THE DECISION TO MOVE, LOCATION CHOICE AND HOUSING MARKET SEGREGATION IN HONG KONG

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgment has been made in the text.

(Signed)_____

Name of Student____Hou Tianya___

DEDICATION

To my parents

ABSTRACT

Mobility is a sign of the energy and efficiency level of a city. Sustainable mobility is one of the toughest challenges in making Hong Kong smarter, with a rapidly-aging society and the pressure on industrial transformation. The constant activities of residential mobility and daily mobility have raised the question on how the polycentric structure deals with the capacity to organize long term of migration trajectories and daily commuting flows in Hong Kong.

The development of new town policy and transportation system has largely increased the options in the relocation process and has highly decreased the travelling distance and times. As a result, the continuing decentralization trend resulting from these modifications has established the current situation of the housing market in certain districts, compelling residents (especially young couples) from the central urban area towards an outlying area. Therefore, the interactions between residential mobility and the daily mobility have enormously increased.

In recent years, many efforts have been made to understand the propensity to move in the terms of a number of individual and household characteristics. However, the "*Axis Structure*" of both two types of mobility as the representation of the relationship between the mobility and urban structure is still unknown in the area of Hong Kong. This research will fill this gap to justify the existence of "*Axis Structure*" of residential mobility and daily mobility by employing a data mining technique- "Link Analysis". At the same time, it will identify the hierarchical polycentric structure as a result of the interaction between residential mobility and daily mobility in Hong Kong.

The main objectives of the thesis are:

1. To uncover the axis structure of residential mobility in Hong Kong using a data mining method-Link Analysis
2. To delineate urban area based on residential mobility routes using the same method-Link Analysis
3. To identify the axis structure of daily mobility in Hong Kong using a data mining method-Link Analysis
4. To reveal the polycentric urban structure and to identify sub-centers in Hong Kong using the same method-Link Analysis
5. To investigate the interaction between residential mobility and daily mobility both considering the effect of household heads and their spouses
6. All the objectives are achieved by using Link Analysis, its challenges and potential advantages are illustrated.

This research contributes to provide a quantitative framework on how to identify the axis structure of residential mobility and daily mobility by using a Link Analysis. Unlike many mobility studies, this work considers residential mobility and daily mobility together. It confirms not only the interaction between these two types of mobility, but also their convergent role in establishing and defining a polycentric structure of Hong Kong. The results tend to highlight the drawbacks of polycentric structure, where some districts seemly become deprived sub-centers because of their poor transportation or unsustainable new town policy, which raises many issues that Hong Kong government should pay attention to in the future.

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

This chapter has five parts. Section 1.1 gives a brief introduction about the background of this research; Section 1.2 identifies research gaps and indicates the originality of this research; Section 1.3 illustrates the objectives of the thesis; Section 1.4 states the significance of this research; and Section 1.5 outlines the structure of the thesis.

1.1 RESEARCH CONTEXT

Hong Kong, as special administrative regions, is located in the southern part of China, which is the world's most densely populated territory covering an area of 1098 square kilometers with the population of over seven millions, and which is divided into Hong Kong Island, the Kowloon Peninsula and the New Territories.

Figure 1.1a The residential mobility patterns before 1970s

Figure 1.1b The residential mobility patterns after 1970s

Figure 1.1 The residential mobility patterns before 1970s and after the 1970s in Hong Kong

The residential mobility pattern of Hong Kong residents has experienced significance changes over the last few decades, as shown in Figure 1.1. In the 1950s, most of residents lived in Hong Kong Island and Kowloon Peninsula. There was a rapid population growth and economic development in these areas in the 1960s. According to the census, about 81% of Hong Kong's population lived in Hong Kong Island and in Kowloon at that time. While after 1970s, the poor living conditions and high rent drove residents with low salaries leave their original urban area and move into new towns in New Territories, which is established to relief the burdens of the central area.

This type of residential mobility from urban area to new towns is still ongoing today. Empirical evidences indicate that the current urban sprawl phenomenon has leaded the advent of the polycentric urban structure (Burger and Meeijers, 2012; Cervero and Wu, 1997; Green, 2007; Kloosterman and Musterd, 2001; Liu et al., 2016; Musterd et al, 2006; Roth et al., 2011; Schmitt et al., 2015; Sun et al., 2016; Vasanen, 2012; Veneri, 2013).

The development of new town policy and transportation system has largely increased the options in the relocation process and has highly decreased the travelling distance and times. As a result, this continuing decentralization trend resulting from these modifications has established the current situation of the housing market in certain districts, compelling residents (especially young couples) from the central urban area towards an outlying area. Therefore, the interactions between residential mobility and daily mobility have enormously increased since the less sustainable transportation and mobility patterns will cause the bad effects on society and environment.

The urban structure acting as the environmental and geographical limits has an important impact on the mobility patterns (Maat et al., 2005). The constant activities of daily mobility and residential mobility raises the question on how the polycentric urban structure deals with the capacity to organize daily commuting flows and the land supply for residence use in each sub-center within a completely different community. Besides, these sub-centers are proved to have important influences on the residential mobility and daily mobility behaviors. People in those sub-centers will develop a mental map of their living area, and repeat their habitual daily mobility activities and the long term residential mobility patterns and trajectories.

The previous study conducted by Sénécal et al. (2013) has developed a model of urban spatial organization in Montréal metropolitan region to validate the interaction between the residential mobility activities and the daily mobility activities in the form of "Axis Structure", which is defined as "radial expansion, transportation routes, streetcar lines, paths and spokes" by Hoyt (1939). However, the concept of "Axis Structure", suggested as a priori rather than justified by researchers, is somewhat problematic. Besides, it is not sure whether this axis representation of the relationship between urban area and mobility will still hold true within different spatial contexts such as the urban area of Hong Kong.

This research will follow this strand to justify the "Axis Structure" of both two types of mobility within Hong Kong by employ a data mining technique-"Link Analysis", and it will answer the question like whether exists a defined area where residents relocate their home in the similar communities, and conduct most of their daily mobility behaviors (especially the commuting to work trips).

1.2 RESEARCH SIGNIFICANCE

Mobility is a sign of the energy and efficiency level of a city. Sustainable mobility[1] is one of the toughest challenges in making Hong Kong smarter, with a rapidly-aging society and the pressure on industrial transformation. Where people live and How they move, has an significant impact on the management of housing markets, labor markets, and transportation networks (Battu et al., 2005; Coulson and Fisher, 2009). Therefore, mobility studies are of big concern of not only the government, but also academic researchers.

Actually, residential mobility and daily mobility highly depends on the structure of urban area. The behaviors of residential mobility and daily mobility activities may keep or change the population composition for each district. Sometimes it assumed that repeated mobility activities conducted by residents will result in spatial inequalities and economical segregated communities (Hedman et al., 2011; Sharkey, 2012). The relationship between two types of mobility and the urban structure is very complex and should be pay much attention to in the academic research.

In recent years, many efforts have been made to understand the propensity to move in the terms of a number of individual and household characteristics. However, the "*Axis Structure*" of both two types of mobility as the representation of the relationship between the mobility and urban structure is still unknown in the area of Hong Kong. This research will fill this gap to justify the existence of "Axis Structure"

[1] In summary, in order to manage mobility behaviors sustainably, Hong Kong should be designed in such a way that it is urban compactness, mixed-use, and transit-oriented. Obviously, it's very difficult to estimate how far away is Hong Kong from being "sustainable", and even more difficult to indicate how sustainable Hong Kong can be achieved.

of residential mobility and daily mobility by employing a data mining technique- "Link Analysis". At the same time, it will identify the hierarchical polycentric structure as a result of the interaction between the residential mobility and the daily mobility in Hong Kong.

1.3 RESEARCH OBJECTIVES

Six research objectives of the thesis have been obtained from a comprehensive literature review (Chapter 2), they are shown as followings:

7. To uncover the axis structure of residential mobility in Hong Kong using a data mining method-Link Analysis
8. To delineate urban area based on residential mobility routes using the same method-Link Analysis
9. To identify the axis structure of daily mobility in Hong Kong using a data mining method-Link Analysis
10. To reveal the polycentric urban structure and to identify sub-centers in Hong Kong using the same method-Link Analysis
11. To investigate the interaction between residential mobility and daily mobility both considering the effect of household heads and their spouses
12. All the objectives are achieved by using Link Analysis, its challenges and potential advantages are illustrated.

1.4 RESEARCH ORIGINALITY

Four points of research originality are identified from the literature review (Chapter 2), they are shown as followings:

1. This study is the first attempt to "*justify*" the "*Axis Structure*" of both two types of mobility-residential mobility and daily mobility rather than "suggest".
2. This study is the unique one to employ an innovative data mining technique-"*Link Analysis*" to identify the interaction between the residential mobility and the daily mobility.
3. This research is assumed as the first study to identify the existence of the hierarchical polycentric structure within the area of Hong Kong so far as I know.
4. This research, being different from other mobility studies, tries to connect residential mobility behaviors with daily mobility behaviors within the area Hong Kong.

1.5 THESIS STRUCTURE

This thesis consists of seven chapters, they are:

Chapter 1 introduces this research though the perspectives of the research context, research significances, research objectives, the research originality, and the thesis structure.

Chapter 2 represents a comprehensive literature review related to residential mobility and daily mobility. It includes five research areas of interests: life cycle model; discrete choice model, sequence based method, mobility and polycentricity, and the interaction between the residential mobility and the daily mobility.

Chapter 3 illustrates the research methodology- Link Analysis, explain the details on how to identify the axis structure of two types of mobility-residential mobility and daily mobility using *link analysis*, how to identify the polycentric structure based on the mobility flows, and how to interact residential mobility and daily mobility together.

Chapter 4 presents the research findings about the axis structure of the residential mobility using link analysis, the polycentric structure based on the residential mobility patterns, and the reasonable explanations for the results.

Chapter 5 presents the research findings about the axis structure of the daily mobility using link analysis, the polycentric structure based on the daily mobility commuting flows, and the interpretation for those findings.

Chapter 6 identifies the interaction between residential mobility patterns and daily mobility patterns, validates the existence of axis representations of the urban structure in terms of both types of mobility by adding the effect of spouses.

Chapter 7 summarizes the research findings and highlights the implications for Hong Kong government.

CHAPTER 2 LITERATURE REVIEW

This chapter represents a comprehensive literature review related to residential mobility and daily mobility. In recent years, there have been a large number of researches on studying and examining various aspects of mobility patterns. Broadly speaking, there maybe have five research areas of interests: an examination of individual behaviors of "Decision to Move" (Life Cycle Model); general theories of "Location Choice" (Discrete Choice Model), the mobility routes or trajectories (Sequence based Model); the relationship between mobility and urban structure (Polycentric Model); the interaction between the residential mobility and the daily mobility. Although these five areas of interest are not mutually exclusive, it is much more convenient to present them separately in the literature review.

2.1 LIFE CYCLE MODEL

There are a lot of studies trying explaining the residential mobility in term of life cycle factors. Obviously, any of changes in household compositions maybe contribute to the "Decision to Move". For example, a new setup of a household, a breakup of the marital relationship, or a birth of a baby could lead to a residential movement.

In life cycle concept, it is postulated that young men and women will live with their parents until their marriage. A change of residence (residential mobility) will happen when they get married, or when they have a baby, or when their children leave, or when one of spouses dies. This concept has been readily accepted as the basic of explanations of residential mobility patterns, see Figure 2.1.

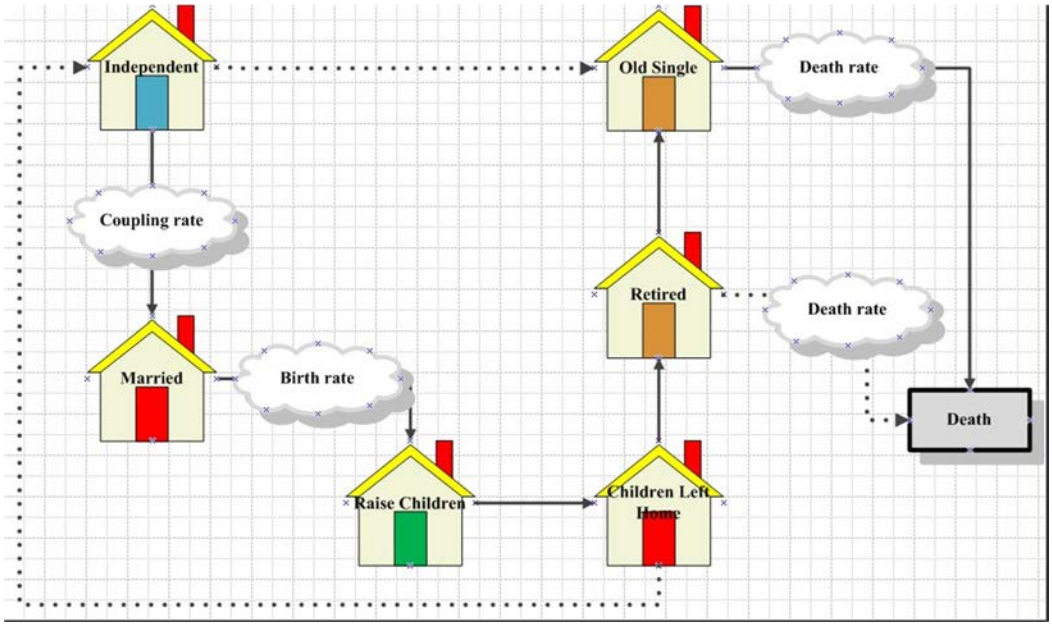


Figure 2.1 Residential Mobility over the Life Cycle.

Source: Ma et al., 2013

Many studies using life cycle model have been conducted in the past two decades. Those researches have examined the influence of the life cycle stage/age (Long, 1992), the education (Bailey, 1993; Dieleman et al., 2000; Schwartz, 1973), the employment (Dieleman et al., 2000; Kan, 2003; Odland, 1997), the household composition (Böheim and Taylor, 1999; Withers,1997), the house tenure, which is the combination effect of age and household structure (Dieleman et al., 2000; Clark, 1994), the length of house tenure (Kan, 2007), the race (South and Crowder, 1997), the marriage (Mulder and Wagner, 1993), the stay duration (Eluru et al., 2009) on the residential mobility behaviors.

However, some authors pointed out there were some weakness in the application of life cycle model in mobility studies (Clark and Onaka, 1983; Hui, 2006; Quigley and Weinberg, 1977; Li and Tu, 2011; Stapleton, 1980).

First of all, the ambiguities and variations about the definition of the life cycle stages indicate that its ability to explain the residential mobility behaviors is highly doubted. It is difficult to reach an agreement on whether a 5-stage classification of the normal lifecycle (Frey, 1978; Speare, 1970), which is the most prominent in studies of the impact lifecycle on residential mobility patterns, is suitable for the research area of Hong Kong. Another problem is that many studies are conducted on only a subset of total population. Therefore, the findings cannot be generalized to reflect the actual status of the societal structure. For example, nontraditional households such as one person households, households with unrelated family members, and non-family nucleus households form an integral part in Hong Kong nowadays, which challenges the feasibility of the traditional life cycle model. As a group, non-family households display marked heterogeneity with respect to age, sex, income, tenure status, and spatial distribution reflecting the complexity of generating

processes for this type of household, which also varied by the degree of mobility involved. When segments of the population do not follow the traditional life cycle, scientists usually ignored them as being of little interest or grouped non-conforming groups into heterogeneous residual categories. These strategies are no longer expedient when about 30% of households in Hong Kong actually consist of nontraditional Households, see Figure 2.2.

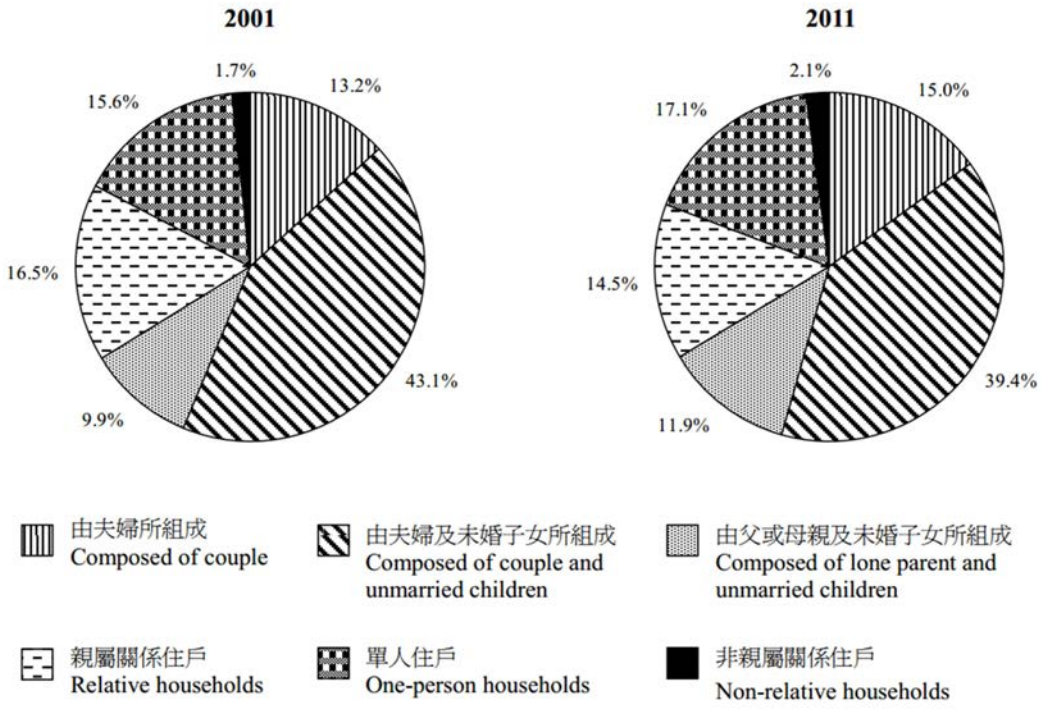


Figure 2.2 Distributions of Domestic Households by Household Composition, 2001 and 2011

Source: Department of Census and Statistics, Hong Kong

Some of the assumptions implicit in the household life cycle model may not be applicable to Hong Kong. The assumption that residents will update their housing conditions continually through life cycle stages becomes less and less acceptable. For example, the young people are assumed to be more likely to leave their parents' home for higher education, better job, or marriage. However, the reality is that some

young people will stay with their parents even after marriage maybe because of the unaffordable housing price in Hong Kong. Some fundamental societal changes in Hong Kong make it necessary to reevaluate the feasibility of the life cycle way to interpret the process of residential mobility. These societal changes includes the increasing instability of marriage, the participation of the female household members in labor market and the proliferation of alternative living arrangements

There is a growing body of literature arguing that the residential mobility should be understood in terms of the housing supply side not only in terms of the housing demand side. The life cycle model describes how the changes in demographic or economic characteristics induce the propensity to move home, which is the interpretation from the perspective of housing demand side, while the differences in housing policies, wealth, and tenure structures will shape the residential mobility process as well (Harvey, 1975; Gray, 1976). Thus, the preference and residential mobility patterns of different tenures usually cannot be directly explained by household life cycle model. The movement of households in the sector of public housing should be explained by the perspective of the allocating and selecting policy of the local public housing office. Since the Hong Kong government highly participates in the housing market, which provides public housing or subsidized housing. The movement of households in the public housing sectors is usually determined by the government. And sometimes the geographical location of public housing may act as a constraint when it comes to settling a new house. Hui (2007) has pointed out that the intervention of Hong Kong government housing policy plays a great role in the decision making process of residential mobility, especially in the sector of the public housing market. For example, the suspension of the HOS

program and the cancellation of loan subsidies have aggravated the lock-in effects among the public households.

In summary, there exist fundamental changes in the traditional family in Hong Kong, the participation of working women, the growth of single parent families as a consequence of the high marital instability and the proliferation of non-family living arrangements. Together with its own drawbacks, the life cycle approach fails to incorporate these changes into the model, therefore the feasibility to explain the residential mobility process in Hong Kong is highly suspected.

In order to overcome the shortcomings of the life cycle model, the Hong Kong researcher Hui (2013) proposed to employ a multivariate method- logistics regression to explain residential mobility patterns. In this model, the residential mobility can be regarded as a binary target variable (move vs. stay) which is affected by a list of independent variables including demographic factors, economic factors, and institutional factors and so on. The coefficients of each independent variable can be estimated to assess their relative importance in their impacts on the residential mobility decision process. Although his research indeed overcome the bad effect of the traditional life cycle model in some degree, still put much attention on explaining the propensity to move, ignore the spatial structure and the variation of communities on the residential mobility behaviors, which is the focus of the discrete choice model.

2.2. DISCRETE CHOICE MODEL

If the "Decision to Move" model indicates whether the residents move or not, while the "Location Choice" model examines where they move. Therefore, residential mobility should be not only explained in terms of the "Decision to Move" model but also should be examined in terms of the "Location Choices" model, which is focus on how individual or household attributes or neighborhoods' attributes influence desirability of choosing residence. When coming to the methods designed for the "Location Choice" model, many scientists preferred the "Discrete Choice method", wherein the analytic goal is to model the probability of moving into the specific residence (Figure 2.3).

