model is represented by the following model :

$$ln(y) = \alpha + \beta_1 \ln(w) + \beta_2 x + u$$

y, w denote the commuting time and income for individual i in year t; x represents observed control variables which influence commuting time such as distance, mode of transport, etc and it u is a random error. The effects of unobserved or omitted variables that are specific to the individual but are constant over time are represented by α, for instance education, residential location household, etc. In the research, it is found that there is a positive relationship of income on travel time, as a result of moving further away from the place of employment. The author include control variables such as relationship status, employment of other household member, and number of children. Beside the positive relationship between income and travel time, the author also found negative relationship between being "single" and commuting time, which suggest that when an individual ceases living with a partner, their commuting time declines, presumably as he/she moves closer to their job. Another finding is that if other household members become employed, commuting time will increase, which could stem from the movement closer to the workplace of other individual. Finally, when the worker has a child, commuting time decreases. It is argued that this relationship is due to the inclination to spend more time with the child.

To interpret regression coefficient estimates with above model, one need to look at the level in which the variables are. For example, as y is in log level, the interpretation of y could be translated to an elasticity of variable y. As income is on log-log level, the interpretation is as follows:

$$\Delta y\% = \beta_1 \% \times \Delta w\%$$

Therefore, both dependent and independent variable become elasticity, so if w change by one percent, one will expect y to change by β_1 percent.

Other example is if the interpretation is on log-level regression. The interpretation is as follows:

The relationship between x and y will be

$$\Delta y\% = 100\% \times (e^{\beta_2} - 1)$$

The interpretation of coefficient β_2 if x is continuous variable is: if x is increased by 1 (unit), y variable changes by ($100 \times \beta_2$) %. If

if one lives in particular district "A", the elasticity of travel time will be changed by $100\% \times (e^{\beta_2} - 1)$.

3.2.2 Limitation

In using linear regression analysis, one should acknowledge that there are several limitation of what the model cannot explained. The relationship between independent and dependent variable is not a causal relationship. As regression analyses only reveal relationships among variables, but do not imply that the relationship to be causal. The result of the analysis can be only tells us the direction (positive or negative) and the magnitude of the explanatory variable to the dependent variable. Therefore, in this research, one cannot state that income has a causation effect to travel time

Besides that, another possible problem is the possibility of reversed causation – that income, itself, is determined by commuting time as workers are willing to travel further for higher wages. As there are previous studies that found an increase in commuting distance increases the probability of accepting a job offer or a residential offer (Clark, et al., 2003). To minimize this problem, this research will only select workers who did not change workplace location within 5 years, so that income is considered constant within 5 years. As stated by Dargay & Ommeren (2005), individuals who remain in the same job, wages are not affected by commuting time, but are, in fact exogenous, so that the effect of income on commuting time can be estimated consistently by least squares regression.

4 SCOPE OF RESEARCH

In this chapter, the area that is identified in this research will be discussed, so the reader could have a clear picture of the condition of the area such as the borderline, population, and economic condition of each cities or regencies. Afterward, the data that is used in this research is also explained, such as the explanation of the data source, description of variables, and general descriptive statistics.

4.1 THE GREATER JAKARTA

4.1.1 General and socio-economic

The Greater Jakarta is one of the biggest mega-city in the world, with a population of 28 million (BPS, 2010) in an area of 3,302 km2 (Demographia, 2018), the area is the second biggest urban area in the world after Tokyo, Japan (Demographia, 2018) and the biggest urban area in Indonesia. The mega-city consists of 6 cities (*kota*) and 3 regency (*kabupaten*), which are Jakarta city, Bogor Regency, Bogor City, Depok City, Tangerang City, Tangerang Region, Tangerang Selatan City, Bekasi Regency, and Bekasi City.

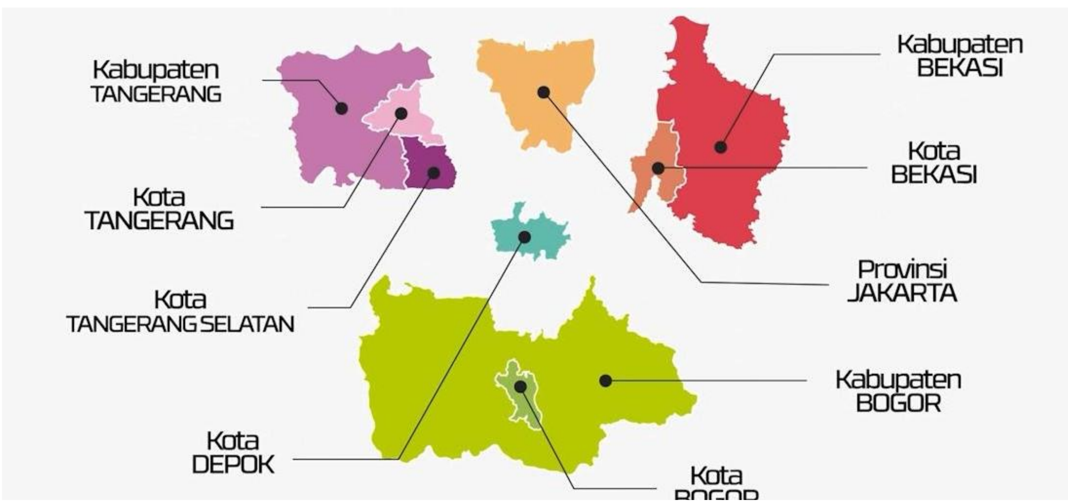

Figure 4 The Greater Jakarta map

City or regency that has the biggest population is Jakarta (9.5 million), followed by Bogor Regency (4.7 million), and Bekasi Regency (2.6 million) (BPS, 2010). The highest population density is Jakarta (15292 km2), Bekasi City (12928 km2) and Tangerang city (12482 km2), as shown in figure 4. Almost 13% of the population of the metropolitan area is commuter, in which are mostly from Depok city (20%), Bekasi city (20%), and Tangerang Selatan (18%) (Badan Pusat Statistik, 2014).