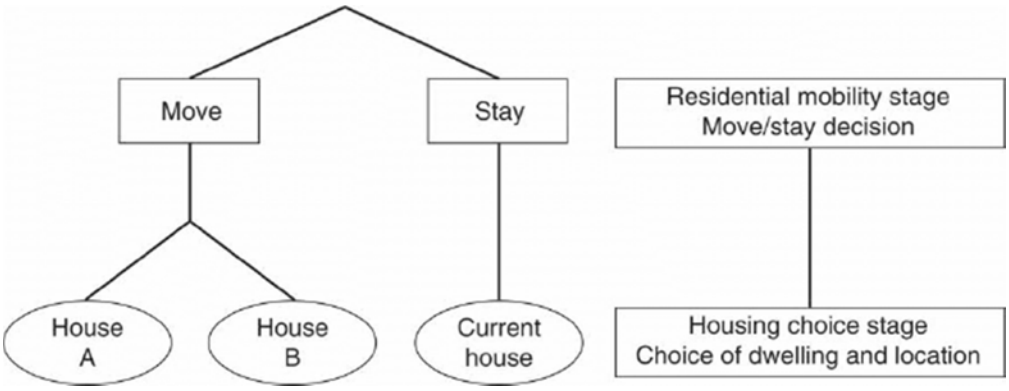


Figure 2.3 Discrete Choice Model

Source: Kim et al., 2005

There is a considerable literature employing and using the "Discrete Choice Method" to explain how multiple residence attribute guide the residential mobility patterns (Bruch and Mare, 2012; VOREL, 2015; Quillian, 2015; Steele et al., 2013; Vorel, 2015). Some researches focus on revealing the preferences of communities attributes (Charles 2005; Mare and Bruch 2003;), some studies put much attention on identifying the relationship between neighborhood attributes and the choosing

location choices (Crowder and South, 2008; Quillian 1999), some utilize the discrete choice model to explore how the discrimination and poor salary affect the decision process of the residential mobility (Pager and Shepherd, 2008), some research aim to discover how the residents segregated by the implication of residential mobility behaviors (Schelling 1969, 2006; Bruch and Mare 2006), and some studies identify how the housing supply factors such as housing policy and other natural factors affect the residential mobility patterns (Kingsley and Johnson 2003; Basolo and Nguyen 2005; Clark 2005).

Admittedly, there are many advantages to employ the discrete choice model. Since the decision process of location choice is determined by many factors of neighborhood, the discrete choice method can incorporate a set of location attributes to predict the probability of a residence to be chosen as a new home and assess the relative importance of each characteristic in the decision process of mobility. However, there exist some drawbacks about the discrete choice model in the application of studying location choices. The discrete choice method relies on the assumptions of the independence of irrelevant alternative (IIA), which might not always be realistic in a given situation. Another problem is that the complication of the discrete choice method makes the results really difficult to interpret (Quillian, 2015). Third, the employment of the discrete choice method opens another problematic issue-The problem of stochasticity caused by discrete choice method is usually dealt with by the aggregating the residential locations into large district, which will result in the multicollinearity problem and the information (VOREL, 2015). Some researchers have pointed out that the discrete choice model has potential sampling biases when using the revealed data, which cannot reflect the actual residential mobility behaviors (Thériault and François, 2013).

2.3 SEQUENCE BASED MODEL

Although the previous studies contribute to the understanding of how the demographic characteristics and the neighborhood attributes affect the residential mobility patterns, the axis structure of mobility patterns is inadequately studied. Previous studies simply consider why a resident moves and overlooks the differences between each place, not to mention the trajectory or the axis structure of mobility behaviors.

The much easier available of related census datasets together with methodological developments in recent years have directed the residential mobility research into new direction to study the route of residential mobility patterns. Sequence analysis is such a representative method advocated by some researchers (Clark et al., 2003; Coulter and Van Ham, 2016; Cornwell B, 2015; Stovel and Bolan, 2003; Van Ham, 2013).

Burgess's (1925) "concentric zone model" assumes that new immigrants will firstly settle near the center of urban area and then move outward into surrounding neighborhoods later. This sequential mobility patterns have a big impact on the property price, the racial structure, and the infrastructure of the geographical locations. His research has provided the theory foundation for many studies on the urban development process, residential mobility, and residential segregation (Schwirian, 1983; Denton and Massey, 1991; Massey et al., 1994). The results imply that there is the residential "career" for each geographical location and its neighborhood, which is the basis to understand the residential mobility patterns. Homer's Hoyt' sector theory brings out the concept of the axis structure of mobility, which is defined as "radial expansion, transportation routes, streetcar lines, paths and spokes", as shown in Figure 2.4. This concept has advanced Burgess's "concentric zone model" from a static state to dynamic state.

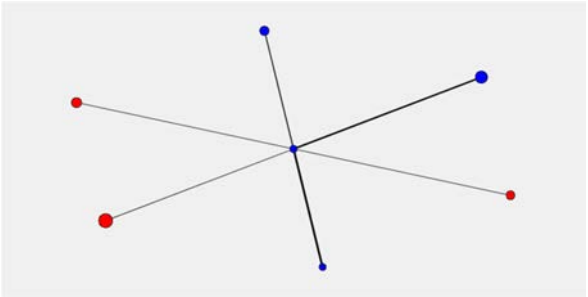


Figure 2.4 Axis Structure of Mobility

Previous models examined the determinants of the propensity to move, while my research attempted to examine the axis structure of residential mobility, which treats the mobility route itself as the focus of the study. Some researchers have proposed the concept of axis structure of mobility (Hoyt, 1939; Sénécal, 2013), but they fail to develop a quantitative model to justify it. We try to fill this research gap by developing a sequence based approach- link analysis to study the longitudinal residential mobility patterns and display how the link analysis produce the axis structure of mobility and show the place attachment to their residence area. In Contrast with the study conducted by Stovel and Bolan (2003), we don't aggregate the geographic place into place types in order to not lose the information inside the data.

Link Analysis is a popular network analysis technique which combines the concept of sequence analysis and the skills of visualization together (Liu et al.). It can identify and visualize connections between different objects. Link analysis makes no assumptions about either the statistical distribution of cases or the causal relationship revealed by the residential mobility route. It can clarify the link between the previous place of residence and the place of present residence to discover the residents' social attachment to specific location. The detail process of how to

conduct the link analysis on the research of residential mobility can be found in Chapter 3.

2.4 MOBILITY AND POLYCENTRICITY

A number of findings in the literature indicate the residential mobility has leaded the development of urban area toward a polycentric structure (Burger and Meeijers, 2012; Cervero and Wu, 1997; Green, 2007; Kloosterman and Musterd, 2001; Liu et al., 2016; Musterd et al, 2006; Roth et al., 2011; Schmitt et al., 2015; Sun et al., 2016; Vasanen, 2012; Veneri, 2013). Usually, the concept of polycentricity has two interpretations. One is that the polycentricity is the sign of decentralization, where residents will go to outlying areas for some career opportunities but don't completely lose the connection with the CBD. Another is that some developed area has already constructed a sub-center, which can be self-supported because of sufficient supply of jobs, services, amenities, attracting many immigrants and commuter to move in. These sub-centers have an important impact on the residential mobility and daily mobility. People in this area will develop a social map, which is confine to the sub-center, and replicate residential mobility routes, daily commuting activities and trajectories (Sénécal et al., 2013).

Therefore, how to measure the polycentric structure has been the focus of many studies. As to the methodological issues, there are three different strands to measure the polycentric urban structures. The first strand is to weigh and judge the status of each area base on a rank-size distribution; the second one is to make a comparison the benchmarking polycentric-city with the "complete" polycentricity; the third one is to utilize the methods from the research area of social network analysis to measure the polycentric urban structure.

The representative studies of the first strand include the researches (Batty, 2013; Meijers, 2008; Parr, 2004; Spiekerman and Wegener, 2004). The rank-size

distribution is regarded as a statistical representation of the polycentric urban structure, with the slope of the regression lines indicating its degree of polycentric structure. In theory, if the region is complete polycentric, the slop of the fitting regression line is flat. If the region is a mono-centric area, the slop of the fitting regression line is rather steep. This rank-size method is very simple and easy to conduct. However, it is prone to get inaccurate estimation, since the regression based on a small set of data points (urban areas for comparison) is not feasible.

For the second strand, two representative examples include the gravity model proposed by Hanssens et al. to estimate the polycentric urban structure (2014), and the connectivity field model advocated by Vasanen (2012). These models have obtained better estimation than the method of rank-size distribution, but they require large amount of data in order to train the model, which is usually not easier to obtain in reality.

The third one is also the most popular strand in recent literature, where many researchers (Burger and Meeijers, 2012; Cervero and Wu, 1997; Green, 2007; Kloosterman and Musterd, 2001; Liu et al., 2016; Musterd et al, 2006; Roth et al., 2011; Schmitt et al., 2015; Sun et al., 2016; Vasanen, 2012; Veneri, 2013) borrow the methods from the research area of social network analysis to analyze the polycentric urban structure in term of daily mobility commuting flows, since the volume of daily commuting flows is in proportion to the attractions of each district. One of our research aims will flow this line of work to discover the polycentric structure in the urban area of Hong Kong, which is regarded as the basis urban structure and social map of both two types of mobility-residential mobility and daily mobility.

In their study, they didn't distinguish the difference between outflow and inflow for each district, which actually reflect different aspects of district characteristics. Another problem is about how to define the value of the "long" commuting trips. Since city centers should have a bounded spatial range, long trip have to be removed to produce a fine result. More knowledge about the transportation characteristics and the spatial structure of a city are required to yield a better definition of the maximum trip length. It is not feasible for Hong Kong where the urban structure is very complex and distinct. Link analysis doesn't relies heavily on spatial scale, where the importance of travelling flows is determined based on the percentage taken part in the total flow in the network, and whose percentage is lower than a specified value will be excluded from the research.

2.5 INTERACTION BETWEEN RESIDENTIAL MOBILITY AND DAILY MOBILITY

In theory, the residential mobility activities should be interacted with the daily mobility activities since they are both based on the same urban structure. The research on how to connect the residential mobility and the daily mobility is relatively few but there are some exceptions.

It seems that Burgess is the first researcher to start this area. Burgess's concentric zone model has proposed the concept of the community, mobility, and promiscuity triangles. In Burgess' theory, it was supposed that most mobility behaviors will be conducted within a defined radius of circle area, which can be regarded as a map of commuting pathways between the residence, work location and other destination location. The ripples-like daily mobility patterns in turn affect the residential mobility patterns. Burgess argued that it will lose the relationship control if residents conducted their mobility activities outside the immediate community area. He believed that the resident behaviors occurring outside of the local area would lose their social relationship (Burgess, 1925).

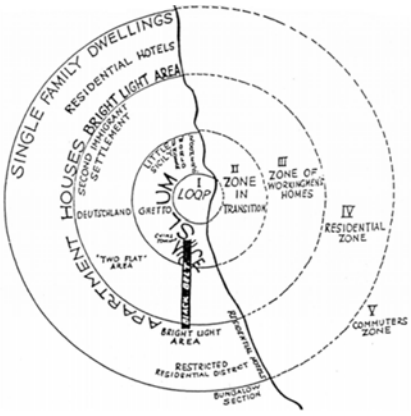


Figure 2.5 Burgess' Centric Zone Model

Source: Burgess, 1925

In the centric zone model (shown in Figure 2.5), the city was assumed to have five centric zones: "(1) the central business zone, (2) the transition zone, (3) the residence zone of workers, (4) the residential zone of middle-class, and (5) the commuter zone of the upper class" (Burgess, 1925).

The Burgess' theory greatly contributed the theory and principles of urban sociology, especially the social expression of the behaviors of residential mobility and daily mobility. He argued that daily mobility activities caused the social disorganization while residential mobility raised the social concentration, which resulted in the balance of the city structure.

Concentric zone theory was really helpful to understand the mobility patterns of residents. Hoyt agreed with Burgess that the city evolved in a decentralization way. However, the shape of the evolution is "radial" rather than "centric", which is shown in Figure 2.6. The mobility activities were conducted along one of streetcar lines liking a spoke which indicated that the Burgess's theory already contradicted with observations of mobility patterns found in USA.

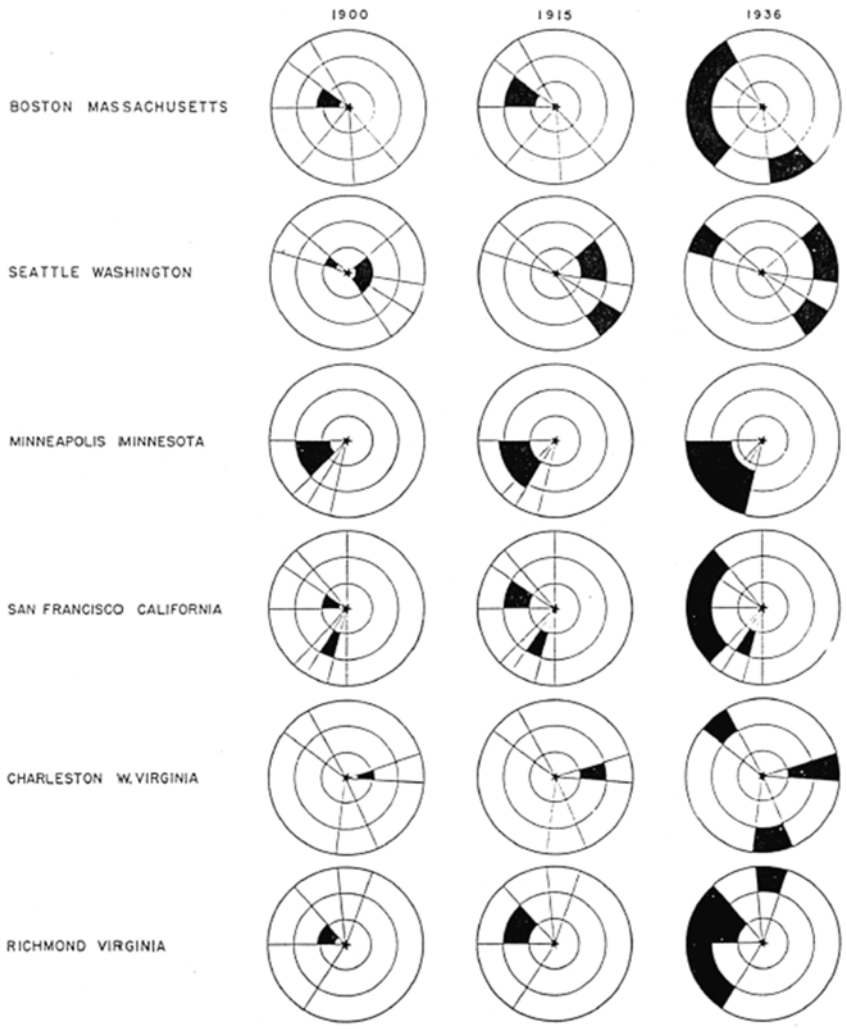


Figure 2.6 Hoyt's Sector Theory

Source: Hoyt, 1939

Both the centric zone model and the sector theory demonstrated the importance of residential mobility behaviors in the process of shaping the urban structure. However, the explanation about the interaction between the residential mobility activities and the daily mobility activities is relatively weak. Adams forward Hoyt's sector theory fatherly by the introduction of the concept of mental map, which is the wedge-shaped images of everyday communities formulated in the head of each residents, see in Figure 2.7. Adams introduced the theory of directional biases, which is the

individual ground based on which all types of mobility are conducted. These directional biases defined a spatial structure which consist of successive residential zones and are connected by a mobility axis. This concept was used to explain how a mental image was built by the daily mobility behaviors and duplicated in the same way over times (Lynch, 1960).

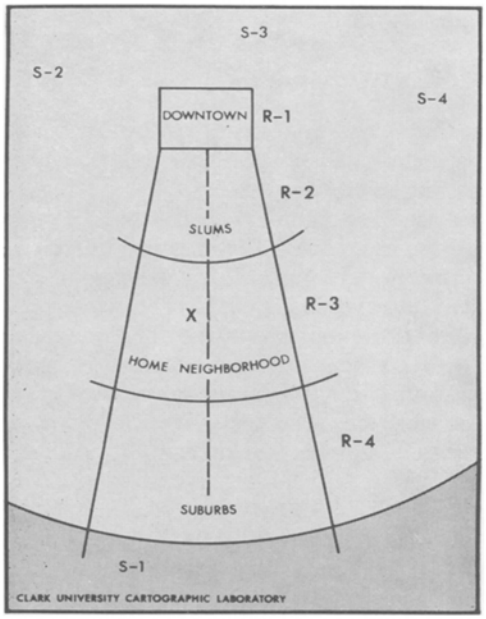


Figure 2.7 Adams' Wedge-Shaped Image of the City

Source: Adams, 1969

Adams argues that the mobility behaviors of residents depend on their mental maps which reflect the city image. He assumed that a mental map of the city will be built for each resident as a spatial frame of reference through the daily mobility activities, where a set of places are regarded as nodes in the map, and nodes will be connected by daily commuting flows, which in turn affect the long term residential mobility routes. Since the metal map is confined to a resident's movement experience, it will control residents' mobility routes, destination locations, and movement field not only for daily mobility activities but also for residential mobility

activities. Mental maps cannot be measured directly, but can be implicated by the attributes of movement fields, indirectly.

Adam's work is innovative to propose a typical mental map, which conforms to a wedge-shaped image of city, as the fundamental urban basis of residential mobility and daily mobility patterns. However, his work lacks flow-up studies on how to connect the residential mobility with the daily mobility, fails to develop a new model of urban spatial organization. Sénécal et al. extended Adam' proposal in further and addressed both types of mobility together to interpret their convergence and connections. The result demonstrated that multiple motilities produced around the secondary sub-centers had already replaced the one direction movement from the CBD to the fringe area, which was stressed by Burgess' theory. Most of mobility behaviors occurred in the certain area nearby the residence along one of the axis of mobility. It also proved that residents show a strong attachment to their belonging sectors, show in Figure 2.8. These sectors were no longer attracted by the central districts but not completely disconnected from them. The well-established local attachment of residents will be sustained by the influence of their spouse.

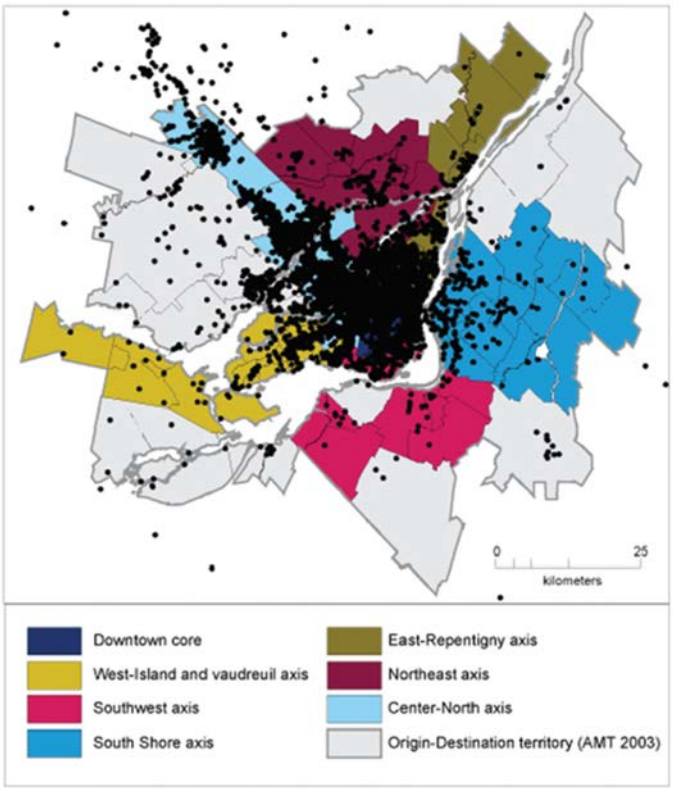


Figure 2.8 The Mobility Conducted for All Purposes

Source: Sénécal et al., 2013

Other researches about the interaction between residential mobility and daily mobility are usually conducted by comparison the changes of daily mobility behaviors especially the commuting to work trips after the relocation, which are measured in terms of distance, time, and transport mode. The representative research is performed by Prillwitz et al (2007). According to their researches, residents usually change their daily commuting habits after they moved to a new residence. Since the activity space take the residence location as the center, the residential relocation will usually cause a change of residents' activity space. On the contrary, daily mobility activities also have an impact on the residential mobility. Residents usually take the daily mobility aspects (e.g. the work location, the nearby

transportation, the car ownership) into consideration when choosing the new home residence. People prefer the location where they can conveniently perform most important daily movement within. The previous studies has demonstrated that there exist mutual interactions between the residential mobility and the daily mobility, where any changes in one type of mobility will contribute to an adjustment of another type of mobility.

The previous studies has demonstrated that there exist mutual interactions between the residential mobility and the daily mobility, where any changes in one type of mobility will contribute to an adjustment of another type of mobility. Our research will follow this strand to test whether the residential mobility and the daily mobility are mutually interacted with each other, and whether both types of mobility are based on the same geographical urban structure in Hong Kong.

CHAPTER 3 METHODOLOY

In this chapter, the research framework is outlined, and how to conduct the link analysis to identify the axis structure is illustrated. The contents of this chapter include “Framework”, “Link Analysis” with the concepts “Association Analysis”, “Degree Centrality”, “Weight”, “Influence Centrality”, and “Identifying the Polycentric Structure”. Finally, the advantages of link analysis over other methods are explained.

3.1 FRAMEWORK

The research design is shown in Figure 3.1, it contains three main parts: the first part is residential mobility model; the second part is daily mobility model; finally, the interaction between two types of mobility is identified. All the research steps are conducted by using the methodology-link analysis, which is an association based data mining technique borrowed from the social network analysis. The data used in the research can be extracted from the 2011 population census (Department of Census and Statistics, Hong Kong).