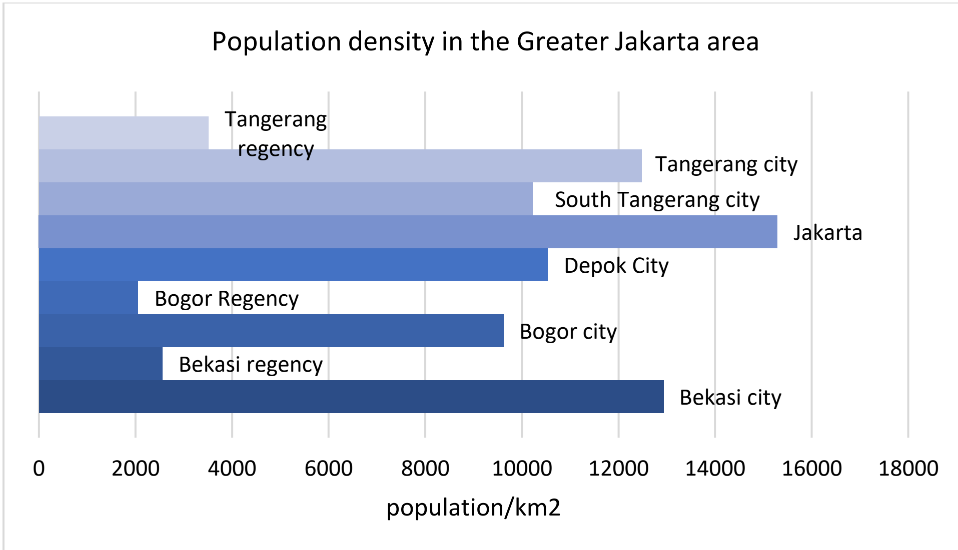

Figure 5 Population density of each city or regency in the Greater Jakarta

Based on Pratiwi & Muta'ali (2018), service sector such as trade, transportation, accommodation, information and communication, financial service, real estate, education, health, etc has the biggest share in the GDP of the metropolitan area. In 2008, the share of service sector to the GDP is 59.1% (Pratiwi & Muta'ali, 2018). The main prime central business district is in Jakarta, specifically in Central Jakarta (Jakarta Utara) and South Jakarta (Jakarta Selatan). It is the country's main premier financial center. In outer Jakarta, there are a lot of large scale residential area, for example in Bintaro (South Tangerang), BSD (Tangerang city), and Bekasi city. The area were mostly constructed in 1980s and is still expanding until now. Other than that there are also many industrial areas in the area, for example Pulogadung (East Jakarta), Berikat Nusantara (North Jakarta), and Jababeka (Bekasi regency).

4.2 The Greater Jakarta Commuter Survey 2014

4.2.1 Measures

As stated by (Neuman, 2007), there are a flow in measurement process for quantitative research: first conceptualization, followed by operationalization, then followed by applying the operational definition or measuring to obtain the data. In this sub-section, the discussion about operationalization and data is explained, which is derived from conceptual framework that is discussed in chapter 3. Below is the data that is needed in order to answer the research question

Table 1 Data requirements

No	Variable	Type
1	Estimated travel time from origin to destination	Continuous
2	Main mode of transport	Categorical
3	Origin city/region	Categorical
4	Destination city/region	Categorical
5	Income	Continuous
6	Modal split	Categorical
7	Congestion	Categorical

The data that is going to be used was obtained from the 2014 Commuting Survey that designed by Indonesian Central Bureau of Statistic (BPS). Conducted in May 2014, the sample consists of 13.120 household from 1312 census block in the Greater Jakarta, which are Jakarta city, Bogor Regency, Bogor City, Depok City, Tangerang City, Tangerang Region, Tangerang Selatan City, Bekasi Region, and Bekasi City. Those household members who had work or study activities outside the city/region were further surveyed. The total number of respondents is 47.421, consists of 5831 commuters and 41590 non-commuters. In total, there are approximately 100 variables in the dataset, consists of commuters' socio-economic characteristics.

Using the definition of commuters from (Badan Pusat Statistik, 2014), which define commuter as a person who do activities outside their city or regency of which they are resided; and routinely travel back on the same day, the data then reduced to only 5831 respondents. Furthermore, as this research particularly interested in looking at income variable, the number of data is further reduced to 4722 respondents. In the dataset, estimation weight is also provided to obtain estimates of population. In this thesis, the weighting will be included in the model building, so that it could represent the population.

4.2.2 Descriptive Statistic

Below are the descriptive statistic or summaries of each variables that will be used in this research. In table 2, it is shown that the observation the travel time is within 1 – 240 minutes, with an average of 64.5 minutes. The income range between Rp 200.000 (~ $14) to Rp 120.000.000 (~ $8518) per month. Modal split, which represent the total number of the choice travel mode, range between 1-5. This means commuters in Greater Jakarta change mode of transport maximum of 5 times. Distance range from 0-104 kilometers.

Table 2 Descriptive statistic of continuous variable

Variable	Obs	Mean	Std.Dev.	Min	Max
Travel time*	4722	64.592	35.604	1	240
Income*	4722	4420000	5330000	200000	1.20e+08
ln_travel time	4721	3.998	.623113	.6931472	5.481
ln_income	4722	15.031	.656	12.206	18.603
Modal split	4722	2.274	.618	1	5
Distance*	4722	21.274	15.107	0	104

*travel time in minutes, income in Rupiah (Rp 14.110 = 1 USD), and distance in kilometers

Table 3 depicts the categorical variable such as the type of transport, origin (city or regency in which they live), destination (city or regency in which they work), and experience congestion (yes or no question). Variable mode of transport explains the main type of transport the respondents use to commute. As shown in the table, private vehicles are still the most used transport for commuting, depicted by the share of motorcycle (57.5%) and private car (12.66%). The variable of congestion explains if the respondents experience congestion or not while they commute.

Table 3 Descriptive Statistic of categorical variable

Categorical Variable	N	Share (%)
Mode of transport	4687	99.26
Bicycle*	20	0.42
Bicycle-taxi	8	0.17
Motorcycle	2715	57.5
Motorcycle-taxi	30	0.64
Picked-up service motorcycle	18	0.38
Company-owned motorcycle	19	0.40
Private car	598	12.66
Company-owned car	87	1.84
Other public transport; no route	538	11.39
Other public transport; with route	14	0.3
Picked-up service car	136	2.88
Ride-sharing car	15	0.32
Train	364	7.71
Bus Rapid Transit	113	2.39
Feeder bus	9	0.19
Others	3	0.06
Origin	4722	100
South Jakarta*	406	8.6
East Jakarta	488	10.33
Central Jakarta	318	6.73
West Jakarta	453	9.59
North Jakarta	272	5.76

Bogor Regency	298	6.31
Bekasi Regency	258	5.46
Bogor City	192	4.07
Bekasi City	513	10.86
Depok City	539	11.41
Tangerang Region	185	3.92
Tangerang City	416	8.81
Tangerang Selatan City	384	8.13
Destination	4722	100
South Jakarta*	195	4.13
East Jakarta	5	0.11
Central Jakarta	122	2.58
West Jakarta	9	0.19
North Jakarta	4	0.08
Bogor Regency	34	0.72
Bekasi Regency	139	2.94
Bogor City	1301	27.55
Bekasi City	497	10.53
Depok City	1001	21.20
Tangerang Region	670	14.19
Tangerang City	648	13.72
Tangerang Selatan City	97	2.05
Congestion	4722	100
Yes*	3690	78.14
No	1032	21.86

*reference category

Table 4 presents the correlation matrix regarding the continuous variables involved in the regression. Income, the main continuous variable that is interested in, has a correlation of 0.206 in 99% confidence level. Based on this, income and travel time has a positive relationship. Other things that can be seen in the table is that the overall variables are positive and significantly correlated with travel time. However, distance is found to have negative effect with income. This correlation is not significantly correlated, which could be ignored.

Table 4 Correlation matrix for OLS regression model (continuous) variables

	(1)	(2)	(3)	(4)
Travel Time	1			
Income	0.206***	1		
Distance	0.286***	-0.00404	1	
Modal Split	0.577***	0.128***	0.283***	1

* p<0.05, ** p<0.01, *** p<0.001

5 RESULTS

In this chapter, all results are presented. First, the discussion of difference of travel time among cities and regencies will be presented. Afterwards, the OLS regression that shows the relationship of income on travel time in the Greater Jakarta will be presented. The analysis and discussion about the results in this chapter will be discussed further in chapter 6.

5.1 TRAVEL BEHAVIOR IN THE GREATER JAKARTA

Using the data from BPS (2010), it has been found that the average of travel time that commuters experience every day is 64.5 minutes, with an average travel distance of 21 km and speed of 0.3 km/hour, which is considered very slow. This shown that there is still an obstacle in the commuting journey in the Greater Jakarta. Obstacles that are identified in the survey are congestion, road accident, and technical transportation issues. The biggest obstacles that play a role in the travel duration is congestion, as shown in figure 6, 78% of commuters experience congestion every day. Another obstacle that has a big influence on the travel duration is technical transportation issues. Almost half of commuters in the Greater Jakarta experience technical issues in both private and public transportation.