Framework	
Residential Mobility Model	**Daily Mobility Model**
Origin-Destination Data: Previous Residence – Present Residence in a district census level **Method:** Link Analysis **Steps:** 1. Identify the axis structure of residential mobility; 2. Define three index: "Degree Centrality", "Weight", and "Influence Centrality"; 3. Delineate the area boundary among the urban area of Hong Kong based on the residential mobility migration flows.	**Origin-Destination Data:** Residence – Work Location in a district census level **Method:** Link Analysis **Steps:** 1. Identify the axis structure of daily mobility; 2. Define three index: "Degree Centrality", "Weight", and "Influence Centrality"; 3. Discover the Hierarchical urban structure of Hong Kong based on the daily mobility commuting flows.
Comparison of Residential Mobility and Daily Mobility	
Origin-Destination Data: Previous Residence – Present Residence and Residence – Work Location of Household Heads and their spouses **Method:** Link Analysis **Steps:** 1. Comparison of Residential Mobility and Daily Mobility in term of Segmentation of Urban Structure, Comparison of Axial Structures and Correlation Analysis of Two Centralities; 2. Origin−Destination study based on the residential mobility history and the daily commuting routes of both the household heads and their spouses	

Figure 3.1 The Framework of the Research Design

a. Residential mobility model

Previous researches on residential mobility have focused on how the life cycle attributes e.g., “age”, “sex”, “income”, “education”, “occupation”, and “household composition”, and so on, influence the propensity to move. These studies only considered why a resident moved and overlooked the geographical direction or pathway of the residential mobility. By contract, my research studied the residential mobility route instead and illustrated how to use link analysis to offer a new insight into the axis structure of residential movement.

By employing link analysis, we are able to identify a finite set of axis structures of residential mobility which describe how residents move their homes. The contours of the geographic districts in Hong Kong can be identified in terms of residential mobility flows.

b. Daily mobility model

From the literature review, the process of residential mobility has resulted in the evolution of urban areas from the mono-centric structure to the polycentric structure. This part has discovered the hierarchical urban structure of the polycentric urban region of Hong Kong by one of innovative data mining methods-link analysis based on the daily mobility commuting flows. The axis structure of the daily mobility is identified in the same manner as the identification of the residential mobility. The intra- and inter-linkage between 32 districts was analyzed in a four-step progress and mapped out in the link map. Finally, the polycentric sub-centers are classified in term of daily mobility commuting flows.

c. Comparison of the Residential Mobility and the Daily Mobility

Being different from many mobility studies, the great contribution of my research is trying to connect the residential mobility and the daily mobility together (particular the daily commuting to work trips). It intends to demonstrate the interaction between two types of mobility and their combination effect in determining an urban boundary of Hong Kong.

3.2 LINK ANALYSIS

Link analysis (Liu et al), known as one of popular data mining techniques, can identify and visualize connections (flows) between different objects (districts). The following questions could be answered by the link analysis:

- Which districts link to which other ones to find the axis structure of mobility?
- What connections between districts can be observed based on Origin-Destination data?
- The link analysis can discover mobility patterns among districts and delineate the city centers similar to how social network analysis determines communities.

In link analysis, the city Hong Kong is mapped into a network or a graph composed of "nodes" and "edges" between them. Each district is denoted as a "node". If there exist commuting flows between two districts, then these two districts (nodes) are linked, and their connection is represented an "edge" in the graph. For example, People will leave their residence (District 1) to their job location (District 2) for work. Therefore, a pair of Origin-Destination data from District 1 to District 2 will be derived, regardless of travelling pattern of trips to work taken by residents between two districts. To the initial district (the residence) the travelling flow is an outflow, while to the end district (the work location) the travelling flow is an inflow. For a district, the total flow count is equal to the sum of the outflow and inflow counts. Noticeably, the following illustration will take the daily mobility model as a representative example, while the residential mobility can be approached in the same manner.

The targeted research area is relatively small which is geographical divided into 18 districts, then further into 32 ones considering to separate the new town region from the other rural part of same district in New Territory. The geographical distribution of those districts is shown in Figure 3.2a. The population and census data have the information about the present residence district, the previous residence district and the most work frequent working place for each resident which can be used to generate the origin-destination table among the districts of Hong Kong. The link map will be constructed based on those data, in which each node represents a district and the links between nodes denote the flows than a user specified value among the corresponding districts, shown in Figure 3.2b, which is an example of link map in term of daily mobility.

Figure 3.2a Geographical Representations of Hong Kong

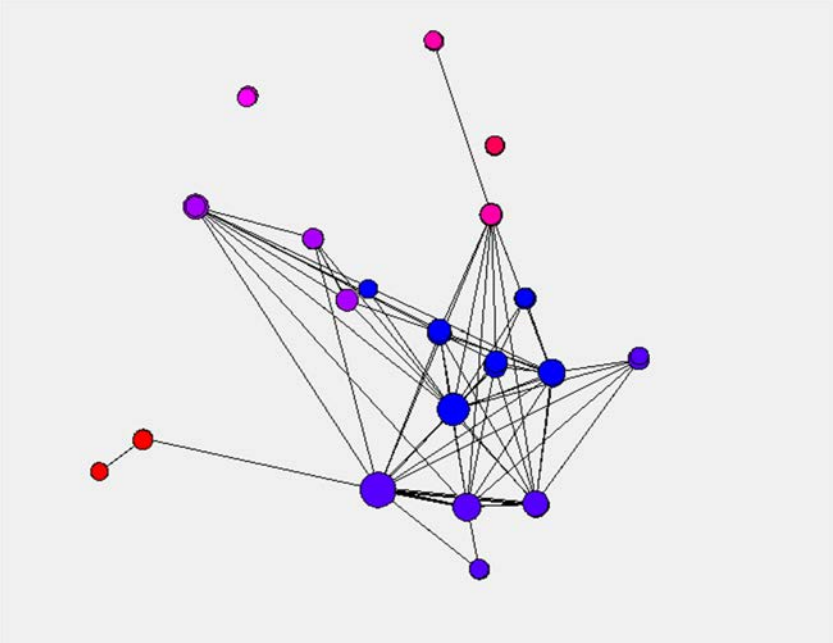


Figure 3.2b Link Map of Hong Kong

Figure 3.2 Geographical Representations and Link Map of Hong Kong

(The nodes in the link map stand for the districts, while the links between nodes correspond to the traveling flows from residence to work location, and whose support value is larger than 3%)

The basic steps of link analysis are as follows:

First, the link analysis obtains association rules through analyzing the origin-destination data. Then the rules are transformed into a graph that consists of nodes and links. Next, a variety of centrality measures are calculated and the hierarchical urban structure is explained. Finally, item clusters (city centers) are detected.

3.2.1 ASSOCIATION ANALYSIS

The connections between districts are investigated by conducting association analysis on the Origin-Destination matrix. The analysis produces a set of rules, which takes the format District *i* => District *j*, the intuitive interpretation of the rule is that: Upon having observed residents originate from District *i*, may increase the belief that residents will go to District *j* for work. The rules should not be interpreted as a direct causation, but as an association between two or more items. The following list shows some hypothetical association discovery rules, for example:

- If a resident live in "Central and Western", then 56.111% of the time he also works in "Central and Western".
- Hong Kong might find that 1.723% of all the residents who live in "Wan Chai" will go to "Central and Western" for work.
- Residents living in Tsuen Wan (New Town) will be 3.67 times as likely to work in the district "Sham Shui Po" than residents chosen at random.

These example rules have a left-hand side (Origin District) and a right-hand side (Destination District). The four important evaluation criteria of association analysis are "confidence", "expected confidence", "support", and "lift" (Liu et al), whose definitions are shown in Table 3.1. The confidence index defines the strength of an association rule, which is the percentage of residents work in a Destination District given that they live in an Origin District. Expected confidence is the proportion of residents who are in District *j*. The level of support represents how frequently the combination occurs in the database. Lift is a measure of the likelihood of the consequent increases given an antecedent, which is equal to the confidence divided by the expected confidence.

Table 3.1 Four Criteria for Association Analysis

Criteria	Definition
Confidence:	The percentage of resident who work in District j given that live in District i.
Expected confidence:	The number of residents who work in District j divided by the total number of residents.
Support:	The percentage of residents who live in District i and work in District j.
Lift:	“Confidence” divided by “Expected Confidence”

3.2.2 DEGREE CENTRALITY

The degree Centrality of districts measures the number of links of each district, which can be regarded as the first index of the topological centrality of a district. It reveals the status of the districts within the urban system of Hong Kong.

In social network analysis, actors which have more connections are assumed as having advantaged positions (Hanneman and Riddle, 2005). Because they may have alternative ways to satisfy their needs, hence are less dependent on other actors. They can utilize more of the social network as a whole because of many connections they being able to access to. Therefore, the "Degree Centrality" is a very simple, but often very effective index to measure one's centrality and importance. Similarly, the districts which are more central, in the terms higher degree or more connections, will have important positions in the urban system.

In undirected network, districts differ from one another only in how many connections they have. However in directed network, it is very important to distinguish "In Degree Centrality" from "Out Degree Centrality". If districts receive many connections, they are often thought to be prominent, or to have high status in urban system. That is, many other districts seek career opportunities from them, and this may indicate their importance. Districts who have unusually high out-degree are district whose residents should go to other districts find the employment chances and also indicating the convenient transportation. The more connection a district has then, the more importance they (may) have. Districts which have more connection have greater opportunities because they have choices, hence more important.

3.2.3 WEIGHT

In fact, the importance and the strength of nodes are also determined by their strength, intensity, or capacity, which is defined as "Weights" (Barrat et al., 2004; Horvath, 2011). Therefore, a weighted network can be created, where the connections among nodes have weights assigned to them. In this research, weights refer to the numbers of commuting residents along connections of districts in the urban system.

In the mathematical representation of the network, the weight of connection $i \rightarrow j$, denoted as w_{ij}, are calculated as the sum of commuters between District i and District j. In the undirected graph, w_{ij} will equal to w_{ji}, while in the directed graph, w_{ij} will have different meanings from w_{ji}.

The weight of a node is the sum of weights connected to this node. The "In Weight" is defined as

$$InWeight_i = \sum_{j \epsilon Neighbor_{in}(i)} w_{ji},$$

where $Neighbor_{in}(i)$ is the neighboring nodes which are connected to Node i. While the "Out Weight" is defined as

$$OutWeight_i = \sum_{k \epsilon Neighbor_{out}(i)} w_{ik},$$

where $Neighbor_{out}(i)$ is the neighboring nodes which are leaving from Node i.

The weight of nodes offers an instinctive index for the representation of the relative importance of districts according to the actual commuting flow generated ($OutWeight_i$) or received ($InWeight_i$) by the districts.

3.2.4 INFLUENCE CENTRALITY

Bonacich (1987) argued that the importance of the node should be determined by its own connections, and also the connections of its adjacent nodes. According Bonacich's ideas, the nodes with the same degree do not have the same importance. "Influence centrality" is actually a combination of "Degree Centrality" and "Weight", which combines the connection weights and node weights of neighboring nodes to solve the above problem (Liu et al.). It is assumed as another more comprehensive index to determine the importance of a district in urban system.

For "In Degree Centrality", the mathematical formula is defined as

$$InDegreeCentality_i = \sum_{j \in Neighbor_{in}(i)} w_{ji} \Big/ \sum_{j \in N} InWeight_j$$

While for "Out Degree Centrality", the mathematical formula is defined as

$$OutDegreeCentality_i = \sum_{k \in Neighbor_{out}(i)} w_{ik} \Big/ \sum_{k \in N} InWeight_k$$

3.2.5 IDENTIFYING THE POLYCENTRIC STRUCTURE

Clustering analysis is one of popular data mining techniques and is employed in many different fields (Pang-Ning T et al., 2006). There are many algorithms for clustering analysis and the most common one is K-means method, which is a distance based clustering method (Pang-Ning T et al., 2006). However, our case is a little different from that position. Each district is characterized in terms of commuting flows rather than in terms of travelling distance. Therefore, the k-means method does not fit well with our situation and we thus use the link analysis which is a connection based method to detect spatially interacted districts in Hong Kong. Link analysis is one of social network analysis methods using community detection algorithm for the clustering task, which can be used to explore spatial relationship, especially to identify spatially correlated locations (e.g., Liu et al., 2014; Thiemann et al., 2010).

It must be kept in mind that the constitution of a polycenter should fulfill two requirements: first, each district should be located close to each other in the same city center. Second, there are higher numbers of flows between districts in the same city center compared to that are not in. The link analysis can cluster N districts into K polycenters where the intra-connection between districts in the cluster is high and inter-connection is low.

3.2.6 ADVANTAGES OF LINK ANALYSIS

The link analysis treat the residential mobility routes itself as the unit of analysis, trying to identify the axis structures of mobility patterns for each district rather than to estimate the propensity to move. This association based method can describe the mobility direction where the mobility originates and where it ends in, which varies for different district. Relatively few studies have incorporated this method so far as I know.

The big difference between the approach proposed by Sun et al (2006) and our approach lies on how to define the "long" work trips. In Sun's study, a parameter "maxLen" is used to define the maximum trip length. The trip with a length longer than a particular user specified value of "maxLen", will be excluded from the research and the equivalent edges will be deleted in a like manner. While in the link analysis the probability of work flows is employed instead of the distance to delineate the work trips containing research values and those rare cases. The links with lower "Support" than a specific value, which were regarded as outliers, will be removed from the calculation in order to generate a good accuracy.

Another advantage of the link analysis approach over the previous approaches is that link analysis is a kind of unsupervised algorithm, which allow us to identify the city centers with little or no idea about the number value of city centers should be. In the unsupervised algorithm, the city centers are detected using link analysis that optimizes the center boundary based on the complete set of origin-destination data. In contrast, the previous approaches belonging to supervised algorithms use predetermined city centers as a starting point to detect the polycentric structures of urban area and some indicators are employ to check the spatial integration and

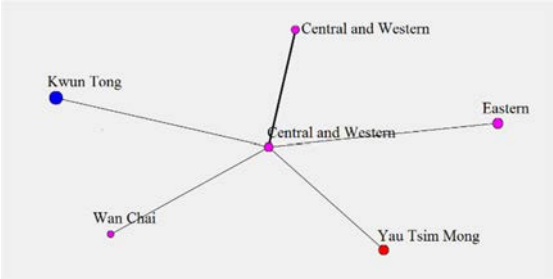
functional balance of those centers. Therefore, the link analysis offers a more extensive approach of studying the intrinsic urban structure of Hong Kong.

CHAPTER 4 RESIDENTIAL MOBILITY MODEL

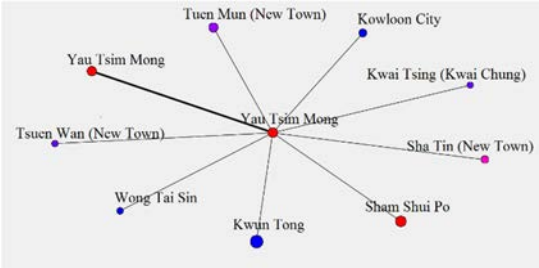
In order to achieve Objective 1and Objective 2, this chapter illustrates the challenges and potential advantages associated with link analysis to identify the axis structure of residential mobility in the geographic landscape of Hong Kong. This chapter has six parts, which are “Axis Structure of Residential Mobility”, “Degree Centrality of Residential Mobility”, “Weight of Residential Mobility”, “Influence Centrality of Residential Mobility”, “Intra-Residential Mobility”, and “Polycentric Structure of Residential Mobility”.

4.1 AXIS STRUCTURE OF RESIDENTIAL MOBILITY

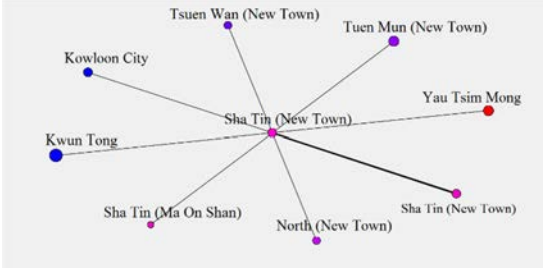
The existence and distinctive pattern of residential mobility are carefully examined using the link analysis based on the Origin-Destination data. A set of axis structures for each district is identified to describe how the residents conduct the movement across the urban area, which can be found in APPENDIX1.



Area-Long Term: Area Boundary of Residential mobility routes originating from the district “Central and Western”



Area-Long Term: Area Boundary of Residential mobility routes originating from the district “Yau Tsim Mong”



Area-Long Term: Area Boundary of Residential mobility routes originating from the district “Sha Tin (New Town)”

Figure 4.1 Axis Structure of Residential Mobility for Three Examples

This kind of star-like axis structure where each district acts a hub in turn is confirmed by the link analysis. The axis structure of residential mobility in three examples shows us that the most of residential mobility activities originating from a district will end in a destination district along one of axes. Each district was therefore connected with a small constellation of axes directing to a small group of the destination districts.

4.2 DEGREE CENTRALITY OF RESIDENTIAL MOBILITY

According to the ranking of “In Degree Centrality” for each district (Table 4.1), Among the districts: the district “Yau Tsim Mong” and the district “Kwun Tong” are two most popular destination districts of residential movement in term of the high value of “In Degree Centrality”, while the district “Southern”, the district “Sai Kung (Other Areas)”, the district “North (Other Areas)”, the district “Tai Po (New Town)”, the district “Kwai Tsing (Tsing Yi)”, the district “Islands (North Lantau)”, and the district “Tai Po (New Town) have relatively lower residential mobility inflows. It is found that most of the lower ranking districts are situated in remote area far from the center exctept the district “Southern” being from Hong Kong Island, and all of them seem to have less land supply to attract the residents to move in. It is interesting to notice that the district “Tuen Mun (New Town)” ranks relatively higher, maybe attributing to its higher housing supply. The district “Sham Shui Po” and the district “Kowloon City” from Kowloon urban area, the district “Eastern” from Hong Kong Island, and two new towns from “Tsuen Wan” and “Sha Tin”, have relatively higher rankings because of their relative sufficient housing supply, accessible geographical locations and convenient nearby transportation. The district “Central and Western” and the district “Wan Chai”, both of which are from the Hong Kong Island, have lower in-connections, since their lands for residence use seem to be rather limited. Other districts seem to be less attractive to the immigrants, maybe due to the inferior geographical locations, insufficient housing supply, and the imperfect community services.

Table 4.1 Rankings of Hong Kong Districts by their "In-Degree Centrality" in Term of Residential Mobility

Rank	District	In-degree Centrality
1	Yau Tsim Mong	12
1	Kwun Tong	12
3	Tuen Mun (New Town)	10
4	Sham Shui Po	9
5	Kowloon City	7
6	Eastern	6
6	Tsuen Wan (New Town)	6
6	Sha Tin (New Town)	6
9	Wong Tai Sin	5
9	Yuen Long (Tin Shui Wai)	5
11	Central and Western	4
11	Sai Kung (Tseung Kwan O)	4
11	Yuen Long (New Town)	4
11	Yuen Long (Other Areas)	4
11	North (New Town)	4
11	Kwai Tsing (Kwai Chung)	4
17	Wan Chai	3
18	Sha Tin (Ma On Shan)	2
19	Southern	1
19	Sai Kung (Other Areas)	1
19	North (Other Areas)	1
19	Tai Po (New Town)	1
19	Kwai Tsing (Tsing Yi)	1
19	Islands (North Lantau)	1
19	Islands (Other Areas)	1

As for "Out Degree Centrality", it is not surprising that there are some changes about the ranking. The overall ranking does not make too much difference except two districts such as the district "Tuen Mun (New Town)" and the district "North (New Town)" with higher value of "In-Degree Centrality" than that of "Out-Degree Centrality". This verifies the existence of the "lock-in" effect, which means that once the residents settle down in these areas, will be reluctant to move out. Among those districts, the district "Sham Shui Po" from Kowloon and the district "Eastern" rank in the top of the list in terms of "Out Degree Centrality". The district "North (New Town)", the district "Sha Tin (Ma On Shan)", the district "Sai Kung (Other Areas)", the district "Islands (North Lantau)", and the district "Islands (Other Areas)", all of

which are situated in the peripheral areas of New Territories, display a strong local attachment or serious lock-in effect. The districts “Central and Western”, “Wan Chai”, and “Southern” from Hong Kong Islands have fewer neighborhoods to output movers. The underlying reason maybe attribute to the fact that residents in those areas don’t have too much push to move out since they are content with their living conditions right now. The remaining districts are in the middle of ranking list, not having too much difference compared with the ranking list in term of “In Degree Centrality”. three new towns “Tuen Mun”, “Sha Tin”, and “Tseung Kwan O”, four districts “Yau Tsim Mong”, “Sham Shui Po”, “Kowloon City”, and “Kwun Tong” from Kowloon, rank relatively higher compared with other districts. The new towns including “Tsuen Wan”, “Kwai Chung”, “North”, “Yuen Long”, and “Tai Po” from New Territory rank relative lower. Most of those districts are situated in the remote part of Hong Kong.

Table 4.2 Rankings of Hong Kong Districts by their “Out-Degree Centrality” in Term of Residential Mobility

Rank	District	Out-degree Centrality	Change
1	Sham Shui Po	10	↑3
1	Eastern	10	↑4
3	Yau Tsim Mong	9	↓2
3	Kwun Tong	9	↓2
5	Sha Tin (New Town)	8	↑3
6	Kowloon City	7	↓2
6	Wong Tai Sin	7	↑2
8	Tuen Mun (New Town)	6	↓5
8	Tsuen Wan (New Town)	6	↓2
10	Central and Western	5	↑1
11	Yuen Long (Tin Shui Wai)	4	↓1
11	Sai Kung (Tseung Kwan O)	4	
11	Yuen Long (New Town)	4	
11	Wan Chai	4	↑3
11	Southern	4	↑4
16	Yuen Long (Other Areas)	3	↓3
16	Kwai Tsing (Kwai Chung)	3	↓1
18	North (Other Areas)	2	↑3

18	Tai Po (New Town)	2	↑3
18	Kwai Tsing (Tsing Yi)	2	↑3
21	North (New Town)	1	↓6
21	Sha Tin (Ma On Shan)	1	↓4
21	Sai Kung (Other Areas)	1	↓3
21	Islands (North Lantau)	1	
21	Islands (Other Areas)	1	

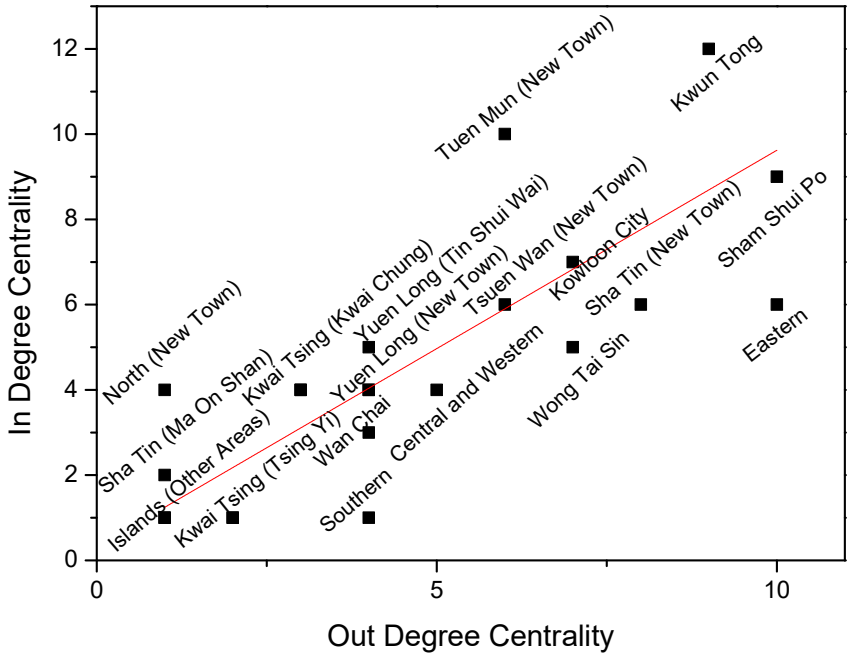


Figure 4.2 The Scatter Plot of Districts in terms of "In-Degree Centrality" vs. "Out-Degree Centrality" with Pearson's Coefficient 0.82936.

From Figure 4.2, it can be concluded that the overall relationship between "In Degree Centrality" and "Out Degree Centrality" is linear, for which Pearson's coefficient is 0.82936. The "In Degree Centrality" calculates the connections directed into the districts as a destination, while the "Out Degree Centrality" refers to the connections leaving from the districts as an origin. In other words, districts which have higher value of in-connections will have higher value of out- connections as well. Districts with higher value of "In Degree Centrality" usually have relative sufficient housing supply and relative good reputation for the perfect community services, which act as pull factors attracting many residents to move in. By contract,

districts with lower value of "Out Degree Centrality" will indicate a local attachment phenomenon with a strong spatial "lock-in" effect[2]. The interpretation for the average value of "In-Degree Centrality" and "Out-Degree Centrality" is more complicated depending on the situations. Districts can be roughly clustered into two groups based on the value of two degree centrality. The group with high values in term of both two degree centrality, includes the district "Eastern" from Hong Kong Island, five districts "Yau Tsim Mong", "Sham Shui Po", "Kowloon City", "Kwun Tong", and "Wong Tai Sin" from Kowloon area, and three new towns "Sha Tin", "Tuen Mun", and "Tsuen Wan", all of which are very active in the residential mobility rate. The remaining districts construct another group with relative lower value of two degree centrality, containing the districts "Central and Western", "Wan Chai", and "Southern" from the urban area of Hong Kong Island, and the new towns "Yuen Long", "Kwai Chung", "Tsing Yi", "North", "Ma On Shan", "North Lantau", the district "Yuen Long (Other Areas)", and the district "Islands (Other Areas)" from New Territories. The reason for that is that residents, who are content with their housing condition, don't need to move out, and the higher housing prices because of geographical advantage have compelled the residents with lower salary difficult to move in.

[2] Lower value of "Out Degree Centrality" is considered a likely sign of a spatial lock-in. This is because residents are still confined to their neighborhood where they live for a long time.

4.3 WEIGHT OF RESIDENTIAL MOBILITY

If the “Degree Centrality” weigh the residential mobility rate of the districts in term of their geographical location together with their transportation connections, while the “Weight” measure the districts in terms of residential mobility flows in addition to their locations and the nearby transportation system. Therefore, the “Weight” of each district is proportional to its size, population distribution or housing supply in some extent. Table 4.3 and Table 4.4 show the ranking of districts in perspective of “In Weight” and “Out Weight”, respectively. The last column indicates the change of the ranking of each district compared with that in term of degree centrality. From the tables, it is not surprising to find that there are some changes in the ranking list, since the index “weight” weighs more factors than the “Degree Centrality” to give a more comprehensive ranking of each district. Generally, the districts with bigger size and larger population will improve the “Out Weight” accordingly, and the districts with larger number of housing supply will improve the “In Weight” consequently.

Table 4.3 Rankings of Hong Kong Districts by their “In-Weight” in term of Residential Mobility

Rank	District	In-Weight	Change
1	Kwun Tong	709	↑1
2	Sham Shui Po	555	↑2
3	Eastern	502	↑3
4	Yau Tsim Mong	476	↓3
5	Tuen Mun (New Town)	469	↓2
6	Kowloon City	358	↓1
7	Sha Tin (New Town)	338	↑1
8	Central and Western	329	↑3
9	Sai Kung (Tseung Kwan O)	258	↑3
10	Wong Tai Sin	256	↓1
11	Tsuen Wan (New Town)	252	↓4
12	North (New Town)	238	↑3
13	Kwai Tsing (Kwai Chung)	236	↑3
14	Yuen Long (Tin Shui Wai)	231	↓4
15	Wan Chai	224	↑2
16	Yuen Long (Other Areas)	175	↓2

17	Yuen Long (New Town)	163	↓4
18	Southern	141	↑2
19	Tai Po (New Town)	133	↑3
20	Sha Tin (Ma On Shan)	120	↓2
21	Islands (Other Areas)	112	↑4
22	Kwai Tsing (Tsing Yi)	102	↑1
23	Islands (North Lantau)	62	↑1
24	Sai Kung (Other Areas)	56	↓4
25	North (Other Areas)	45	↓4

Table 4.4 Rankings of Hong Kong Districts by their "Out-Weight" in term of Residential Mobility

Rank	District	Out-Weight	Change
1	Eastern	585	↑1
2	Sham Shui Po	546	↓1
3	Kwun Tong	517	↑1
4	Yau Tsim Mong	495	↓1
5	Kowloon City	446	↑1
6	Tuen Mun (New Town)	422	↑2
7	Central and Western	383	↑1
8	Sha Tin (New Town)	339	↑3
9	Wong Tai Sin	291	↓2
10	Tsuen Wan (New Town)	280	↓1
11	Wan Chai	257	↑3
12	Southern	223	↑3
13	Kwai Tsing (Kwai Chung)	215	↑4
14	Sai Kung (Tseung Kwan O)	208	↓2
15	North (New Town)	194	↑6
16	Tai Po (New Town)	184	↑3
17	Yuen Long (Tin Shui Wai)	153	↓6
18	Yuen Long (New Town)	143	↓5
19	Yuen Long (Other Areas)	140	↓3
20	Kwai Tsing (Tsing Yi)	134	
21	Sha Tin (Ma On Shan)	109	↑1
22	Sai Kung (Other Areas)	86	↑1
23	Islands (Other Areas)	84	↑2
24	Islands (North Lantau)	58	
25	North (Other Areas)	46	↓7

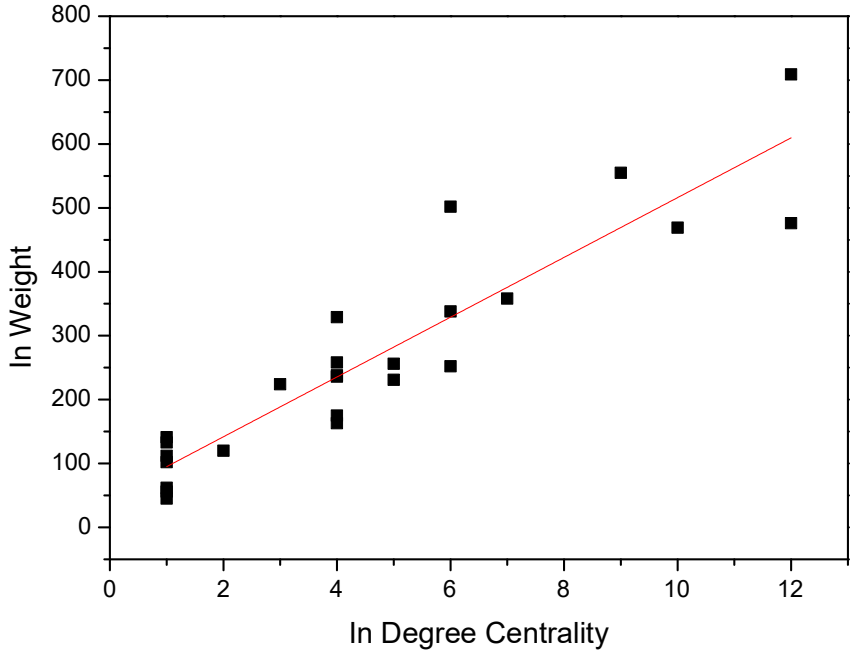


Figure 4.3 Log-log Plot of "In-Weight" over "In-Degree Centrality" for Residential Mobility. The Pearson's Coefficient is 0.92155.

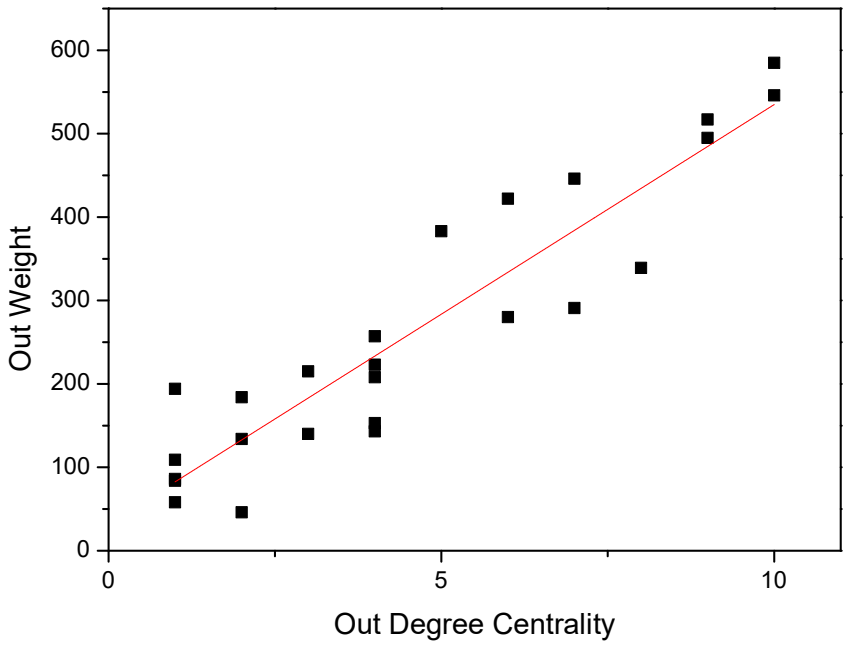


Figure 4.4 Log-Log Plot of "Out-Weight" over "Out-Degree Centrality" for Residential Mobility, the Pearson's Coefficient is 0.92753.

From Figure 4.3 and Figure 4.4, it is concluded that there is a nearly linear relationship between the index "Weight" and the index "Degree Centrality", which means the volume of residential mobility flows is nearly linear with the degree of each district, confirming the truth that the more the districts are linked and the more easily to attract or compel the residents move in or out. The prefix of "In" or "Out" indicates that the district act as different roles as migration origin or migration destination, which reflects the different characteristics of each district.

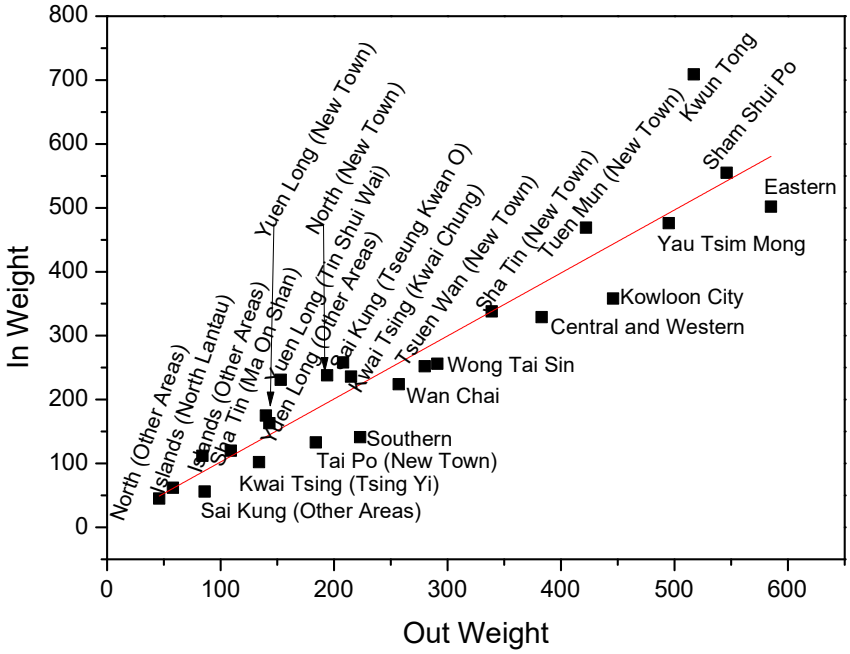


Figure 4.5 The Scatter Plot of districts in terms of "In Weight" vs. "Out Weight"

The Distribution of districts based on "In Weight" and "Out Weight" are illustrated in Figure 4.5. The composition of each group has changed a bit. The district "Wan Chai" leave the district "Central and Western" to form a separate Group with middle value of "In Weight" and middle value of "Out Weight", while the district "Central and the district" together with the district "Yau Tsim Mong" constitute another group are high in both "In Weight" and "Out Weight". Group 3 is

featured as relatively low “In Weight” and relative high “Out Weight”, including the district “Kwun Tong”, the district “Eastern”, the district “Kowloon City”, the district “Sham Shui Po”, and two new towns “Sha Tin” and “Tuen Mun”. The last group is as same as before including four new towns “Tai Po”, “North”, “Tsuen Wan”, and “Kwai Chung”, one district from Hong Kong Island “Southern”, one district from Kowloon “Wang Tai Sin”, and one district from New Territories “Islands (Other Areas)”, which is characterized as low “In Weight” and “Out Weight”.

4.4 INFLUENCE CENTRALITY OF RESIDENTIAL MOBILITY

Up to now, it is found that the index “Degree Centrality” judges the linkage between each district due to their geographical locations and the corresponding transportation settings by the residential mobility connections, while the “Weight” measures the hierarchical level of districts in term of the residential mobility flows caused by the district size, the population distribution, the weigh against between the housing demand and the housing supply. It is more reasonable and scientific to rank the districts by considering all the above factors. Therefore, the index “Influence Centrality” is the combination of “Degree Centrality” and “Weight”, which rate the districts in different angles. The index “Centrality” judges the districts in term of the connections between districts (reflected in “Degree Centrality”) together with weights of neighboring districts (reflected in “Weight”) as a whole. Centrality measures utilize social network concepts to determine the influence of each district in the urban system. It is assumed that “Influence Centrality” estimate districts more accurately and comprehensively than “Degree Centrality” and “Weight”. The rankings of Hong Kong districts by “In Influence Centrality” and “Out Influence Centrality” are shown in Table 4.5 and Table 4.6 with the last column indicating the changes of the ranking compared with the rankings in term of “Weight”. It is not surprising to see there is a little adjustment of the ranking list since the index “Influence Centrality” is calculated in a different judging standard. The relationship between “In-Influence Centrality” and “In-Weight” is nearly linear, and also the same situation for “Out-Influence Centrality” and “Out-Weight”, which are shown in Figure 4.6 and Figure 4.7, respectively.

Table 4.5 Rankings of Hong Kong Districts by their "In-Influence Centrality" in Term of Residential Mobility

Rank	District	In-Influence Centrality	Change
1	Kwun Tong	0.047943111	
2	Sham Shui Po	0.034867717	
3	Eastern	0.031197431	
4	Yau Tsim Mong	0.030279859	
5	Tuen Mun (New Town)	0.028368252	
6	Kowloon City	0.021180609	
7	Central and Western	0.018580823	↑1
8	Sha Tin (New Town)	0.016286894	↓1
9	Wong Tai Sin	0.013916501	↑1
10	Tsuen Wan (New Town)	0.013916501	↑1
11	Wan Chai	0.011469644	↑4
12	Sai Kung (Tseung Kwan O)	0.011469644	↓3
13	Kwai Tsing (Kwai Chung)	0.011393179	
14	North (New Town)	0.011163787	↓2
15	Yuen Long (Tin Shui Wai)	0.011087322	↓1
16	Yuen Long (Other Areas)	0.007799358	
17	Yuen Long (New Town)	0.007417036	
18	Southern	0.006728858	
19	Tai Po (New Town)	0.005428965	
20	Sha Tin (Ma On Shan)	0.004129072	
21	Islands (Other Areas)	0.003670286	
22	Kwai Tsing (Tsing Yi)	0.003287965	
23	Sai Kung (Other Areas)	0.001911607	↑1
24	Islands (North Lantau)	0.001376357	↓1
25	North (Other Areas)	0.001223429	

Table 4.6 Rankings of Hong Kong Districts by their "Out-Influence Centrality" in Term of Residential Mobility

Rank	District	Out-Influence Centrality	Change
1	Eastern	0.0380792	
2	Sham Shui Po	0.0354794	
3	Kwun Tong	0.0341795	
4	Yau Tsim Mong	0.0316562	
5	Kowloon City	0.0263802	
6	Tuen Mun (New Town)	0.0227864	
7	Central and Western	0.0213335	
8	Sha Tin (New Town)	0.0179691	
9	Wong Tai Sin	0.0165163	
10	Tsuen Wan (New Town)	0.0144518	
11	Wan Chai	0.012846	

12	Kwai Tsing (Kwai Chung)	0.0107815	↑1
13	Southern	0.0107815	↓1
14	Sai Kung (Tseung Kwan O)	0.009558	
15	Yuen Long (Tin Shui Wai)	0.0079523	↑2
16	Yuen Long (New Town)	0.0078758	↑2
17	North (New Town)	0.00757	↓2
18	Yuen Long (Other Areas)	0.0067289	↑1
19	Tai Po (New Town)	0.0067289	↓3
20	Kwai Tsing (Tsing Yi)	0.0044349	
21	Islands (Other Areas)	0.0036703	↑2
22	Sha Tin (Ma On Shan)	0.0026763	↓1
23	North (Other Areas)	0.0023704	↑2
24	Sai Kung (Other Areas)	0.0019116	↓2
25	Islands (North Lantau)	0.0013764	↓1

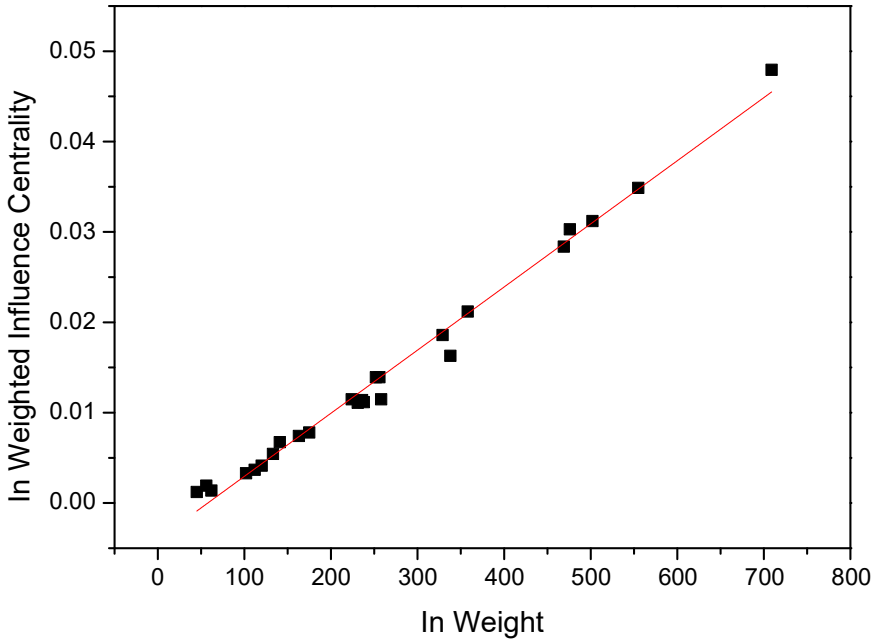


Figure 4.6 Log-Log Plot of "In-Weighted Influence Centrality" over "In-Weight" for Residential Mobility. The Pearson's Coefficient is 0.99423.