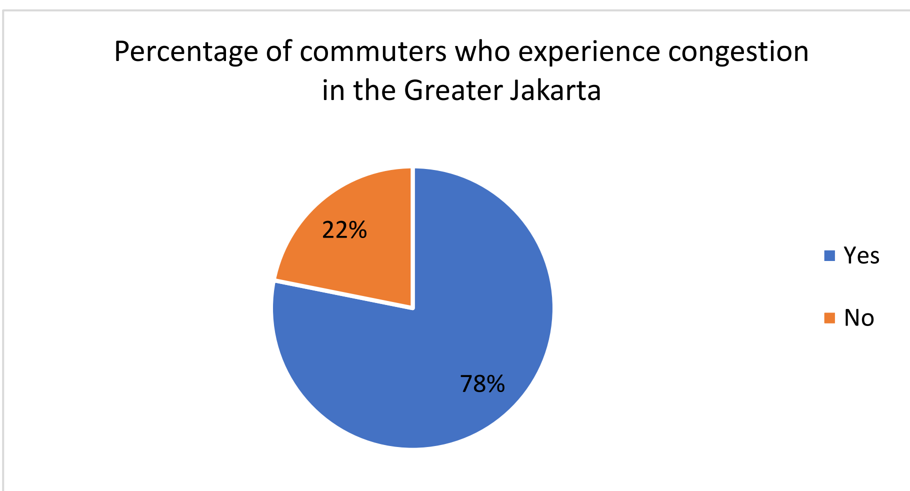

Figure 6 Percentage of commuters who experience congestion in the Greater Jakarta

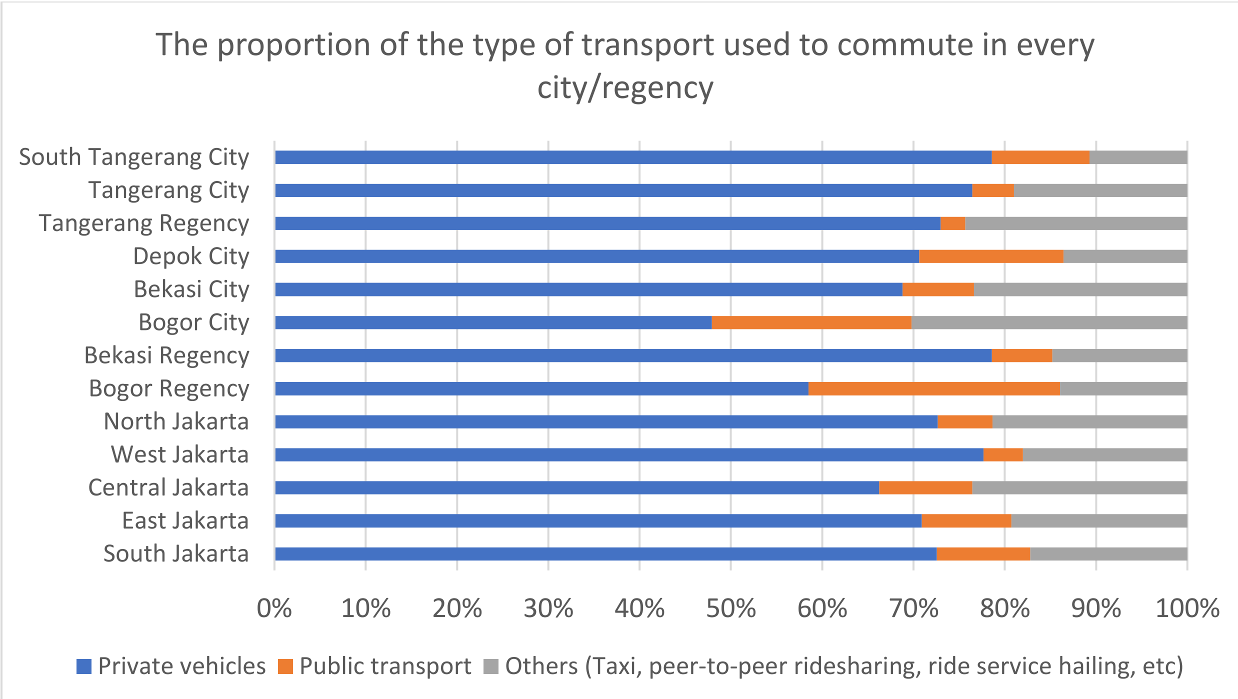

Figure 7 The type of transport used to commute in every city/regency in the Greater Jakarta

Figure 7 depicts the proportion of the type of transport used to commute in every city or regency. As seen above, it is shown that private vehicles is still the most used transport for commuting in every city and region. The city that uses the most private vehicles is South Tangerang city and Bekasi regency, almost 80% of the population use private vehicles to commute. The city that uses the least private vehicles is Bogor city. Less than 50% of people in Bogor city use private vehicles. Other findings that can be seen from above is the use of public transport is very low, only about 10-15% of people in every city/regency use public transport as their main mode of transport. In fact, categories “others”, such as taxi, peer-to-peer ridesharing, and ride service hailing has bigger percentage than public transport. This could imply that public transportation provision is still low in the area.