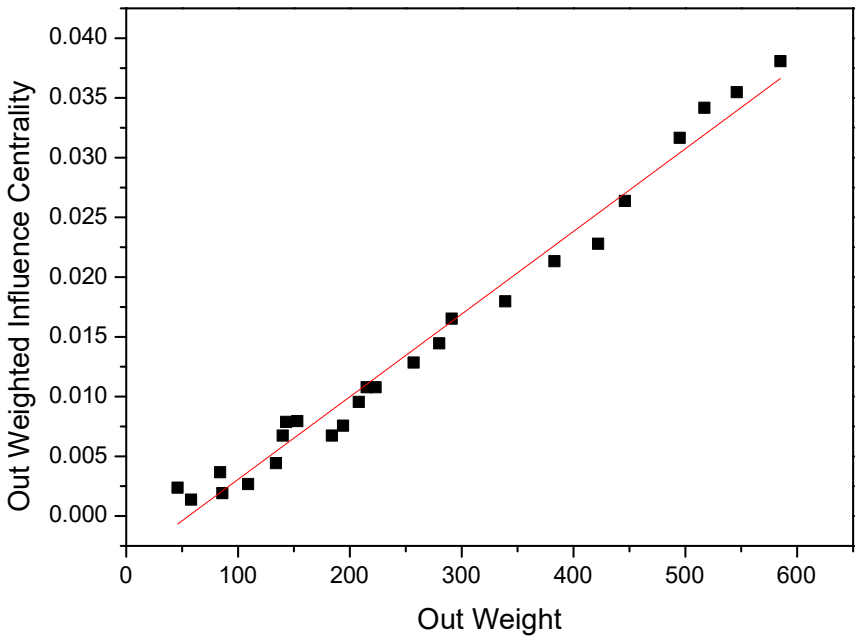


Figure 4.7 Log-Log Plot of "Out-Weighted Influence Centrality" over "Out-Weight".

The Pearson's Coefficient is 0.99082.

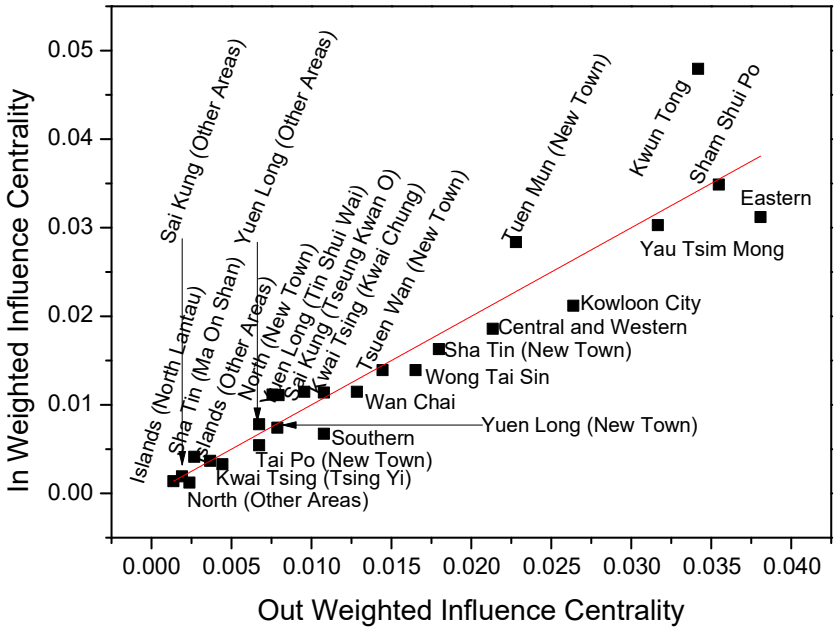


Figure 4.8 The Scatter Plot of Districts in terms of "In-Weighted Influence Centrality" vs. "Out-Weighted Influence Centrality"

Figure 4.8 shows that the Groups divided by considering the combination of “In Influence Centrality” and “Out Influence Centrality”. The graph reveals that the composition for each group does not change at all though there a small adjustment among the rankings of district in the same group since the relationship between “Weight” and “Influence Centrality” is almost linear.

4.5 INTRA-RESIDENTIAL MOBILITY

Table 4.7 shows the intra-residential mobility within the same district (the previous residence and the present residence are in the same district) with the last columns indicating the percentage rate accounted for in the in-migration flows and in the out-migration flows, respectively. The intra-residential mobility reflects the self-sufficient ability of each district to provide the housing supply to its own residents. Usually, many residents from the districts “Central and Western”, “Eastern”, “Wan Chai” and “Southern” in Hong Kong Island prefer to move their home within their own district. Being as the historical, political, and economic center of Hong Kong, the residents with higher incomes are reluctant to move out these honorable areas. Noticeable, the districts “Yau Tsim Mong”, “Sham Shui Po”, “Kowloon City”, and “Wong Tai Sin” from Kowloon area have relatively higher intra-residential mobility rate since they are regarded as the secondary urban area after the districts from Hong Kong Island. The intra-residential mobility activities are more complicated. Some districts from New Territories such as the district “Tai Po (New Town)”, the district “Sai Kung (Other Areas), the district “Islands (Other Areas)”, the district “Kwai Tsing (Tsing Yi)”, the district “North (New Town)”, and the district “Tuen Mun (New Town)” have relative higher intra-residential mobility rate, while the new towns including “Kwai Chung”, “Sha Tin”, “Tsuen Wan”, “Ma On Shan”, “Yuen Long”, “North Lautau”, “Tseung Kwan O”, and “Tin Shui Wai”, and the districts “North (Other Areas)”, “Yuen Long (Other Areas) from New Territories, have relatively lower intra-residential mobility rate. Noticeable, the district “Yuen Long (Tin Shui Wai)” has been labeled as “City of Misery” because of the accumulation of severe family and social issues, which result in the fact that once the residents decided to relocate their homes, they will prefer to escape from this district. Other

districts with lower intra-residential mobility rate maybe have similar situations with the district “Yuen Long (Tin Shui Wai)”, attributing to their remote location, fewer job opportunities, and high density of public houses. However it doesn’t mean that the districts with higher short distance residential mobility (intra-residential mobility) don’t have problems. The lower intra-residential mobility rate maybe reflects a serious spatial lock-in problem among those districts either because they are too poor to move out to pursue better housing condition or the public housing policy compel those who are asset-rich and income-poor.

Table 4.7 Rankings of Hong Kong Districts by Intra-Residential Mobility

District	Counts	As an Origin (%)	As a Destination (%)
Central and Western	172	52.27964	44.90862
Wan Chai	92	41.07143	35.79767
Eastern	285	56.77291	48.71795
Southern	88	62.41135	39.46188
Yau Tsim Mong	172	36.13445	34.74747
Sham Shui Po	231	41.62162	42.30769
Kowloon City	167	46.64804	37.44395
Wong Tai Sin	96	37.5	32.98969
Kwun Tong	250	35.26093	48.3559
Sai Kung (Tseung Kwan O)	70	27.13178	33.65385
Sai Kung (Other Areas	25	44.64286	29.06977
Tsuen Wan (New Town)	87	34.52381	31.07143
Tuen Mun (New Town)	193	41.15139	45.7346
Yuen Long (New Town)	46	28.22086	32.16783
Yuen Long (Tin Shui Wai)	48	20.77922	31.37255
Yuen Long (Other Areas)	43	24.57143	30.71429
North (New Town)	99	41.59664	51.03093
North (Other Areas)	16	35.55556	34.78261
Tai Po (New Town)	71	53.38346	38.58696
Sha Tin (New Town)	120	35.50296	35.39823
Sha Tin (Ma On Shan)	35	29.16667	32.11009
Kwai Tsing (Kwai Chung)	84	35.59322	39.06977
Kwai Tsing (Tsing Yi)	43	42.15686	32.08955
Islands (North Lantau)	18	29.03226	31.03448
Islands (Other Areas)	48	42.85714	57.14286

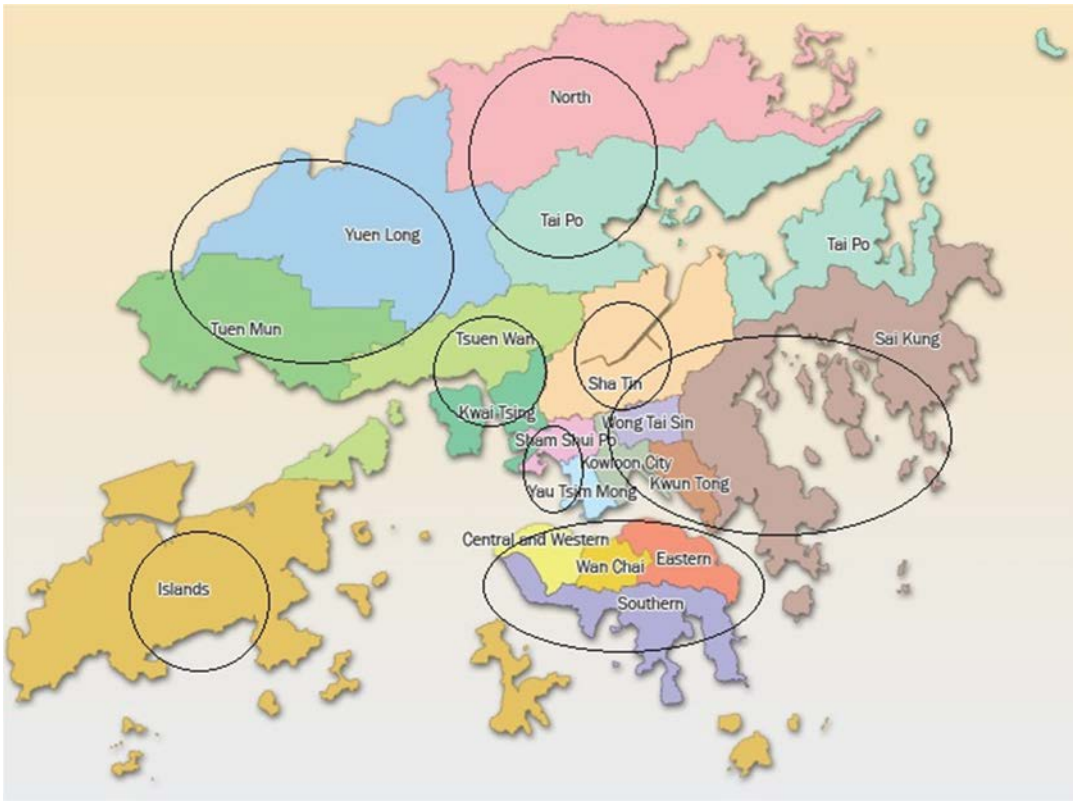


Figure 4.9 Polycentric Strucutre in term of Residential Mobility in Hong Kong

The Figure 4.9 displays a comprehensive analytic classification of the structure of residential pathways among the urban area of Hong Kong. It reveals that the residential mobility activities maybe occur in a fixed and unchanging order, or designed to happen within a defined area boundary. It is well assumed that the home district's characteristics play an important effect on the residential mobility behaviors. Each specific district is regarded as a unique combination of job opportunities, educational resources, and social relationships for different groups of residents, and this combination acts as the pushing or pulling factors, which will attract or compel movers from or into other districts. The residential mobility flows from the original district to the destination district have linked each district together to construct several areas within which the linkages are very strong. Several groups of residential mobility trajectories are identified, they are: Group 1 containing the

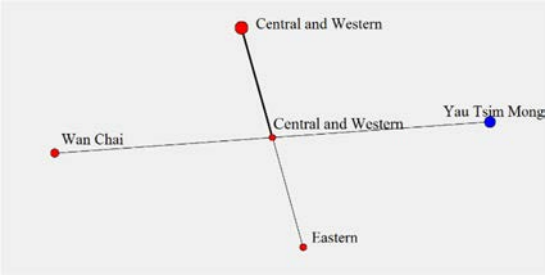
district “Central and Western”, the district “Wan Chai”, the district “Eastern”, and the district “Southern”; Group 2 containing the district “Yau Tsim Mong” and the district “Sham Shui Po”; Group 3 containing the district “Kowloon City”, the district “Wong Tai Sin”, the district “Kwun Tong”, and the district “Sai Kung (Tseung Kwan O)”, Group 4 containing the district “Tsuen Wan (New Town)”, the district “Kwai Tsing (Kwai Chung)” and the district “Kwai Tsing (Tsing Yi)”; Group 5 containing the district “Sha Tin (New Town)” and the district “Sha Tin (Ma On Shan)”; Group 6 containing “North (New Town)”, the district “North (Other Areas)” and “Tai Po (New Town)”; Group 7 containing “Tuen Mun (New Town)” , the district “Yuen Long (New Town)”, the district “Yuen Long (Tin Shui Wai)”, and the district “Yuen Long (Other Areas)”; Group 8 containing the district “Islands (North Lantau)” and the district “Islands (Other Areas)”. Most of short term residential mobility activities occurred within each group accordingly.

CHAPTER 5 DAILY MOBILITY MODEL

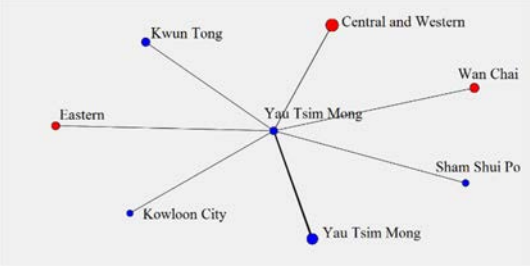
In order to achieve Objective 3 and Objective 4, this chapter illustrates the challenges and potential advantages associated with link analysis to identify the axis structure of daily mobility in the geographic landscape of Hong Kong. This chapter has six parts, which are “Axis Structure of Daily Mobility”, “Degree Centrality of Daily Mobility”, “Weight of Daily Mobility”, “Influence Centrality of Daily Mobility”, “Intra-Daily Mobility”, and “Polycentric Structure of Daily Mobility”.

5.1 AXIS STRUCTURE OF DAILY MOBILITY

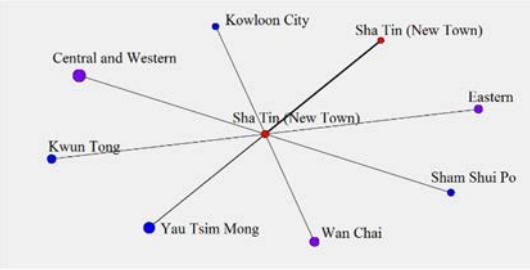
The existence and distinctive pattern of daily mobility are carefully examined using the link analysis based on the Origin-Destination data. A set of axis structures for each district is identified to describe how the residents conduct the daily commuting activities across the area of Hong Kong, which can be found in APPENDIX2.



Area-Short Term: Daily mobility routes originating from the district “Central and Western”



Area-Short Term: Daily mobility routes originating from the district “Yau Tsim Mong”



Area-Short Term: Daily mobility routes originating from the district “Sha Tin (New Town)”

Figure 5.1 Axis Structure of Daily l Mobility for Three Examples

This kind of star-like axis structure where each district acts a hub in turn is confirmed by the link analysis. The axis structure of daily mobility in three examples shows us that the most of daily mobility activities originating from a district will end in a destination district along one of axes. Each district was therefore connected with a small constellation of axes directing to a small group of the destination districts.

5.2 DEGREE CENTRALITY OF DAILY MOBILITY

According to the ranking of "In Degree Centrality" for each district (Table 1), the emerging hierarchical urban structure is confirmed to exist in Hong Kong. Among the districts: the district "Central and Western" and the district "Yau Tsim Mong" are the two most popular districts as the supply centers for employment in term of the high value of "In Degree Centrality", while the district "Southern", the district "Sai Kung (Tseung Kwan O)", the district "Tuen Mun (New Town)", the district "Yuen Long (New Town)", the district "North (New Town), and the district "Tai Po (New Town) are regarded as the least importance districts because all of them have less extra working opportunities for others. The interesting thing is found that most of them are new towns except that the district "Southern" is from Hong Kong Island, and all of them are situated in the fringe area of Hong Kong. Five districts "Wan Chai", "Eastern", "Sham Shui Po", "Kowloon City", and "Kwun Tong" from urban area attract commuters from a fairly high number of districts, attributing to the nearby convenient transportation. The new towns "Kwai Chung", "Tsuen Wan", and "Sha Tin" have relative high value of In Degree Centrality but still fall behind most of districts from urban area. Although the district "Islands (Other Area)" is situated far from the central area, it can supply some job positions for the residents from Islands district including Lantau New Town because of the existence of Hong Kong International Airport.

Table 5.1 Rankings of Hong Kong Districts by their In-Degree Centrality in term of Daily Mobility

Rank	District	In-degree Centrality
1	Central and Western	13
2	Yau Tsim Mong	13
3	Wan Chai	11
4	Eastern	9
5	Kwun Tong	9

6	Kowloon City	7
7	Sham Shui Po	5
8	Kwai Tsing (Kwai Chung)	4
9	Tsuen Wan (New Town)	3
10	Wong Tai Sin	2
11	Sha Tin (New Town)	2
12	Islands (Other Areas)	2
13	Southern	1
14	Sai Kung (Tseung Kwan O)	1
15	Tuen Mun (New Town)	1
16	Yuen Long (New Town)	1
17	North (New Town)	1
18	Tai Po (New Town)	1

In term of "Out Degree Centrality", three new towns "Tuen Mun", "Sha Tin", and "Tseung Kwan O" and four the districts from Kowloon such as "Yau Tsim Mong", "Sham Shui Po", "Kowloon City", and "Kwun Tong" rank relatively higher compared with other districts. The districts from Hong Kong Islands such as "Eastern", "Central and Western", "Wan Chai" and "Southern" have few neighborhoods to output labors. The new towns including "Tsuen Wan", "Kwai Chung" "North", "Yuen Long", and "Tai Po", and the district "Islands (Other Areas)" from New Territory, rank relative lower, most of which are situated in the remote part of Hong Kong.

Table 5.2 Rankings of Hong Kong Districts by their Out-Degree Centrality in term of Daily Mobility

Rank	District	Out-degree Centrality
1	Tuen Mun (New Town)	9
2	Kwun Tong	8
3	Sham Shui Po	8
4	Sha Tin (New Town)	8
5	Yau Tsim Mong	7
6	Kowloon City	6
7	Sai Kung (Tseung Kwan O)	6
8	Eastern	5
9	Central and Western	4
10	Tsuen Wan (New Town)	4
11	Wong Tai Sin	4
12	Wan Chai	3
13	Kwai Tsing (Kwai Chung)	3

14	Southern	3
15	Islands (Other Areas)	2
16	North (New Town)	2
17	Yuen Long (New Town)	1
18	Tai Po (New Town)	1

The diversity detected in the pattern of “In Degree Centrality” and “Out Degree Centrality” might be regarded as in working order to a proficient behavior as a whole system, where each core district exchange residents or worker with a few less ranking districts.

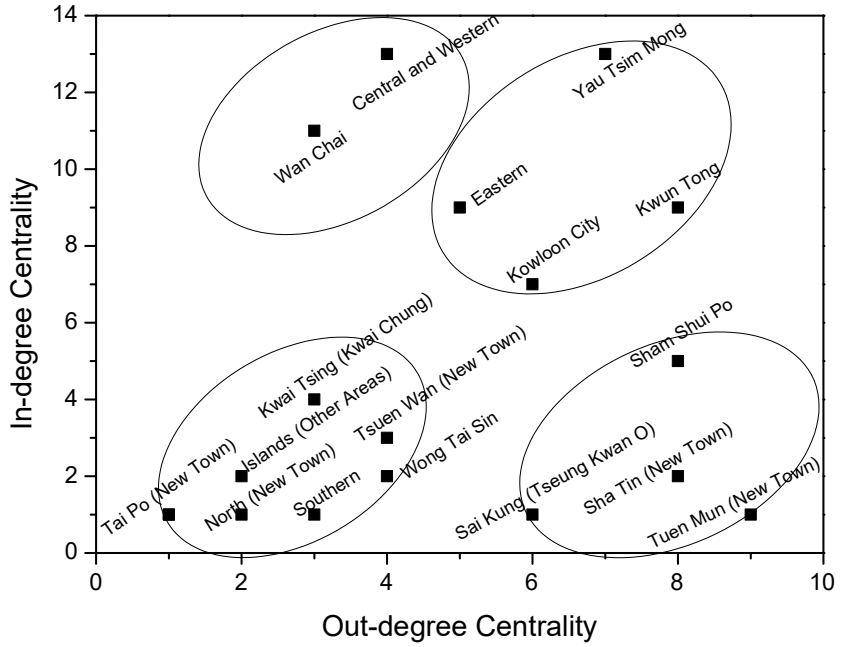


Figure 5.2 The Scatter Plot of Districts in terms of “In-Degree Centrality” vs. “Out-Degree Centrality” for Daily Mobility

The Hong Kong districts can be clustered into different groups based on the combination of “In Degree Centrality” and “Out Degree Centrality” (Figure 5.2). The “In Degree Centrality” calculates the connections directed into the districts as a destination, while the “Out Degree Centrality” refers to the connections leaving from the districts as an origin. Group 1 containing the district “Central and Western” and

the district “Wan Chai” has high value of “In Degree Centrality” while low value of “Out Degree Centrality”. Group 2 containing the district “Eastern” from Hong Kong Island, the districts “Yau Tsim Mong”, “Kowloon City” and “Kwun Tong” from Kowloon have high values for both “In Degree Centrality” and “Out Degree Centrality” compared with other districts. Group 3 characterized by low “In Degree Centrality” and low “Out Degree Centrality” include four new towns “Tai Po (New Town)”, “North (New Town)”, “Tsuen Wan (New Town)” , and “Kwai Tsing (Kwai Chung)”, one district from Hong Kong Island “Southern”, one district from Kowloon “Wang Tai Sin”, and one district from New Territories “Islands (Other Areas)”. The remaining new towns such as “Sai Kung (Tseung Kwan O)”, “Sha Tia (New Town)”, and “Tuen Mun (New Town)” together with one district from Kowloon “Sham Shui Po” form Group 4 with low “In Degree Centrality” and high “Out Degree Centrality”.