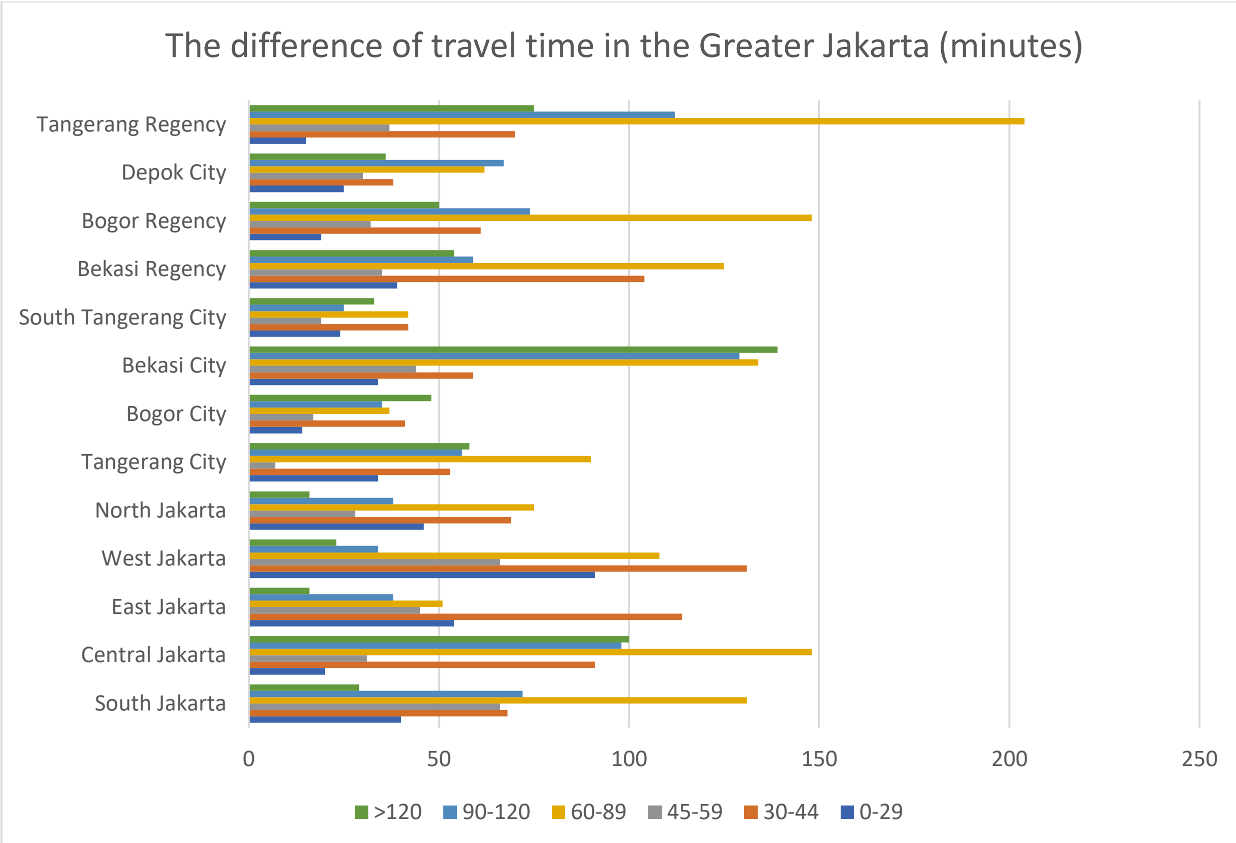

Figure 8 The difference of travel time in the Greater Jakarta by cities and regencies (in minutes)

In figure 8, it is shown that on average, most commuters experience 60-89 minutes travel time duration. There are some differences among the cities and regencies, for example in Bekasi city, it is shown that there is big portion of the population that experience travel time higher than 60 minutes. On the contrary, city such as Tangerang city, experience lower travel time compared with other cities and regencies, which in the interval of 0-60 minutes. Other than that, it is also shown that cities and regencies that has long commuting distance (on average) is on the outside of Jakarta. This may shows that transport inefficiency, such as congestion or lack of public transport is occurred mainly in the outside of Jakarta. The differences of travel time, however, cannot say much about the distance traveled by commuters, as congestion highly influence the travel time that is incurred. To provide us more information about the proximity of workplace to their residential location, one could analyze the distance and the flow of commuters from their residential location to their workplace.

Figure 9 Commuter flow between cities and regencies in the Greater Jakarta (Data: BPS, 2010)

In figure 9, the distribution of commuters throughout the Greater Jakarta is presented. As shown in the figure, the biggest flow of commuters are from Bogor Regency, followed by East Jakarta and Depok city, which all of them mostly travel to their neighbor cities or regencies. For example, most of commuters from Bogor regency travel to its neighbor city, which is Bogor city, on the south of Bogor regency. This pattern also the same with other cities and regencies. After their neighbor cities and regencies, it is also shown that the second destination is Central Jakarta and South Jakarta. This is logical, as the main central business district is in both cities. Another finding is commuters from Bogor city and regency travel mutually from one another, showing that both city complement each other economically.

5.2 RELATIONSHIP BETWEEN INCOME AND TRAVEL TIME

OLS models are performed to provide an estimation on the relationship of the origin location of workers and income to travel time. Table 5 & 6 depict the OLS regression results predicting travel time. In table 5, the regression is unweighted and in table 6, the regression is weighted. The interpretation and analysis of the result will be explained in the next sub-section.

Table 5 OLS regression results predicting travel time in log form (unweighted), 2014

VARIABLES	(1)	(2)	(3)	(4)	(5)
Income	0.148***	0.132***	0.0887***	0.0799***	0.0768***
	(0.0163)	(0.0159)	(0.0139)	(0.0136)	(0.0136)
Mode of Transport (ref: bicycle)					
Bicycle-taxi	0.374	0.106	0.372	0.180	0.228
	(0.271)	(0.264)	(0.229)	(0.224)	(0.224)
Motorcycle	0.610***	0.360**	0.414***	0.244*	0.260**
	(0.158)	(0.153)	(0.133)	(0.131)	(0.131)
Motorcycle_taxi	0.404**	0.144	0.361**	0.176	0.192
	(0.189)	(0.184)	(0.159)	(0.156)	(0.156)
PUS motorcycle	0.661***	0.448**	0.457***	0.313*	0.317*
	(0.204)	(0.199)	(0.173)	(0.169)	(0.169)
Company motorcycle	0.531**	0.289	0.378**	0.212	0.222
	(0.207)	(0.201)	(0.175)	(0.171)	(0.171)
Private car	0.783***	0.509***	0.528***	0.343**	0.358***
	(0.161)	(0.157)	(0.136)	(0.134)	(0.134)
Company car	0.842***	0.566***	0.494***	0.312**	0.317**
	(0.171)	(0.166)	(0.144)	(0.142)	(0.142)
OPT_noroute	0.661***	0.401**	0.539***	0.358***	0.376***
	(0.161)	(0.157)	(0.136)	(0.134)	(0.133)
OPT_withroute	0.797***	0.533**	0.527***	0.350*	0.348*
	(0.219)	(0.213)	(0.185)	(0.181)	(0.181)
PUS car	0.837***	0.573***	0.566***	0.390***	0.424***
	(0.166)	(0.162)	(0.140)	(0.138)	(0.138)
Ridesharing car	1.032***	0.758***	0.607***	0.430**	0.432**
	(0.218)	(0.212)	(0.185)	(0.181)	(0.181)
Train	0.758***	0.654***	0.423***	0.363***	0.360***
	(0.164)	(0.159)	(0.138)	(0.136)	(0.136)
BRT	0.801***	0.579***	0.617***	0.467***	0.472***
	(0.169)	(0.164)	(0.143)	(0.140)	(0.140)
Feeder bus	0.960***	0.681***	0.531**	0.350	0.361*
	(0.261)	(0.253)	(0.220)	(0.216)	(0.216)
Others	0.316	0.359	-0.0144	0.0312	0.0897
	(0.350)	(0.339)	(0.295)	(0.289)	(0.289)
Modal Split (ref: 2)					
3	0.216***	0.201***	0.110***	0.104***	0.106***
	(0.0379)	(0.0367)	(0.0321)	(0.0314)	(0.0314)
4	0.361***	0.313***	0.202***	0.175***	0.176***
	(0.0492)	(0.0478)	(0.0417)	(0.0409)	(0.0408)
5	0.781***	0.672***	0.368***	0.309***	0.314***
	(0.107)	(0.104)	(0.0908)	(0.0889)	(0.0888)
Origin (ref: Jakarta Selatan)					
Jkt_Timur	0.185***	0.161***	0.0738**	0.0619*	0.0569*
	(0.0390)	(0.0378)	(0.0330)	(0.0323)	(0.0331)