5.3 WEIGHT OF DAILY MOBILITY

Table 5.3 and Table 5.4 display the rankings of Hong Kong districts by their "In Weight" and "Out Weight" with the change of the ranking of each district indicated in the last column. The results reveal that the ranking of districts by "In Weight" and "Out Weight" are a little different from the rankings by their "In Degree Centrality" and "Out Degree Centrality". It is because that the "Degree Centrality" judges the districts in term of their geographical topology and their transportation connections, while the "Weight" assess the districts not only in the perspective of their geographical location and the transportation system by also in terms of the volume of the commuting flows, which is comparatively related to the size of each district and its population distribution and job opportunities. Generally, the "weight" weigh more factors than the "Degree Centrality" to give a more comprehensive ranking of each district. Usually, the districts with bigger area and larger populations will improve the "Out Weight" accordingly, and the districts with larger number of career opportunities will improve the "In Weight" consequently.

Table 5.3 Rankings of Hong Kong Districts by their In-Weight in term of Daily Mobility

Rank	District	In Weight	Change
1	Central and Western	1599	
2	Yau Tsim Mong	1320	
3	Wan Chai	976	
4	Kwun Tong	857	↑1
5	Eastern	775	↓1
6	Sham Shui Po	541	↑1
7	Kwai Tsing (Kwai Chung)	481	↑1
8	Kowloon City	474	↓2
9	Sha Tin (New Town)	400	↑2
10	Tsuen Wan (New Town)	336	↓1
11	Tuen Mun (New Town)	306	↑4
12	Islands (Other Areas)	294	
13	Southern	250	
14	Wong Tai Sin	230	↓4
15	Tai Po (New Town)	161	↑3

16	Yuen Long (New Town)	156	
17	North (New Town)	148	
18	Sai Kung (Tseung Kwan O)	133	↓4

Table 5.4 Rankings of Hong Kong Districts by their Out-Weight in term of Daily Mobility

Rank	District	Out Weight	Change
1	Yau Tsim Mong	764	↑4
2	Eastern	742	↑6
3	Tuen Mun (New Town)	738	↓2
4	Central and Western	711	↑5
5	Kwun Tong	680	↓3
6	Sham Shui Po	648	↑3
7	Sha Tin (New Town)	546	↓3
8	Kowloon City	522	↓2
9	Wan Chai	454	↑3
10	Sai Kung (Tseung Kwan O)	430	↓3
11	Wong Tai Sin	424	
12	Tsuen Wan (New Town)	377	↓2
13	Kwai Tsing (Kwai Chung)	367	
14	Tai Po (New Town)	262	↑4
15	North (New Town)	254	↑1
16	Southern	252	↓2
17	Yuen Long (New Town)	251	
18	Islands (Other Areas)	179	↓3

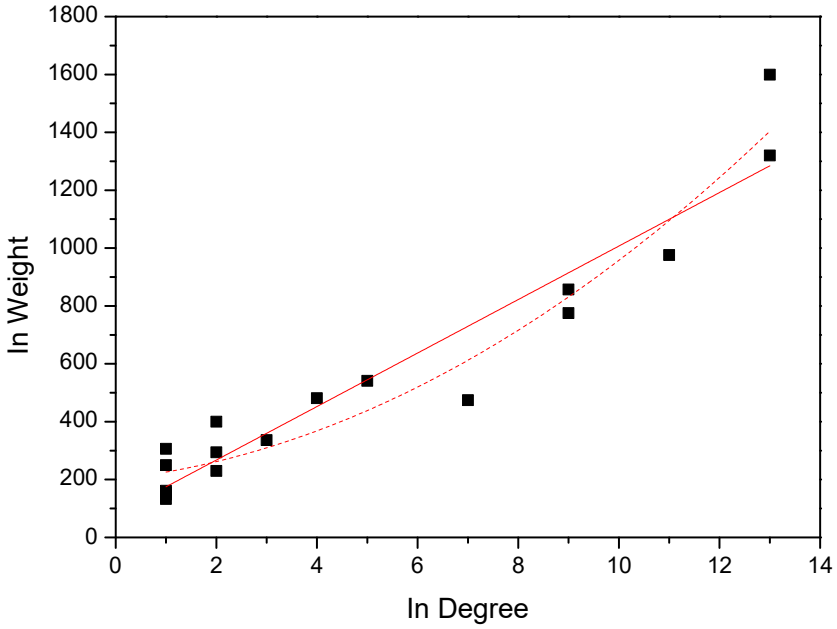


Figure 5.3 Log-Log Plot of "In-Weight" over "In-Degree" for Daily Mobility. The Pearson's Coefficient is 0.95798 and the Equation for Polynomial Fitting is $y=19.44053*x+5.62433*x^2$.

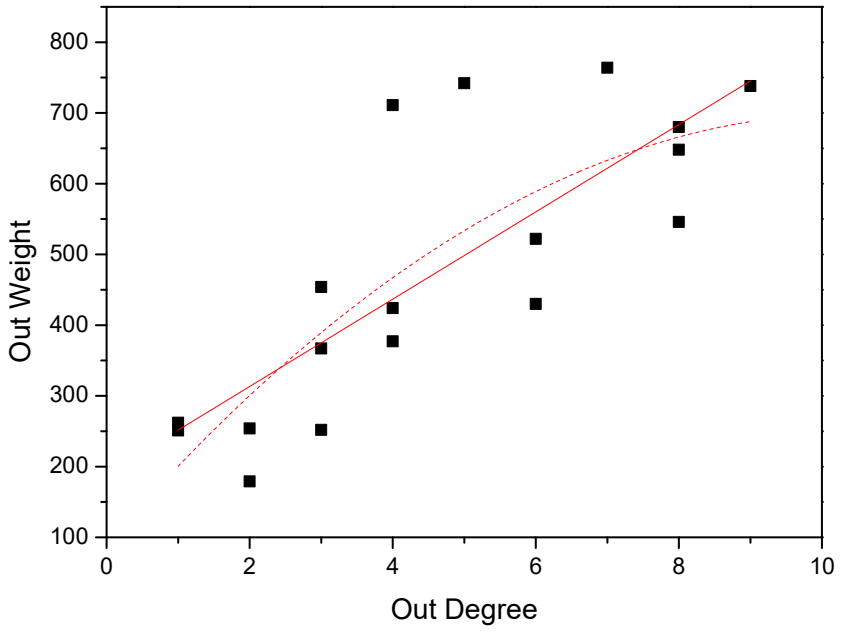


Figure 5.4 Log-Log Plot of "Out-Weight" over "Out-Degree" for Daily Mobility. The Pearson's Coefficient is 0.79983 and the Equation for Polynomial Fitting is $y=116.82616*x+5.59106*x^2$.

In Figure 5.3 and Figure 5.4, it is found that the relationship between the "Weight" and the "Degree Centrality" shows the volume of commuting flow is nearly linear with the degree of each district justifying the truth that the more the districts are linked and the more easily to attract the commuting workers. The direction of "In" or "Out" indicates that the district act as different roles as origin or destination, which demonstrate its totally different characteristics of the district.

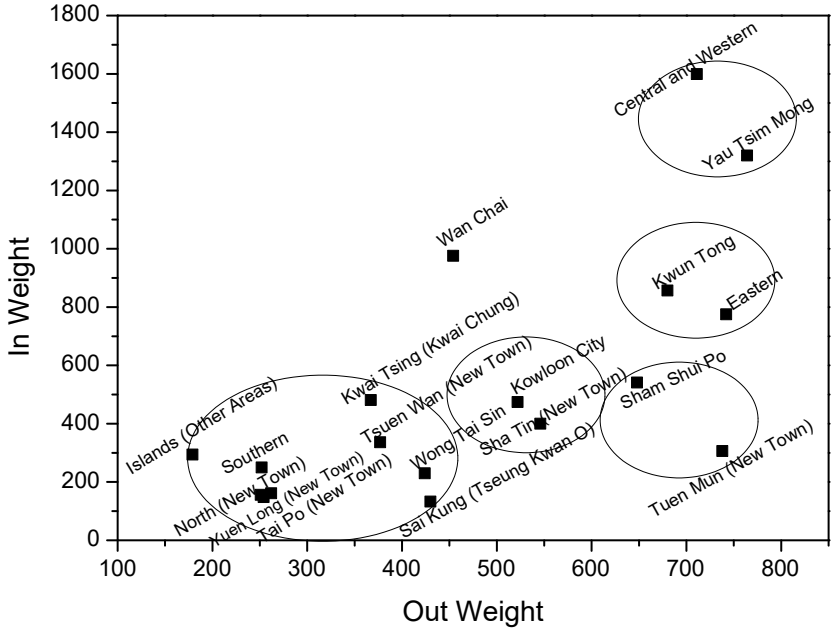


Figure 5.5 The Scatter Plot of Districts in terms of "In-Weight" vs. "Out-Weight" for Daily Mobility

The results of clustering analysis based on "In Weight" and "Out Weight" are illustrated in Figure 3. The composition of each group has changed a bit. The district "Wan Chai" leave the district "Central and Western" to form a separate Group with middle value of "In Weight" and middle value of "Out Weight", while the district "Central and the district" together with the district "Yau Tsim Mong" constitute another group are high in both "In Weight" and "Out Weight". Group 3 is featured as relatively low "In Weight" and relative high "Out Weight", including the district "Kwun Tong", the district "Eastern", the district "Kowloon City", the district "Sham Shui Po", and two new towns "Sha Tin" and "Tuen Mun". The last group is as same as before including four new towns "Tai Po (New Town)", "North (New Town)", "Tsuen Wan (New Town)", and "Kwai Tsing (Kwai Chung)", one district from Hong Kong Island "Southern", one district from Kowloon "Wang Tai Sin", and one

district from New Territories “Islands (Other Areas)”, which is characterized as low “In Weight” and “Out Weight”.

5.4 INFLUENCE CENTRALITY OF DAILY MOBILITY

From the previous discussion, “Degree Centrality” and “Weight” describe the characteristics of districts in totally different perspectives. The former one indicates the connections between districts due to their geographical locations and the corresponding transportation settings, while the latter one measure the hierarchical level of districts in term of the commuting flows caused by the district size, the population distribution and the employment opportunities. It is subjective and one - sided, or, in a word, unscientific to rate the districts depending only on part of factors. All the characteristics should be weighed against each other to give a reasonable estimation. In such a case, the “Influence Centrality” is actually a generation of “Degree Centrality” and “Weight” which considers the connections between districts and weights of neighboring districts as a whole. Centrality measures utilize social network concepts to determine the influence of each district in the urban system. It is assumed that “Influence Centrality” judge districts more accurately and comprehensively than “Degree Centrality” and “Weight”. The rankings of Hong Kong districts by “In Influence Centrality” and “Out Influence Centrality” are shown in Table 5.5 and Table 5.6 with the last column indicating the changing rankings compared with the rankings by “Weight”. It is not surprising to notice the little adjustment of ranking of each district since considering the different judging standard. The relationship between “Influence Centrality” and “Weight” is nearly linear, which is show in Figure 5.6 and Figure 5.7.

Table 5.5 Rankings of Hong Kong Districts by “In-Influence Centrality” in term of Daily Mobility

Rank	District	In-degree Influence Centrality	Change
1	Central and Western	0.074457647	
2	Yau Tsim Mong	0.058159817	

3	Wan Chai	0.040717323	
4	Kwun Tong	0.032922708	
5	Eastern	0.030415349	
6	Kowloon City	0.017115448	↑2
7	Sham Shui Po	0.015970784	↓1
8	Kwai Tsing (Kwai Chung)	0.013408917	↓1
9	Tuen Mun (New Town)	0.009320833	↑2
10	Tsuen Wan (New Town)	0.008176169	
11	Sha Tin (New Town)	0.007249537	↓2
12	Islands (Other Areas)	0.004960209	
13	Wong Tai Sin	0.004796686	↑1
14	Southern	0.003270468	↓1
15	Tai Po (New Town)	0.003161452	
16	North (New Town)	0.002670882	↑1
17	Yuen Long (New Town)	0.002561866	↓1
18	Sai Kung (Tseung Kwan O)	0.002180312	

Table 5.6 Rankings of Hong Kong Districts by Out-influence Centrality in term of Daily Mobility

Rank	District	Out-degree Influence Centrality	Change
1	Yau Tsim Mong	0.033522294	
2	Eastern	0.033195247	
3	Central and Western	0.031996075	↑1
4	Tuen Mun (New Town)	0.030687888	↓1
5	Kwun Tong	0.029270686	
6	Sham Shui Po	0.028889131	
7	Sha Tin (New Town)	0.022566227	
8	Kowloon City	0.021421563	
9	Wan Chai	0.018914205	
10	Sai Kung (Tseung Kwan O)	0.017715033	
11	Wong Tai Sin	0.012264254	
12	Tsuen Wan (New Town)	0.011337621	
13	Kwai Tsing (Kwai Chung)	0.010410989	
14	Southern	0.008721247	↑2
15	Islands (Other Areas)	0.006268396	↑3
16	North (New Town)	0.004851194	↓1
17	Tai Po (New Town)	0.003161452	↓2
18	Yuen Long (New Town)	0.002561866	↓1

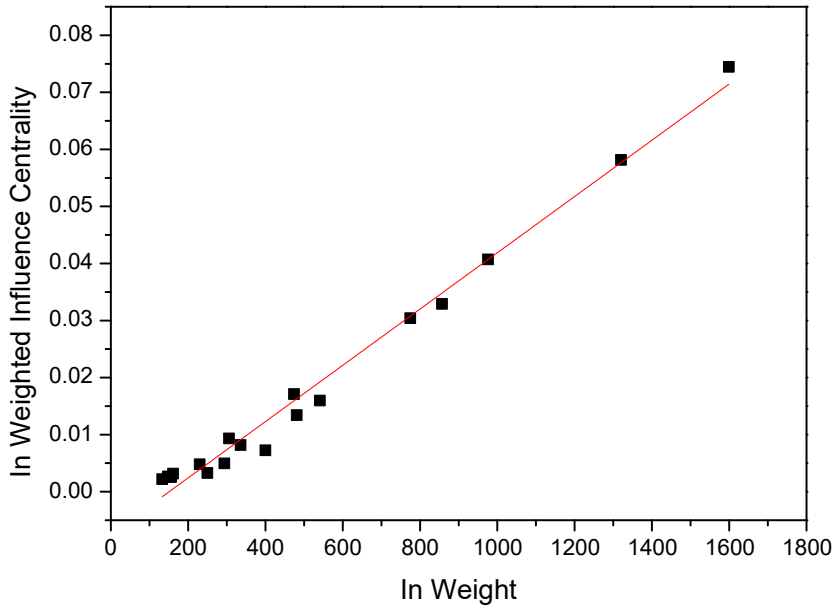


Figure 5.6 Log-Log Plot of "In-Influence Centrality" over "In-Weight" for Daily Mobility. The Pearson's Coefficient is 0.99331.

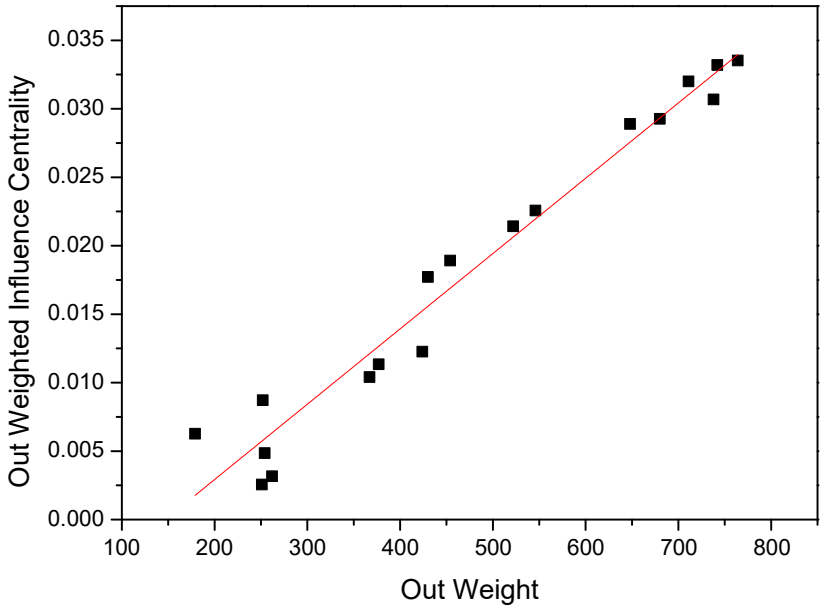


Figure 5.7 Log-Log Plot of "Out-Influence Centrality" over "Out-Weight" for Daily Mobility. The Pearson's Coefficient is 0.98083.

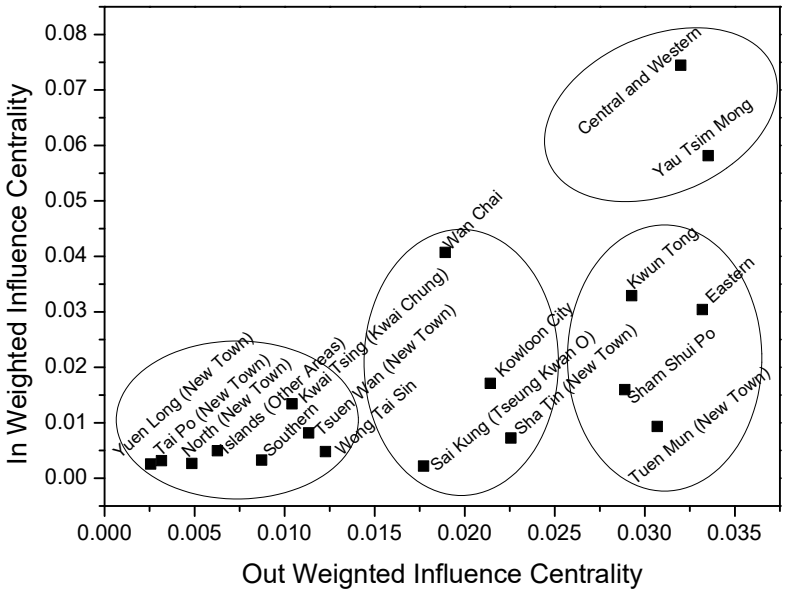


Figure 5.8 The Scatter Plot of Districts in terms of "In-Influence Centrality" vs. "Out-Influence Centrality" for Daily Mobility

Figure 5.8 shows that the Groups divided by considering the combination of "In Influence Centrality" and "Out Influence Centrality". The graph reveals that the composition for each group does not change at all though there a small adjustment among the rankings of district in the same group since the relationship between "Weight" and "Influence Centrality" is almost linear.

5.5 INTRA-DAILY MOBILITY AND OTHERS

Table 5.7 shows the ranking of intra-commuting flows within the same district (the residence and the work location are in the same district), which reflects the self-sufficient ability of each district to provide the employment opportunities to its own residents. The districts "Central and Western", "Eastern", "Wan Chai" and "Southern" from Hong Kong Island usually rank in the top of the list, since the main area on the Hong Kong Island is the historical, political and economic center of Hong Kong. They must be full of career opportunities to support their residents and the residents from other district. Noticeable, the district "Yau Tsim Mong" has relative higher self-sufficiencies because it is the central location. Contrary to "Yau Tsim Mong", "Wong Tai Sin" ranks lowest in Districts of Kowloon. The underlying reasons are that "Wong Tai Sin" is known as the district with over 85% of the residents living in public houses. It is not surprising that "Wong Tai Sin" lack the job opportunities for its residents. The new town districts have relatively lower ranking in the list, which implies the working market in the new town cannot keep up with the development of housing market. Most residents in new town still have their jobs in Kowloon and Hong Kong Island so they need travel a long time and distance between the New Towns and city center for work. In a word, new towns seem to be not self-reliant in some degree. However, the districts from Kowloon don't function better than the new town districts with regard to self-sufficiency. The reason for that attributed to their geographical locations with relative convenient transportation systems, which make their residents to seek more suitable and promising career opportunities in their neighboring districts more easily. Therefore, it is not reasonable to judge the districts just in only the factor of self-sufficiency, should incorporating with other factors too.

Table 5.7 Rankings of Hong Kong Districts by the Provision of Jobs demanded by each District's Own Residents.

Rank	District	Intra-flows (From District A to District A (%))
1	Central and Western	56.82138
2	Yau Tsim Mong	34.81675
3	Islands (Other Areas)	29.60894
4	Eastern	28.57143
5	Wan Chai	27.7533
6	Kwai Tsing (Kwai Chung)	27.24796
7	Kwun Tong	26.47059
8	Southern	23.80952
9	Tuen Mun (New Town)	23.17073
10	Tai Po (New Town)	22.1374
11	Sham Shui Po	20.21605
12	North (New Town)	19.29134
13	Yuen Long (New Town)	18.7251
14	Kowloon City	17.62452
15	Sha Tin (New Town)	17.03297
16	Tsuen Wan (New Town)	16.44562
17	Wong Tai Sin	13.20755
18	Sai Kung (Tseung Kwan O)	9.302326

Table 5.8 shows the rankings of pairs of districts base on the link support values which is higher than 1%. From the table, it is found that only a few links emerging from the districts transport a large number of commuting flows, revealing the high heterogenetic and hierarchical urban structure existing in Hong Kong. Since the support values are distributed in a varied pattern, the respective commuting flows exhibit a variety of values, which implies the urban structure of Hong Kong functions hierarchically. And it is also found that the intra-district commuting flows dominate in the ranking list. There are two reasons for this phenomenon: First, residents obviously prefer to working near their home. Second, the districts in the ranking list must have the ability to supply the job opportunity to their own residents. The ranking of inter-district commuting flows is lower that of intra-district commuting flows as a whole. The direction of the links should be paid much

attention to, which corresponds to the direction of commuting flows from which residence (origin) to which work location (destination). Among the destinations in Hong Kong Island, the district “Central and Western” is the most popular, that of a prime center of Hong Kong, the district “Wan Chai” follows behind it. The district “Yau Tsim Mong” is the top employment supplier center and highly connected with the district “Sham Shui Po” in Kowloon.

Table 5.8 Ranking of Pairs of Hong Kong Districts by their Link Support Values in term of Daily Mobility

Rank	Pairs of linked districts	Support Value
1	Central and Western → Central and Western	4.101106
2	Yau Tsim Mong → Yau Tsim Mong	2.700233
3	Eastern → Eastern	2.152066
4	Kwun Tong → Kwun Tong	1.827226
5	Wan Chai → Central and Western	1.746016
6	Tuen Mun (New Town) → Tuen Mun (New Town)	1.735864
7	Eastern → Central and Western	1.715562
8	Eastern → Wan Chai	1.380571
9	Sham Shui Po → Sham Shui Po	1.329814
10	Wan Chai → Wan Chai	1.279058
11	Sham Shui Po → Yau Tsim Mong	1.197848
12	Yau Tsim Mong → Central and Western	1.147092
13	Kwai Tsing (Kwai Chung) → Kwai Tsing (Kwai Chung)	1.015125

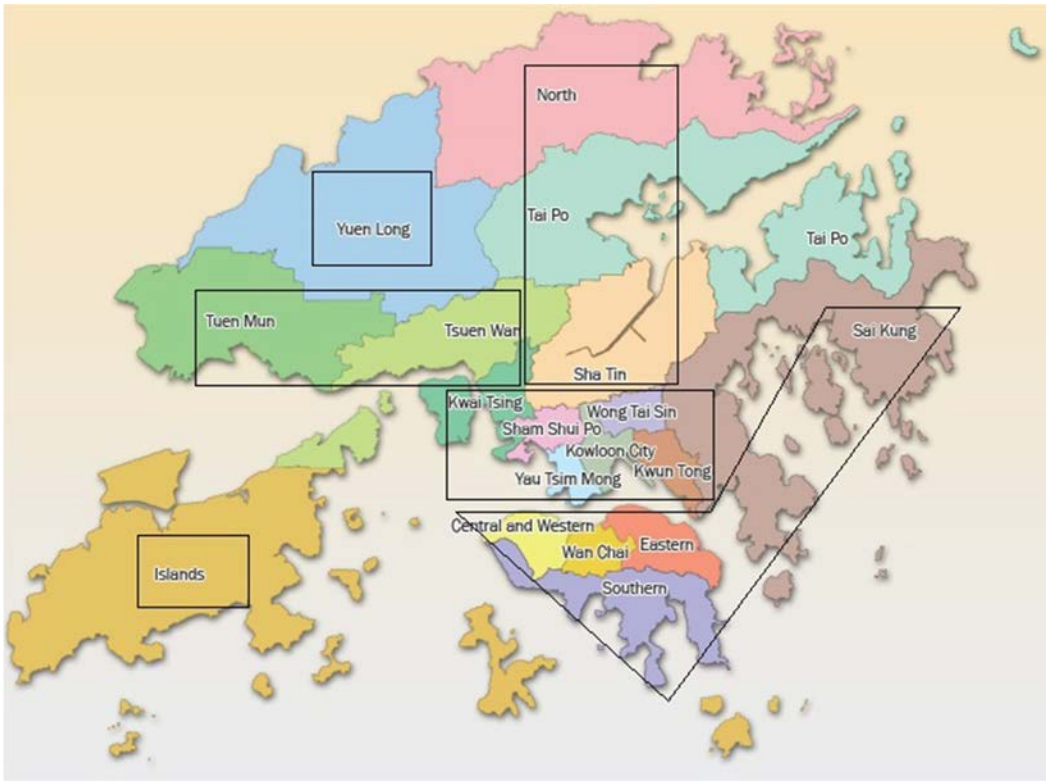


Figure 5.9 Polycentric Structure in term of Daily Mobility in Hong Kong

The polycentric urban structure suggests the existence of several urban groups in Hong Kong (Figure 5.9). They are Group 1 containing the district “Central and Western”, the district “Wan Chai”, the district “Eastern”, the district “Southern” and the district “Sai Kung (“Tseung Kwan O)”, Group 2 containing the district “Yau Tsim Mong”, the district “Sham Shui Po”, the district “Kowloon City”, the district “Wong Tai Sin”, the district “Kwun Tong”, and the district “Kwai Tsing (Tsing Yi)”, Group 3 containing the district “Tsuen Wan (New Town)”, the district Tuen Mun (New Town) and the district “Kwai Tsing (Kwai Chung)”, Group 4 containing the district “North (New Town)” and the district “Sha Tin (New Town)”, and district and the rest of districts “Tai Po (New Town)”, “Yuen Long (New Town)” and “Islands” make up Group 5, Group 6, and Group 7 separately.

In those groups, the less ranking districts will pivot around the high degree central districts and could be illustrated as the sign of a fact usually noticed in urban networks where uppermost functional districts attract workers from less important districts, acting as polycentric terminals. In such settings, residents of the satellite districts prefer commuting to the top functional districts for working rather than to a similar level district.

With respect to the geographic location of the polycentric poles, most of districts from Group 1 are in Hong Kong Island with only one exception the district “Sai Kung (“Tseung Kwan O)” in New Territory. Most of districts from Group 2 are from the region of Kowloon with an exception the new town “Tsing Yi”. This phenomenon is attributing to the transportation system of Hong Kong, the new town “Tseung Kwan O” is comprehensively served by the MTR system's Tseung Kwan O Line connecting to Hong Kong Island. At the same times, the new town “Kwai Tsing (Tsing Yi)” is served by MTR Tung Chung Line and Airport Express connecting to Kowloon.

CHAPTER 6 INTERATION BETWEEN RESIDENTIAL MOBILITY AND DAILY MOBILITY

In order to achieve Objective 5, the following two hypotheses have been singled out:

Hypothesis 1: The residential mobility and the daily mobility, which are mutually interacted, are based on the similar urban structure.

Hypothesis 2: Most of mobility, both the long term mobility-residential mobility and the short term mobility-daily mobility occur within the defined communities. In other word, the intra-mobility and short distance mobility are commonly seen in the location choices.

6.1 HYPOTHESIS 1

6.1.1 COMPARISON OF AXIS STRUCTURES OF TWO TYPES OF MOBILITY

According to the definition of "Axis" given by Homer Hoyt' sector theory (1939), "Axis" is actually another representation of mobility patterns. The axis structure of residential mobility refers to the routes of how residents move homes, while the axis structure of daily mobility represents the routes of how residents travel to work, which have been already obtained from previous link analysis and can be found in APPENDIX1 and APPENDIX2, respectively.

The axis structure of residential mobility in APPENDIX1 shows us that the most of residential mobility activities originating from a district will end in a destination district along one of axes. Each district was therefore connected with a small constellation of axes directing to a small group of the destination districts. The axis structure of daily mobility in APPENDIX2 has the similar pattern with that of APPENDIX1. The comparison of the axis structures of two types of mobility for each district is described in Table 6.1, the detail can be found in APPENDIX3.

From the comparison, some findings are detected:

First, the number of axes for residential mobility is not necessary in agreement with the number of axes for daily mobility, but they have some overlapping. The table shows No. of axes for residential mobility, No. of axes for daily mobility, and No. of the overlapping axes for each district, respectively. The districts from the urban area of Hong Kong Island have relatively smaller No. of axes of both two types of mobility compared to that of the district from the urban area of Kowloon. However, the overlapping rate for the districts of Hong Kong Island is higher than that for the districts of Kowloon. The situation for the districts from New Territories

is more complicated: some districts have relatively higher No. of axes, such as the new towns “Tseung Kwan O”, “Tsuen Wan”, “Tuen Mun”, and “Sha Tin”. However, the overlapping rate is relatively small for those districts. The remaining new towns have relatively lower No. of axes with the ralatively higher overlapping rate, such as “North”, “Tai Po”, “Kwai Chung”, “Tsing Yi”, “North Lautau”, and the new town “Islands (Other Areas)”. The difference of axis structures of new town districts maybe attributes to the difference of accessibility of each districs. For example, the district “Sha Tin (New Town)” is much more attractive, due to its relatively central location and its connection to the metro network, while the district “North (New Town)” was not really integrated with the central districts because of its remote location and poor accessibility. Beside these two sub-centers, the district “Sai Kung (Tseung Kwan O)” seems to be the next potential district, because of the MTR station, that will play a new role in the accessibility.

Second, it is interesting to notice that many inter-mobility trips occur very often between different urban areas, such as the cross-sea commuting trip from the district “Sai Kung (Tseung Kwan O)” in New Territories to the district “Eastern” in Hong Kong Island. This is because that the MTR system has successfully connected two geographically isolated districts, at the same time, the bus system has linked the new town “Sai Kung (Tseung Kwan O)” to Kowloon comprehensively. So that is the reason why many inter-mobility trips happen between the district “Sai Kung (Tseung Kwan O)” and those districts in Kowloon urban area. However, not all the new towns share the same situation with the new town “Tseung Kwan O”, the bad example is the new town “Tin Shui Wan”. Suffering from lack of attractiveness and poor accessibility, some new towns cannot play a critical role as expected in the sustainable development of urban areas. It is also noticeable that some districts have

no axis structure for daily mobility, such as the district “Sai Kung (Other Areas)”, the new town “Tin Shui Wan”, the new town “Ma On Shan”, the district from other areas of Yuen Long, and the district from other areas of North. Another interesting phenomenon is some districts don’t have common axes, for example the district “Kwai Tsing (Tsing Yi)” and the district “Island (North Lantau)”. Most of planned periphery new towns such as the district “Yuen Long (Tin Shui Wan)” and the district “Sha Tin (Ma On Shan)” became mono-functional residential areas with less job opportunities, only connected to the central districts by car or bus. The rural areas such as the district “Yuen Long (Other Areas)” and the district “North (Other Areas)” are isolated from the central part of Hong Kong because their remote location, Lot of them are still waiting for a MTR connection. However, there are some exceptions, like the new town “Sai Kung (Tseung Kwan O)”has successfully connected to the CBD by the current MTR network.

Table 6.1 Comparison of No. of Axis of Two Type of Mobility

	No. of Axes for Residential mobility	No. of Axes for Daily Mobility	No. of the overlapping Axes
Central and Western	5	4	4
Wan Chai	4	3	3
Eastern	10	5	5
Southern	4	3	2
Yau Tsim Mong	9	7	6
Sham Shui Po	10	8	5
Kowloon City	7	6	4
Wong Tai Sin	7	4	4
Kwun Tong	9	8	6
Sai Kung (Tseung Kwan O)	4	6	4
Tsuen Wan (New Town)	6	4	3
Tuen Mun (New Town)	6	9	3
Yuen Long (New Town)	4	1	1

North (New Town)	1	2	1
Tai Po (New Town)	2	1	1
Sha Tin (New Town)	8	8	4
Kwai Tsing (Kwai Chung)	3	3	2
Kwai Tsing (Tsing Yi)	2	1	0
Islands (North Lautau)	1	1	0
Islands (Other Areas)	1	2	1

6.1.2 CORRELATION OF INFLUENCE CENTRALITY OF TWO TYPES OF MOBILITY

As indicated in the previous studies, there are three indices to measure the status of each district in term of daily mobility or residential mobility. They are “Degree Centrality”, “Weight”, and “Influence Centrality”, where the “Influence Centrality” is actually a generation of “Degree Centrality” and “Weight” which considers the connections between districts and weights of neighboring districts as a whole. Centrality measures utilize social network concepts to determine the influence of each district in the urban system. It is assumed that “Influence Centrality” judge districts more accurately and comprehensively than “Degree Centrality” and “Weight”. Therefore, the residential mobility and daily mobility is compared just in term of “Influence Centrality”.

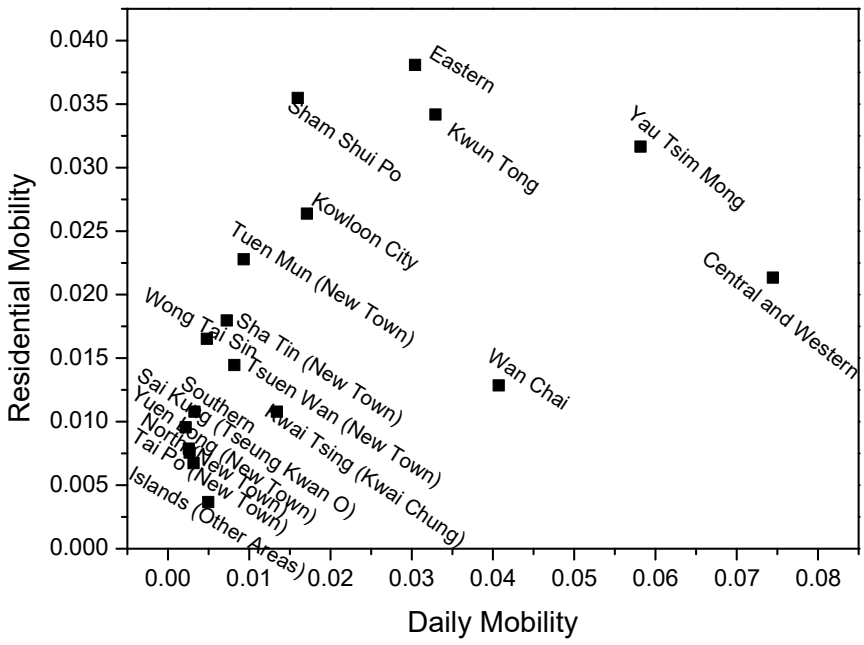


Figure 6.1 Correlation of Influence Centrality of two types of Mobility

The comparison of the centrality values of two types of mobility is shown in Figure 6.1. The centrality based on the daily mobility measure each district in term of the daily commuting flows caused by the district size, the population distribution and the employment opportunities, together with the connections between districts due to their geographical locations and the corresponding transportation settings. While the centrality based on the residential mobility measure each district in term of the residential migration flows caused by the district size, the population distribution and the land supply, combined with the effect of its geographical locations and the transport system. From the Figure, most of the districts from Hong Kong Island and Kowloon have relative higher centrality values for both residential mobility and daily mobility, while most of districts of new towns and rural areas from New Territories have relative lower centrality values for both types of mobility. Since the districts from urban areas have more job opportunities and good transportation accessibility, it is not surprising that their centrality values in term of daily mobility is higher than those of districts from New Territories. The top ranking status of districts will result in a good reputation, which in turn attract more residents to migrate into. At the same time, the fewer career chances and poorer accessibility make the districts from the New Territories less attractive.

6.1.3 COMPARISON OF POLYCENTRIC STRUCTURES OF TWO TYPES OF MOBILITY

This section will conduct the research on the relationships between residential mobility and daily mobility by comparing polycentric structures identified by the mobility flows, which are the results of Chapter 4 and Chapter 5.

Polycentric Structure of Residential Mobility

Polycentric Structure of Daily Mobility

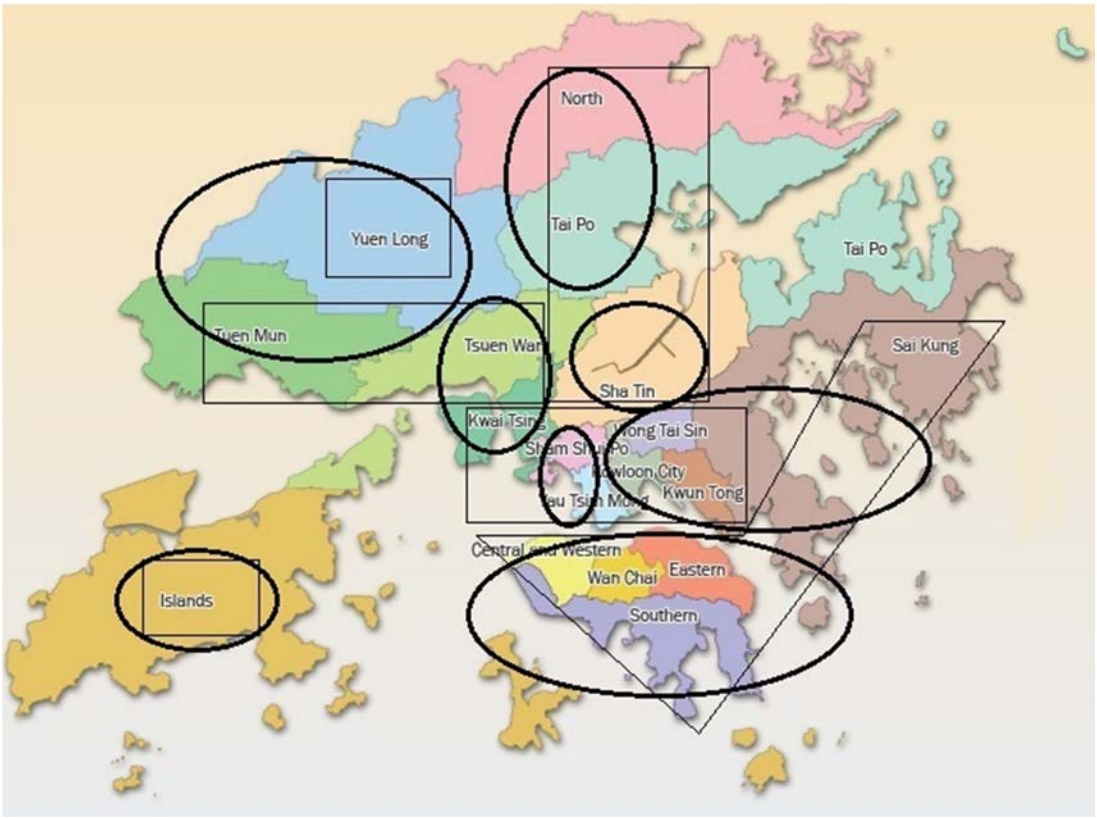


Figure 6.2 Comparison of Polycentric Structure of Two Types of Mobility

The combination of the residential mobility patterns and the daily mobility patterns has produced an interesting map (Figure 6.2). The figure illustrates the convergence of the area defined based on two types of mobility.

In terms of the daily mobility analysis based on the Origin−Destination dataset, the research has identified that the Hong Kong urban area includes six territorial segments. These are Group 1 containing the district “Central and Western”, the district “Wan Chai”, the district “Eastern”, the district “Southern” and the district “Sai Kung (Tseung Kwan O)”, Group 2 containing the district “Yau Tsim Mong”, the district “Sham Shui Po”, the district “Kowloon City”, the district “Wong Tai Sin”, the district “Kwun Tong”, and the district “Kwai Tsing (Tsing Yi)”, Group 3 containing the district “Tsuen Wan (New Town)”, the district Tuen Mun (New Town) and the district “Kwai Tsing (Kwai Chung)”, Group 4 containing the district “North (New Town)” and the district “Sha Tin (New Town)”, and district and the rest of districts “Yuen Long (New Town)” and “Islands” make up Group 5 and Group 6 separately. Most of daily commuting trips happened in each segment accordingly.

With the residential history data reflected in the census data, the other combination of segments was discovered in the Hong Kong urban area. They are Group 1 including the district “Central and Western”, the district “Wan Chai”, the district “Eastern”, and the district “Southern”; Group 2 including the district “Yau Tsim Mong” and the district “Sham Shui Po”; Group 3 including the district “Kowloon City”, the district “Wong Tai Sin”, the district “Kwun Tong”, and the district “Sai Kung (Tseung Kwan O)”; Group 4 including the district “Tsuen Wan (New Town)”, the district “Kwai Tsing (Kwai Chung)” and the district “Kwai Tsing (Tsing Yi)”; Group 5 including the district “Sha Tin (New Town)” and the district “Sha Tin (Ma On Shan)”; Group 6 including “North (New Town)”, the district “North (Other

Areas)" and "Tai Po (New Town)"; Group 7 including "Tuen Mun (New Town)" , the district "Yuen Long (New Town)", the district "Yuen Long (Tin Shui Wai)", and the district "Yuen Long (Other Areas)"; Group 8 including the district "Islands (North Lantau)" and the district "Islands (Other Areas)". Most of long term residential mobility activities occurred within each group accordingly.

From the comparison of the segmentation based on two different algorithms-daily commuting patterns and the residential mobility patterns, it is interesting to find that the two segmentations have many overlaps. In other words, the daily commuting activities especially the residence-work trips and the long term residential mobility activities actually take place within the similar urban area. It justifies that there really exist interactions between the daily mobility and the residential mobility. The combination of both two segmentation of journeys with the perimeter of urban areas has provide a map of mobility trajectories and routes both in the long term and short term while given considering their associations for community life.

6.2 HYPOTHESIS 2

6.2.1 METHOD

Based on the results of previous chapters, this research will be conducted essentially on the relationships between certain previously identified urban areas and mobility patterns found on segments of the urban system in Hong Kong. In order to validate the Hypothesis 2, the experiment will be conducted by ways of the Origin−Destination study based on the residential mobility history and the daily commuting routes of both the household heads and their spouses, which are extracted from the census data, to elaborate counts of moves tables. To qualify the research, each residents must have lived in two different districts-the past residence address and the present residence address at the census district, including with their spouses, anywhere in Hong Kong, since the effect of spouses on the decision process cannot be easily neglected. Their workplace was also identified to examine the effect of labor market on the mobility patterns.

The census has the records about the past residential locations, the present residence locations, and the present work place for each household head and the same information about their spouses will be included too. The husbands and wives from different places move to a new residence to form a family. The number of the sample data is 2388.