Jkt_Pusat	-0.251***	-0.300***	-0.265***	-0.300***	-0.311***
	(0.0441)	(0.0429)	(0.0372)	(0.0365)	(0.0373)
Jkt_Barat	-0.228***	-0.197***	-0.177***	-0.157***	-0.174***
	(0.0422)	(0.0409)	(0.0356)	(0.0349)	(0.0356)
Jkt_Utara	-0.157***	-0.156***	-0.172***	-0.171***	-0.178***
	(0.0458)	(0.0444)	(0.0386)	(0.0378)	(0.0378)
Kab_Bogor	0.0176	0.107**	-0.324***	-0.245***	-0.240***
	(0.0452)	(0.0442)	(0.0391)	(0.0387)	(0.0395)
Kab_Bekasi	0.154***	0.193***	-0.0242	0.0117	0.0175
	(0.0469)	(0.0455)	(0.0398)	(0.0390)	(0.0408)
Kota_Bogor	0.0845	0.0836*	-0.425***	-0.403***	-0.313***
	(0.0517)	(0.0501)	(0.0454)	(0.0444)	(0.0504)
Kota_Bekasi	0.155***	0.137***	0.00283	-0.00309	0.00304
	(0.0393)	(0.0381)	(0.0333)	(0.0326)	(0.0336)
Kota_Depok	0.228***	0.300***	0.0885***	0.147***	0.147***
	(0.0388)	(0.0378)	(0.0329)	(0.0325)	(0.0336)
Kab_Tangerang	0.0884*	0.0858*	-0.148***	-0.139***	-0.161***
	(0.0525)	(0.0508)	(0.0446)	(0.0437)	(0.0450)
Kota_Tangerang	0.0189	0.0121	-0.0575	-0.0589*	-0.0732**
	(0.0420)	(0.0406)	(0.0354)	(0.0347)	(0.0362)
Kota_TangSel	0.109***	0.118***	0.0434	0.0524	0.0370
	(0.0417)	(0.0404)	(0.0352)	(0.0345)	(0.0355)
Distance			0.0225***	0.0215***	0.0213***
			(0.000559)	(0.000552)	(0.000560)
Congestion (ref: Yes)					
No		-0.358***		-0.256***	-0.250***
		(0.0221)		(0.0190)	(0.0191)
Destination (ref: Jakarta Selatan)					
Jkt_Timur					0.210
					(0.319)
Jkt_Pusat					0.193***
					(0.0636)
Jkt_Barat					0.289*
					(0.157)
Jkt_Utara					0.243
					(0.262)
Kab_Bogor					0.00842
					(0.0959)
Kab_Bekasi					0.101*
					(0.0587)
Kota_Bogor					0.190***
					(0.0431)
Kota_Bekasi					0.167***
					(0.0459)
Kota_Depok					0.169***
					(0.0444)
Kab_Tangerang					0.163***
					(0.0455)
Kota_Tangerang					0.166***
					(0.0460)
Kota_TangSel					0.0628
					(0.0638)
Constant	1.026***	1.581***	1.783***	2.146***	2.018***
	(0.281)	(0.274)	(0.238)	(0.234)	(0.237)

Observations	4,031	4,031	4,031	4,031	4,031
R-squared	0.209	0.258	0.437	0.462	0.466

Note: Numbers in parentheses are standard errors. ref. = reference category. Income and travel time (dependent variable) are natural logarithm (ln) form.

Table 6 OLS regression results predicting travel time in log form (weighted), 2014

VARIABLES	(1)	(2)	(3)	(4)	(5)
ln_income	0.188***	0.170***	0.109***	0.100***	0.0960***
	(0.000660)	(0.000641)	(0.000552)	(0.000541)	(0.000543)
Mode of Transport					
Bicycle-taxi	0.401***	0.144***	0.396***	0.219***	0.282***
	(0.0120)	(0.0116)	(0.00991)	(0.00971)	(0.00969)
Motorcycle	0.501***	0.259***	0.337***	0.177***	0.199***
	(0.00680)	(0.00661)	(0.00564)	(0.00554)	(0.00552)
Motorcycle_taxi	0.244***	-0.0148*	0.256***	0.0761***	0.100***
	(0.00809)	(0.00787)	(0.00671)	(0.00659)	(0.00657)
PUS motorcycle	0.524***	0.313***	0.347***	0.208***	0.217***
	(0.00866)	(0.00841)	(0.00718)	(0.00704)	(0.00701)
Company motorcycle	-0.0335***	-0.352***	0.0359***	-0.187***	-0.178***
	(0.00801)	(0.00779)	(0.00664)	(0.00653)	(0.00651)
Private car	0.650***	0.388***	0.428***	0.257***	0.280***
	(0.00694)	(0.00675)	(0.00575)	(0.00565)	(0.00564)
Company car	0.683***	0.421***	0.370***	0.203***	0.213***
	(0.00736)	(0.00716)	(0.00611)	(0.00600)	(0.00599)
OPT_noroute	0.479***	0.224***	0.443***	0.268***	0.290***
	(0.00694)	(0.00675)	(0.00575)	(0.00565)	(0.00564)
OPT_withroute	0.654***	0.411***	0.464***	0.305***	0.307***
	(0.00911)	(0.00884)	(0.00755)	(0.00741)	(0.00738)
PUS car	0.807***	0.536***	0.559***	0.383***	0.415***
	(0.00710)	(0.00691)	(0.00589)	(0.00579)	(0.00579)
Ridesharing car	0.922***	0.670***	0.533***	0.376***	0.392***
	(0.00924)	(0.00897)	(0.00767)	(0.00752)	(0.00749)
Train	0.677***	0.562***	0.377***	0.311***	0.316***
	(0.00707)	(0.00685)	(0.00586)	(0.00574)	(0.00573)
BRT	0.682***	0.469***	0.563***	0.420***	0.433***
	(0.00730)	(0.00709)	(0.00605)	(0.00593)	(0.00592)
Feeder bus	0.850***	0.582***	0.476***	0.307***	0.325***
	(0.0117)	(0.0114)	(0.00974)	(0.00955)	(0.00951)
Others	0.127***	0.178***	-0.150***	-0.102***	-0.0503***
	(0.0184)	(0.0178)	(0.0152)	(0.0149)	(0.0148)
Modal Split					
3	0.241***	0.220***	0.109***	0.101***	0.105***
	(0.00159)	(0.00154)	(0.00132)	(0.00129)	(0.00129)
4	0.426***	0.381***	0.208***	0.186***	0.188***
	(0.00207)	(0.00201)	(0.00173)	(0.00169)	(0.00169)
5	1.217***	1.061***	0.225***	0.161***	0.175***
	(0.00341)	(0.00332)	(0.00297)	(0.00292)	(0.00292)
Origin					
Jkt_Timur	0.186***	0.159***	0.0724***	0.0587***	0.0541***

	(0.00158)	(0.00153)	(0.00131)	(0.00129)	(0.00132)
Jkt_Pusat	-0.230***	-0.280***	-0.255***	-0.288***	-0.301***
	(0.00223)	(0.00217)	(0.00185)	(0.00181)	(0.00184)
Jkt_Barat	-0.218***	-0.178***	-0.170***	-0.145***	-0.164***
	(0.00172)	(0.00167)	(0.00143)	(0.00140)	(0.00143)
Jkt_Utara	-0.121***	-0.117***	-0.149***	-0.145***	-0.150***
	(0.00204)	(0.00197)	(0.00169)	(0.00165)	(0.00165)
Kab_Bogor	-0.0242***	0.0473***	-0.336***	-0.273***	-0.283***
	(0.00168)	(0.00164)	(0.00142)	(0.00141)	(0.00146)
Kab_Bekasi	0.187***	0.237***	0.0228***	0.0644***	0.0576***
	(0.00186)	(0.00181)	(0.00155)	(0.00153)	(0.00161)
Kota_Bogor	0.0919***	0.0948***	-0.443***	-0.418***	-0.322***
	(0.00260)	(0.00252)	(0.00222)	(0.00217)	(0.00234)
Kota_Bekasi	0.118***	0.102***	-0.0358***	-0.0403***	-0.0358***
	(0.00157)	(0.00152)	(0.00131)	(0.00128)	(0.00133)
Kota_Depok	0.214***	0.289***	0.0855***	0.143***	0.144***
	(0.00166)	(0.00162)	(0.00138)	(0.00137)	(0.00140)
Kab_Tangerang	0.115***	0.106***	-0.138***	-0.133***	-0.151***
	(0.00203)	(0.00196)	(0.00170)	(0.00166)	(0.00171)
Kota_Tangerang	-0.0227***	-0.0381***	-0.0725***	-0.0809***	-0.0853***
	(0.00176)	(0.00170)	(0.00146)	(0.00143)	(0.00149)
Kota_TangSel	0.120***	0.128***	0.0629***	0.0710***	0.0583***
	(0.00182)	(0.00176)	(0.00151)	(0.00148)	(0.00151)
Distance			0.0231***	0.0221***	0.0221***
			(2.17e-05)	(2.15e-05)	(2.20e-05)
Congestion					
No		-0.359***		-0.248***	-0.237***
		(0.000885)		(0.000749)	(0.000752)
Destination					
Jkt_Timur					0.268***
					(0.00596)
Jkt_Pusat					0.208***
					(0.00260)
Jkt_Barat					0.308***
					(0.00611)
Jkt_Utara					0.183***
					(0.00899)
Kab_Bogor					0.0632***
					(0.00351)
Kab_Bekasi					0.126***
					(0.00224)
Kota_Bogor					0.220***
					(0.00174)
Kota_Bekasi					0.235***
					(0.00185)
Kota_Depok					0.196***
					(0.00180)
Kab_Tangerang					0.181***
					(0.00185)
Kota_Tangerang					0.218***
					(0.00185)
Kota_TangSel					0.124***
					(0.00257)
Constant	0.533***	1.115***	1.543***	1.900***	1.746***

	(0.0117)	(0.0114)	(0.00973)	(0.00958)	(0.00966)
Observations	2,483,806	2,483,806	2,483,806	2,483,806	2,483,806
R-squared	0.253	0.299	0.487	0.508	0.513

Note: Numbers in parentheses are standard errors. ref. = reference category. Income and travel time (dependent variable) are natural logarithm (ln) form.

Income	0.148***	0.132***	0.0887***	0.0799***	0.0768***
R-squared	0.209	0.258	0.437	0.462	0.466

ln_income	0.188***	0.170***	0.109***	0.100***	0.0960***
R-squared	0.253	0.299	0.487	0.508	0.513

Comparing both unweighted and weighted regression in table 5 and 6, there are slightly differences of the coefficient and level of explained variance. However, the significance of both models, especially on income which is the variable that this research focus on, is still significant in 99% confidence level. Table 5 depicts the model with unweighted frequency, therefore the number of observation is not representing the number of the population. As shown in table 5, in the first model (1), a 1% increase of income is associated with a 0.148% longer travel time in 99% confidence level with an explained variance of 20.9%. When adding control variables and variable dummies in stage 2 and 3, the variable of income loses explanatory power, particularly after distance is took into account (model 3), which has to do with the substantial effect of distance on travel time. With respect to mode of transport, number of modal split, origin regency/city, and distance, it has been found that a 1% increase of income will increase the travel time by 0.089% in 99% confidence level and explained variance of 43.7%. In stage 4 and 5, the explanatory power of income is relatively constant, as the coefficient only changes within an interval of 0.01. In stage 5, with the explained variance of 46.6%, it is found that a 1% increase of income is associated with a 0.0768% longer travel time in 99% confidence level.

Table 6 depicts the model with weighted frequency. Therefore, the number of observations represent the number of population. Compared with the model with unweighted frequency, it can be seen that overall, the explanatory power which is depicted as coefficient is increasing. Other than that, the R squared that depicts the variance explained is also increasing. This means that the model with weighted frequency relatively is more representing the population. The first model (1), a 1% increase of income is associated with a 0.19% longer travel time in 99% confidence level with an explained variance of 25.3%. When adding control variables and variable dummies in stage 2 and 3, the variable of income also loses explanatory power, particularly after distance is took into account (model 3). With respect to mode of transport, number of modal split, origin regency/city, and distance, it has been found that a 1% increase of income will increase the travel time by 0.11% in 99% confidence level and explained variance of 48.7%. In stage 4 and 5, the explanatory power of income is also relatively constant, as the coefficient only changes within an interval of 0.01. In stage 5, with the explained variance of 51.3%, it is found that a 1% increase of income is associated with a 0.096% longer travel time in 99% confidence level.

5.2.1 Robust Regression

One of the assumptions that needs to be met in order to have a good model is heteroskedasticity test. In testing it, one could use Breusch-Pagan / Cook-Weisberg test for heteroscedasticity. Heteroscedasticity means "differently scattered". This test is attempting to test if the variance of the error term is constant or random. The test statistic follows a chi-square distribution and has the null hypothesis of the error variances are all equal (homoscedasticity). It measures how errors increase across the explanatory variable (Y). A large chi-square would indicate that the heteroskedasticity was present.

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of ln_p611b

         chi2(1)      =    35.48
         Prob > chi2  =   0.0000
```

Using the last weighted regression (table 7, model 5), the Breusch-Pagan / Cook-Weisberg test for heterskedasticity above shows that the probability value of the chi-square statistic is less than 0.05. Therefore the null hypothesis of constant variance is rejected at 5% level of significance. It implies the presence of heteroscedasticity in the residuals. There are several explanation in why heteroscedasticity is present, which are could be due to measurement error, model misspecifications, or subpopulation differences. In this case, it might be due to the differences of subpopulation, as the observation level is on city or regency level. As a result, several subpopulation of city could be clustered. The consequences of the presence is that the OLS estimates are no longer BLUE (Best Linear Unbiased Estimator).

UCLA: Statistical Consulting Group (2019) explained that when data is contaminated with outliers or influential observations, one could use robust regression as an alternative to least squares regression. The idea of robust regression is to weigh the observations differently based on how well behaved the observations are, which then form into weighted and reweighted least squares regression. Therefore, to deal with heteroskedasticity, one could run a robust standard errors in the regression, so that the problem of heteroscedasticity is not present anymore. The result of OLS regression that is already corrected is presented in Table 8.

Table 7 OLS regression results predicting travel time in log form (weighted, robust), 2014

VARIABLES	(1)	(2)	(3)	(4)	(5)
Income	0.186***	0.0988***	0.168***	0.108***	0.0944***
	(0.000772)	(0.000595)	(0.000739)	(0.000611)	(0.000591)
Mode of Transport (ref: bicycle)					
Bicycle-taxi	0.320***	0.185***	0.0668***	0.361***	0.248***
	(0.0180)	(0.0146)	(0.0174)	(0.0149)	(0.0140)
Motorcycle	0.423***	0.146***	0.186***	0.304***	0.170***
	(0.0113)	(0.00969)	(0.0113)	(0.00965)	(0.00967)
Motorcycle_taxi	0.0747***	-0.0542***	-0.180***	0.123***	-0.0270**
	(0.0131)	(0.0114)	(0.0131)	(0.0114)	(0.0114)
PUS motorcycle	0.445***	0.175***	0.238***	0.311***	0.185***
	(0.0125)	(0.0104)	(0.0123)	(0.0105)	(0.0104)
Company motorcycle	-0.111***	-0.216***	-0.423***	0.00373	-0.206***
	(0.0130)	(0.0110)	(0.0132)	(0.0109)	(0.0110)
Private car	0.579***	0.233***	0.324***	0.401***	0.257***
	(0.0114)	(0.00975)	(0.0113)	(0.00971)	(0.00973)
Company car	0.608***	0.174***	0.352***	0.339***	0.184***
	(0.0115)	(0.00992)	(0.0115)	(0.00991)	(0.00992)
OPT_noroute	0.403***	0.241***	0.155***	0.412***	0.263***
	(0.0114)	(0.00975)	(0.0113)	(0.00971)	(0.00973)
OPT_withroute	0.578***	0.276***	0.342***	0.432***	0.279***
	(0.0127)	(0.0104)	(0.0126)	(0.0105)	(0.0104)
PUS car	0.745***	0.367***	0.487***	0.536***	0.404***
	(0.0115)	(0.00981)	(0.0114)	(0.00977)	(0.00980)
Ridesharing car	0.845***	0.345***	0.599***	0.500***	0.363***
	(0.0129)	(0.0105)	(0.0128)	(0.0105)	(0.0105)
Train	0.602***	0.281***	0.494***	0.344***	0.284***
	(0.0114)	(0.00978)	(0.0114)	(0.00976)	(0.00977)
BRT	0.608***	0.393***	0.401***	0.532***	0.404***
	(0.0116)	(0.00993)	(0.0115)	(0.00989)	(0.00991)
Feeder bus	0.776***	0.279***	0.517***	0.443***	0.293***
	(0.0121)	(0.0104)	(0.0121)	(0.0104)	(0.0104)
Others	0.0481*	-0.137***	0.101***	-0.184***	-0.0834***
	(0.0258)	(0.0136)	(0.0269)	(0.0128)	(0.0158)
Modal Split (ref: 2)					
3	0.109***	0.0990***	0.215***	0.109***	0.103***
	(0.00132)	(0.00130)	(0.00156)	(0.00132)	(0.00131)
4	0.209***	0.185***	0.376***	0.209***	0.187***
	(0.00157)	(0.00157)	(0.00180)	(0.00157)	(0.00157)
5	0.225***	0.160***	1.058***	0.225***	0.173***
	(0.00265)	(0.00295)	(0.00267)	(0.00265)	(0.00291)
Origin (ref: Jakarta Selatan)					
Jkt_Timur	0.184***	0.0569***	0.158***	0.0700***	0.0531***
	(0.00154)	(0.00130)	(0.00150)	(0.00133)	(0.00134)

Jkt_Pusat	-0.231***	-0.291***	-0.279***	-0.259***	-0.302***
	(0.00223)	(0.00191)	(0.00221)	(0.00192)	(0.00195)
Jkt_Barat	-0.218***	-0.143***	-0.179***	-0.168***	-0.161***
	(0.00178)	(0.00143)	(0.00173)	(0.00146)	(0.00145)
Jkt_Utara	-0.134***	-0.160***	-0.130***	-0.164***	-0.164***
	(0.00208)	(0.00178)	(0.00207)	(0.00177)	(0.00178)
Kab_Bogor	-0.0272***	-0.278***	0.0428***	-0.339***	-0.286***
	(0.00181)	(0.00141)	(0.00178)	(0.00142)	(0.00146)
Kab_Bekasi	0.187***	0.0615***	0.236***	0.0209***	0.0562***
	(0.00184)	(0.00140)	(0.00171)	(0.00149)	(0.00150)
Kota_Bogor	0.0874***	-0.417***	0.0915***	-0.443***	-0.319***
	(0.00249)	(0.00197)	(0.00245)	(0.00200)	(0.00214)
Kota_Bekasi	0.116***	-0.0427***	0.100***	-0.0383***	-0.0333***
	(0.00146)	(0.00119)	(0.00142)	(0.00121)	(0.00124)
Kota_Depok	0.216***	0.143***	0.290***	0.0857***	0.145***
	(0.00166)	(0.00136)	(0.00165)	(0.00136)	(0.00139)
Kab_Tangerang	0.123***	-0.127***	0.118***	-0.134***	-0.144***
	(0.00217)	(0.00180)	(0.00210)	(0.00184)	(0.00189)
Kota_Tangerang	-0.0250***	-0.0845***	-0.0402***	-0.0763***	-0.0904***
	(0.00170)	(0.00142)	(0.00165)	(0.00145)	(0.00146)
Kota_TangSel	0.117***	0.0684***	0.126***	0.0602***	0.0566***
	(0.00163)	(0.00133)	(0.00159)	(0.00136)	(0.00139)
Distance		0.0221***		0.0231***	0.0222***
		(2.54e-05)		(2.61e-05)	(2.63e-05)
Congestion (ref: Yes)					
No		-0.244***	-0.354***		-0.232***
		(0.000777)	(0.000958)		(0.000789)
Destination (ref: Jakarta Selatan)					
Jkt_Timur					0.255***
					(0.00256)
Jkt_Pusat					0.212***
					(0.00260)
Jkt_Barat					0.301***
					(0.00337)
Jkt_Utara					0.174***
					(0.00657)
Kab_Bogor					0.0590***
					(0.00308)
Kab_Bekasi					0.105***
					(0.00228)
Kota_Bogor					0.220***
					(0.00153)
Kota_Bekasi					0.234***
					(0.00163)
Kota_Depok					0.200***
					(0.00158)
Kab_Tangerang					0.188***
					(0.00168)
Kota_Tangerang					0.220***
					(0.00165)
Kota_TangSel					0.127***
					(0.00246)
Constant	0.641***	1.951***	1.219***	1.594***	1.796***
	(0.0159)	(0.0129)	(0.0156)	(0.0130)	(0.0129)

Observations	2,495,717	2,495,717	2,495,717	2,495,717	2,495,717
R-squared	0.252	0.506	0.297	0.485	0.511

Note: Numbers in parentheses are standard errors. ref. = reference category. Income and travel time (dependent variable) are natural logarithm (ln) form.

Table 8 depicts the model with weighted frequency and corrected coefficient (robust). Compared with the result in table 7, the variance explained and the coefficient of income do not move that much. In the first model (1), a 1% increase of income is associated with a 0.186% longer travel time. With respect to mode of transport, number of modal split, origin regency/city and distance, it has been found that the explanatory power is decreased to 0.108% in 99% confidence level and explained variance of 48.5%. The last model, the coefficient is relatively constant. A 1% increase of income is associated with 0.0944% longer travel time in 99% confidence level.

The results also depicts the elasticity of travel time among all cities and regencies in the Greater Jakarta. As shown above, Depok city has the biggest elasticity of travel time, compared with Jakarta Selatan. For workers that live in Kota Depok, they experienced 0.156% higher travel time than workers that live in Jakarta Selatan. Second to Kota Depok is South Tangerang city, which has the elasticity of 0.058%. The top 5 highest elasticity of travel time are Depok city, South Tangerang city, Bekasi regency, East Jakarta, and Bekasi city. On another side, city or regency that have negative correlation with travel time are Jakarta Pusat, Jakarta Barat, Jakarta Utara, Kabupaten Bogor, Kota Bogor, Kota Bekasi, Kabupaten Tangerang and Kota Tangerang. This means that, if people is commuting from abovementioned cities/regency, they will experience a reduced travel time, in consider with their workplace, if compared with people that commute from Jakarta Selatan.

It is acknowledged that the explained variance of the model is relatively small, as the model could only explains ~51.3% of the variance. The reason of which is due to the level of variable used in this research. As this research use city-regency level, the generalization is harder than for instance, neighborhood level. Neighborhood level data has higher explained variance due to relatively similar characteristic of people. To summarize, income is positively and linearly related to the travel time, so if there is an increase of income, considering other explanatory variable is constant, it will also increase the duration of travel time.

6 DISCUSSION AND CONCLUSIONS

This chapter discusses the results presented in chapter 5 and concluding the answers to the research questions. First, the existing travel behavior among cities or regencies in the Greater Jakarta is discussed. After that, the relationship between income and travel time is then addressed. The discussion is reflected with respect to the previous literature. At the end of this chapter, a synthesis of key points about the research is addressed.

6.1 TRAVEL BEHAVIOR IN THE GREATER JAKARTA

As shown in chapter 5, it is found that travel behavior across the Greater Jakarta more or less has the same general characteristic. This is in line with studies by White (1988), Zhao & Li (2016), Rodrigue, et al. (2017), that argued household in certain rings around city (center) have nearly the same characteristic, such as tastes and level of income, which translates to the similarity of their commuting behavior. In general, there are 3 similarity of commuting behavior across the Greater Jakarta that could be found, which are (1) commuters tend to work to their neighboring city or regency, (2) commuters experience long travel time, even though the distance is not that far. Commuters that experience longer travel time reside outside the central city, and (3) there are more commuters that use hailing ride service than public transport.

Contradict with the hypothesis of this research, which is employment is still centralized in central city of Jakarta, it is found that commuters in each city or regency travel mostly to their neighbor city or regency (Figure 9). For example, most of Bogor city commuters travel to Bogor regency, which is on the north border of the city. The central, which is Jakarta city, is the second dominant destination for work. Others commute in more unsystematic movement, which is a combination of radial and random movement across the urban area. This implies that the urban structure of Greater Jakarta is not entirely monocentric and business district is not heavily centralized in one city anymore. As Lin, et al. (2013) argued, monocentric cities has a strong high density center with high concentration of jobs and amenities and radial movements of people from periphery toward center. It may be that there is an emerging business district location outside Jakarta, in which become the work location. As the Greater Jakarta has random movement of people and also still has a dominant center, it could be that the Greater Jakarta has a composite form. However to what extent the urban structure of Greater Jakarta is non-monocentric is needed to be further studied, as the result of this thesis only identify the commuter flow pattern.

Despite the relatively near commuting destination, which is their neighbor city or regency, commuters in Greater Jakarta is still experience long travel time. Moreover, commuters that experience longer travel time are from outer of Jakarta. This implies that there is still inefficiency in transportation network across Greater Jakarta, especially regarding unplanned transportation. This could also be seen in the type of transportation use to commute. All of cities or regencies have private vehicles and ride-hailing service as the highest transportation used to commute. Due to the high use of private vehicles, congestion then emerged and resulted in longer travel time.

As discussed above, there is a contradict findings regarding commuting behavior in Greater Jakarta. In a monocentric mega-city, people travel mostly to one employment center and also led to long trips (Lin, et al., 2013). There is a tendency to commute in proximity to their residential location; so it is not commute to the central city anymore. The longer commuting time, however, on average still long. This could be stem from the congestion, but not entirely due to the long trip to central city.

6.2 RELATIONSHIP BETWEEN INCOME AND TRAVEL TIME

As discussed above, employment in the Greater Jakarta is not that centralized in only one CBD. There could be a different employment centers across greater Jakarta. This is supported by the finding of positive relationship between travel time and income. As presented in chapter 5, it is shown that the relationship between income and travel time is positive. For every increase in income will be resulted in higher travel time. This means that people with higher income tend to have higher travel time and on contrary, people with lower income will have lower travel time. In chapter 4 it is explained that even though the central business area in the Greater Jakarta is mainly in the Jakarta city, multiple “amenities” sub-centrals are emerging outside the city. Sub-centrals in outskirt of the Greater Jakarta area, such as BSD (Tangerang city) or Bintaro (Tangerang Selatan city) are now provided with plenty amenities and services, with relatively uncrowded traffic. People could easily access services such as supermarkets, bank, etc without needing them to go to farther places. Bole (2010) denotes this kind of area as “secondary commercial districts” or “secondary business districts”, which is a district located in outlying areas, serving community or regional trade. These districts tend to resemble small-scale central business districts. It is explained that the main reason for the development of secondary business districts lies in the new location conditions for companies that expect lower transport and communications costs from locations on the periphery as well as lower costs arising from the agglomerations of similar companies. Therefore, along with worker’s residential location, workers could work nearer, for example their neighbor city or regency. However, this does not necessarily mean that Greater Jakarta is becoming polycentric. Huang, et al. (2015) explains that a suburbanization of city's residential population does not necessarily mean that its urban spatial structure has also changed to a non-monocentric form, especially if employment is still heavily concentrated in the city center. To what extent the development of more employment subcenters outside of the central business district has emerged will need to be further studied.

Several studies in line with the results of this thesis. Dargay & Ommeren (2005) explains that the positive association between income on travel time is due to the result of moving further away from the place of employment. In the Greater Jakarta, it could also be argued, as the biggest number of commuters is working in DKI Jakarta province, which also has the highest congestion level compared to other regencies and cities in the Greater area. Therefore, people then move farther away from their workplace (city's outskirt or other districts), which relatively has lower congestion, so that they have better environment to live. As Meyer (2000) argues, the pattern of residence duplicates that of site amenities, the wealthier inhabitants "always responding to the appeal of more attractive residential districts, further and ever further removed from the center". It is also stated that low-income people today tend to follow the fastest and busiest routes of movement, high-income ones to avoid them.

Warsida, et al. (2013) also find that there is a positive relationship between income and travel time in the Greater Jakarta. It is stated there is a different job opportunities in the Greater Jakarta, so that the high-paid jobs tend to concentrate in certain area, therefore to be able to have a higher wage, in consideration with their skills and job, they have to commute far from their residential location. It could be that there is an imbalance between job that are available in the area where they are residing. For example, between job availability and person's skills. There are many terms that explain this phenomenon, such as "job imbalance" Sultana (2002), "spatial mismatch" (Bunel & Tovar, 2014) or different "job accessibility" (Cheng & Bertolini, 2013).

The results of the analysis show that there could be two possibilities that could emerged. Firstly, if the secondary business districts are continue to develop and employment will be decentralized, this could help increasing the job opportunity outside the Greater Jakarta. Several evidence has shown that there is a decrease in commuting time due to decentralization of employment (Alpkokin, et al., 2010) (Yao, 2017). However, if the secondary business districts could not "keep up" with the development of central business district, workers with low income could be influenced. The main reason lies in the increase of housing prices in the central city, "pushing" low income people to outer Jakarta, therefore they will have lower job accessibility.

6.3 Conclusion

Understanding how commuting behavior and socio-economic characteristic drive commuting behavior is crucial in order to identify the accessibility of people to jobs. Looking into the current commuting behavior in the Greater Jakarta, the commuting behavior of Greater Jakarta is not entirely follow monocentric pattern. Residential household location is dispersed, in which an increase of income will be resulting in reside farther away from their work location. Business district in Greater Jakarta is not only concentrated in one city, so there might be possibility of emerging business district outside Jakarta. One of highlights in this thesis is the fact that beside congestion, the imbalance between the location of jobs and housing could be the root cause of longer commuting and suggests that developing new secondary business district may benefit the workers to have short commuting time. Beside investigating job accessibility, another research that could be carried out in the future on the basis of this thesis is how to integrate worker's skills into space. Targeted employment or housing and employment center development could be integrated with transport planning in transport policies aiming for greater accessibility.

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