Most of moves originating from a district (residential mobility and daily mobility especially the work commuting trips) were associated with a destination located along one of the axes in a segmented urban area. Each district was therefore associated with a group of axes to different destination districts, which constructs an

area boundary. So that, an area boundary will be validated if a majority of moves originating on the defined urban area ended there as well.

Their schematic diagram is displayed in Figure 6.3.

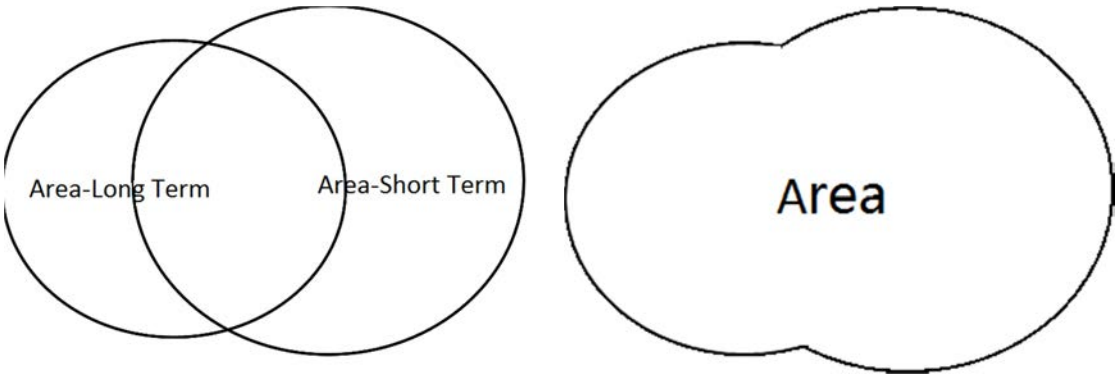
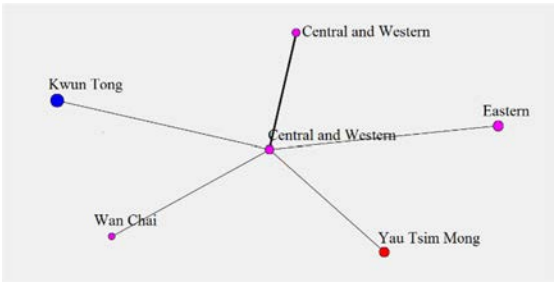


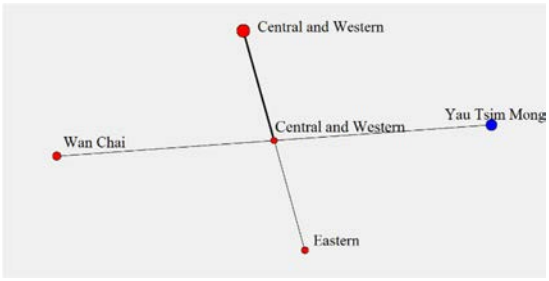
Figure 6.3 Convergence of the Area Boundary of Two Types of Mobility

Area-Long Term stands for an urban boundary governing the residential mobility patterns based on the DIST-PDIST5YR data at the census district level，which can be inferred from APPENDIX1. While *Area-Short Term* stands for an urban boundary restraining the daily mobility trips based on the Origin-Destination data at the census district level, which can be inferred from APPENDIX2. Their combinations of *Area-Long Term* and *Area-Short Term*, which is denoted *Area*, can be mathematically represented as *Area=Area-Long Term* ∪ *Area-Short Term*.

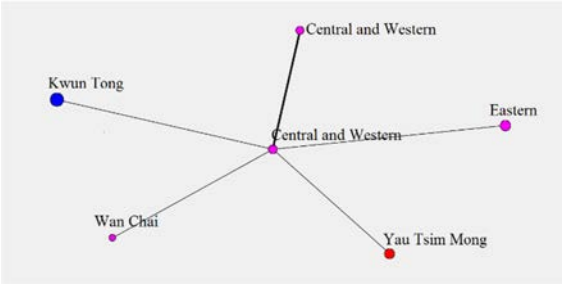
If the moves of both mobility types originating from a district is connected with a destination district occur within the defined area boundary, it will be defined as the short distance mobility. While the mobility taking place outside of the defined community area will be defined as the long distance mobility.



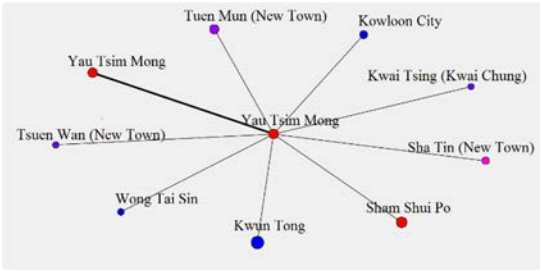
Area-Long Term: Area Boundary of Residential mobility routes originating from the district "Central and Western"



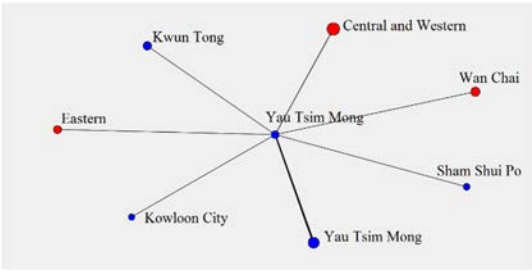
Area-Short Term: Daily mobility routes originating from the district "Central and Western"



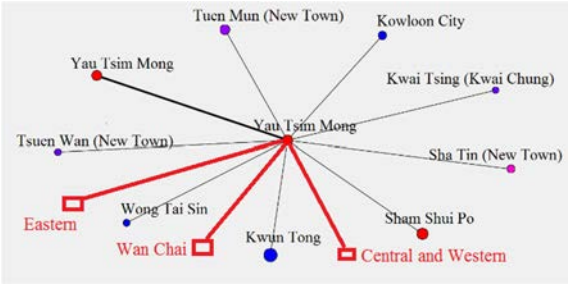
Area: The Combination of Area Boundary of Two Types of mobility routes originating from the district " Central and Western"



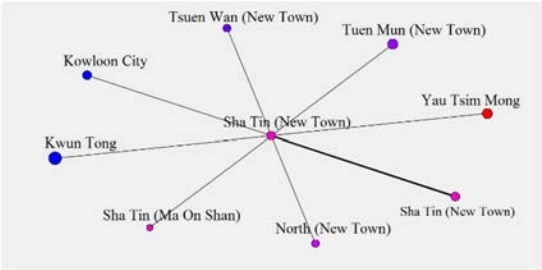
Area-Long Term: Area Boundary of Residential mobility routes originating from the district "Yau Tsim Mong"



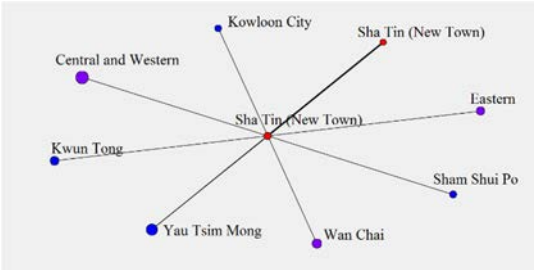
Area-Short Term: Daily mobility routes originating from the district "Yau Tsim Mong"



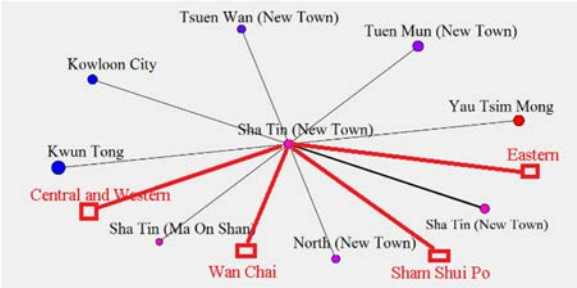
Area: The Combination of Area Boundary of Two Types of mobility routes originating from the district "Yau Tsim Mong"



Area-Long Term: Area Boundary of Residential mobility routes originating from the district "Sha Tin (New Town)"



Area-Short Term: Daily mobility routes originating from the district "Sha Tin (New Town)"



Area: The Combination of Area Boundary of Two Types of mobility routes originating from the district "Sha Tin (New Town)"

Figure 6.4 Three Examples of How to Combine the Area Boundary of Two Types of Mobility

Figure 6.4 shows three representative examples of how to combine the area boundary of both long term mobility and short term mobility routes for three districts, such as the district "Central and Western", the district "Yau Tsim Mong", and the new town "Sha Tin".

Take the district "Central and Western" for example, the boundary choice of mobility for this district is delineated based on three criteria: The residential mobility pattern (The result gained from Part 1), the daily mobility pattern (The result gained from Part2), and the district boundaries. Two axial structures taking the district "Central and Western" as an origin district, have been previously outlined in APPENDIX1 and APPENDIX2. The urban area axial structure based on the residential mobility pattern includes five axes, they are the axis "Central and

Western-Central and Western", the axis "Central and Western-Wan Chai", the axis "Central and Western-Eastern", the axis "Central and Western- Yau Tsim Mong", and the axis "Central and Western-Kwun Tong", while the urban area axial structure based on the daily mobility pattern contains four axes, they are the axis "Central and Western-Central and Western", the axis "Central and Western-Wan Chai", the axis "Central and Western-Eastern", the axis "Central and Western- Yau Tsim Mong". Therefore the final area boundary of the district "Central and Western" is the combination of two axial structures covering the districts "Central and Western", "Wan Chai", "Eastern", "Yau Tsim Mong", and "Kwun Tong". For other districts, the two area boundaries and their combination of the axial structures can be concluded in the same way based on the APPENDIX1 and APPENDIX2.

6.2.2 RESULTS

With the residential mobility data (Previous residence-Current residence) of household head, the number of the intra- residential mobility (residents changed their homes within the same district.) is determined (Table 6.2).

Table 6.2 The Intra-Residential Mobility of Household Heads.

Household Head	No.	%
Intra-Residential Mobility		
1	707	29.61%
0	1681	70.39%
All	2388	100%

Note. 1: Same District; 0: Other districts.

Table 6.2 shows that more than two thirds (70.39%) of household heads have no rules to follow when they are changing their residence address, which is regarded as long distance residential mobility. Besides, only 707 respondents out of the sample size follow the axis of the home district when they are moving home, which accounts for 29.61%.

With the daily mobility data (Residence-Work place) of household head, the number of the intra-daily mobility (residents work in the district where they live in) is determined. The results are shown in Table 2.

Table 6.3 The Intra-Daily Mobility of Household Heads.

Household Head	No.	%
Intra-Daily Mobility		
1	279	11.68%
0	2109	88.32%
All	2388	100%

Note. 1: Same District; 0: Other districts.

From Table 6.3, we can see the number of intra-daily mobility is 279, which accounts for 11.68%. The result indicates few residents work and live in the same district.

The combination result of intra-residential mobility and intra-daily mobility can be found in Table 6.4.

Table 6.4 The Intra-Mobility of Household Heads

Household Head			No.	%
Intra-Residential Mobility	Intra-Daily Mobility			
1	1		89	3.73%
1	0		618	25.88%
0	1		190	7.96%
0	0		1491	62.44%
	707 (29.61%)	279 (11.68%)	2388	100%
		897 (37.56%)		

Note. 1: Same District; 0: Other districts.

By adding the effect of work place on the mobility pattern, the number of intra-mobility only considering the effect of household head is 897 (897/2388=37.56%). The explainable power has been increased 7.96%. It has 89 cases of both two types of mobility activities occurring within the home district, which only takes up 3.73%.

Up to now, the methodological strategy only using intra mobility seems not be able to verify the initial hypothesis. However, the mobility activities can be completed not only in the home district, but near the home district, or along the axial structure of the home district. The mobility activities within the axis of the home district can be defined as short distance mobility. With the mobility history data, the objective here is to determine the number of mobility behavior found along the axis. The number of the short distance residential mobility and the short distance daily mobility is shown in Table 6.5 and Table 6.6. The former table shows the number of

residential mobility activities occurring along the axis of the home districts, while the latter one shows the number of daily mobility activities especially the work commuting trips happening along the axis of the home districts.

Table 6.5 The Short Distance Residential Mobility of Household Heads

Household Head	No.	%
Axis-Residential mobility		
1	1155	48.37%
0	1233	51.63%
All	2388	100%

Note. 1: Within the Axis; 0: Outside the Axis

From Table 6.5, it can be seen that about half of residents will move their home along the axis of their original districts, which accounts for the percentage of 48.38% in the total sample size. It demonstrates that there is a prevailing local attachment to the axis. Compared with the intra residential mobility, the explainable power has been greatly improved, which indicate most of residents will move near the home district rather than move homes within the same district.

Table 6.6 The Short Distance Daily Mobility of Household Heads

Household Head	No.	%
Axis-Daily Mobility		
1	1312	54.94%
0	1076	45.06%
All	2388	100%

Note. 1: Within the Axis; 0: Outside the Axis

From Table 6.6, it is concluded that about 54.94% (1312/2388) of household heads will go to working locations within the defined axis, which is relatively more than the intra daily mobility. The findings have indicated a strong relationship between the daily mobility activities and the local attachment, since residents will

choose the appropriate houses considering the effect of work location on the daily mobility route.

Table 6.7 The Short Distance Mobility of Two Types of Household Heads

Household Head			No.	%
Axis-Residential Mobility	Axis-Daily Mobility			
1	1		616	25.80%
1	0		539	22.57%
0	1		696	29.15%
0	0		537	22.49%
	1155 (48.37%)	1312 (54.94%)	2388	100%
		1851 (77.51%)		

Note. 1: Within the Axis; 0: Outside the Axis

As for short distance mobility, the number of mobility within the area delineated by the residential mobility pattern of household head is 1155. Considering the effect of daily mobility on the choice of residence, the number of short distance mobility increased from 1155 (1155/2388=48.37%) to 1851 (1851/2388=77.51%). The job location of 54.94% of household heads is located in the axis of their home district, and the similar percentage (48.37%) hold true for residential mobility. For most households, the district where they live today is the same to or nearby where they spent their childhood. The residence address and the working address are in the immediate neighborhood nearby the home district where most of mobility activities originate and end in.

In summary, only considering the effect of the household heads in the decision process of mobility, the results show that the number of intra-mobility is 897, which account for 37.56% (897/2388) of the total sample size. In the respective of short distance mobility, 77.51% of respondents move their homes along the axial structures. Finally, the remaining motilities 22.49%（537/2388）don’t happen neither in their own district nor in the defined area boundary, which are defined as

long distance mobility. Either or both of types mobility behavior of residents is supposed to have a strong local attachment, the research results only considering the effects of the household heads seem already be able to allow us to verify our initial hypothesis.

Spouse's Effects

In theory, each family member especially the household head's spouse will exert a big influence on the decision process of the mobility. Therefore, in order to improve the verification of Hypothesis2, the influences of the previous residence and the present work locations of spouses are added into the analysis. Household heads and spouses could have two different previous residence addresses or two different workplaces. It is hypothesized that the likelihood of an identity is reflected by household heads and spouses share the similar mobility trajectories'.

The results of intra mobility of household heads and their spouses are shown in Table 6.8 and the results of short distance mobility of household heads and their spouses are shown in Table 6.9.

Table 6.8 The Intra Mobility of Two Types of Household Heads and Their Spouses

Household Head		Household Head's Spouse		No.	%
Intra-Residential Mobility	Intra-Daily Mobility	Intra-Residential Mobility	Intra-Daily Mobility		
1	1	0	1	19	0.80%
1	1	0	0	70	2.93%
1	0	0	1	54	2.26%
1	0	0	0	564	23.62%
0	1	1	1	15	0.63%
0	1	1	0	53	2.22%
0	1	0	1	28	1.17%
0	1	0	0	94	3.94%
0	0	1	1	78	3.27%
0	0	1	0	454	19.01%
0	0	0	1	76	3.18%

0	0	0	0	883	36.98%
707 (29.61%)	279 (11.68%)	600 (25.13%)	270 (11.31%)	2388	100%
	897 (37.56%)		777 (32.54%)		
			1505 (63.02%)		

Note. 1: Same District; 0: Other Districts.

Combined the effect of household head's spouse, the total number of intra-mobility is 1505 (1505/2388=63.02%). The explainable power has been largely improved from 37.56% to 63.02%. This verifies that spouses really exert an important influence on the decision process of the mobility.

Table 6.9 The Short Distance Mobility of Two Types of Household Heads and Their Spouses

Household Head		Household Head's Spouse		No.	%
Axis-Residential Mobility	Axis-Daily Mobility	Axis-Residential Mobility	Axis-Daily Mobility		
1	1	1	1	152	6.37%
1	1	1	0	103	4.31%
1	1	0	1	210	8.79%
1	1	0	0	151	6.32%
1	0	1	1	158	6.62%
1	0	1	0	124	5.19%
1	0	0	1	134	5.61%
1	0	0	0	123	5.15%
0	1	1	1	275	11.52%
0	1	1	0	125	5.23%
0	1	0	1	208	8.71%
0	1	0	0	88	3.69%
0	0	1	1	185	7.75%
0	0	1	0	104	4.36%
0	0	0	1	120	5.03%
0	0	0	0	128	5.36%
1155 (48.37%)	1312 (54.94%)	1226 (51.34%)	1442 (60.39%)	2388	100%
	1851 (77.51%)		1898 (79.48%)		
			2260 (94.64%)		

Note. 1: Within the Axis; 0: Outside the Axis

The total number of short distance mobility within the urban area considering the effects of both household head and spouse is 2260 (2260/2388= 94.64%), which has increase 17.13% (94.64%-77.51%). 51.34% of spouses move along the axis and 60.39% of them go to work in the route within the defined area boundary.

The mobility patterns verify that both the household heads and their spouses display a similar local attachment to the home district. In terms of the intra-mobility, the household heads are likely (897 cases) to move within their districts while their spouses have 777 cases. For the short distance mobility, the total number of short distance mobility conducted by the spouse is 1898, which is proportionately similar to that by the household heads (77.51% vs. 79.48%). The results show that the influence that the spouses exert on the mobility process is equal to the influence of household heads. Most of moves will follow the axial structures within the defined area boundary. The mobility activities will occur following along at least one of mobility axis structures, either to the axial structures of the households head or to the axial structures of the spouses. The compilation shows that the short distance mobility activities are conducted, of both household heads and spouses combined, for 94.64% with the boundaries of the axis.

To summarize, there are following findings:

First, the total number of mobility activities within the boundary of axis is 2260, which account for 94.64%, of which about 63.02% of households will conduct the intra mobility in the same district. As expected, the results prove that the axis structure plays an important role in the mobility process. The mobility behavior of residents in the territory of the axis is tantamount to a strong local attachment.

Second, the level of rootedness in the local ties revealed by daily mobility is similar to the residential mobility, concluded from the table such as 1155 vs. 1312 for household heads and 1226 vs. 1442 for spouses. It is undeniable that the urban area as sphere of activity based on the pattern of the daily working trips has an important effect on the residential mobility patterns. For most households, the district where they live today is the same to or nearby where they spent their childhood. The residence address and the working address are in the immediate neighborhood nearby the home district where most of mobility activities originate and end in.

Third, the household head and spouse have similar weight in the decision process of two types of mobility. It is impossible to determine whether it is the household head or the spouse who affects the other. However, the combination of effects of both indicates a strong attachment to the axis.

CHAPTER 7 CONCLUSIONS

6.1 RESEARCH FINDINGS FROM RESIDENTIAL MOBILITY MODEL

This part utilized social network analysis methods such as the association based link analysis combined with one of clustering techniques 1) to identify the individual's residential mobility patterns 2) to produce four indices to describe how the character of residential location affect the residential mobility trajectory in the district census level 3) and to delineate the contours of the geographic districts in Hong Kong in terms of residential mobility flows, where districts are strongly linked by the short distance mobility within the defined area boundary.

For the first aim, we have identified a finite set of residential axis structures which describe how the residents move their homes. The axis structure of residential mobility in APPENDIX 1 shows us that the most of residential mobility activities originating from a district will end in a destination district along one of axes. Each district was therefore connected with a small constellation of axes directing to a small group of the destination districts.

The residents' mobility behaviors are assumed to have a strong linkage with the districts' characteristics. Different locations with different resources may influence individuals' mobility behaviors within different types of residential area. Each district exhibits markedly different characteristics such as population size, job opportunities, educational resources, and social identity for different groups of residents, and this combination of characteristic act as the pushing or pulling factors, which will attract or compel movers from or into other districts. Four indices "Degree Centrality", "Weight", "Influence Weighted Centrality" and "Intra-Residential Mobility Rate" represent the diversity of different residential locations,

which contribute the differences of residential mobility behaviors. Those indices reflect that the residential mobility flows across the geographic landscape are unevenly distributed among different districts, which also indicate the uneven distribution of resources allocated among those districts.

Most important, the districts are categorized into eight proper groups based on the connections of the residential mobility flows. This grouping has provided a map to describe how the districts channel the residential mobility flows from and into. Most of residential mobility behaviors occur within the defined area boundary. In other words, short distance mobility becomes the most popular mobility pattern among the residents especially in the New Towns. This phenomenon maybe reflects a serious spatial lock-in problem among those districts either because they are too poor to move out to pursue better housing condition.

6.2 RESEARCH FINDINGS FROM DAILY MOBILITY MODEL

The daily mobility model utilized one of data mining techniques-link analysis combined with one of clustering techniques 1) to identify the axis structure of daily mobility 2) to produce four indices to describe how the characteristics of location to affect the daily commuting behaviors in the district census level 3) and to delineate polycentric centers in Hong Kong in terms of daily mobility flows, where districts are strongly linked by the short distance daily mobility within the defined area boundary.

For the first aim, we have identified a finite set of the axis structures of daily mobility for each district which describe how the residents conduct the daily mobility activities from the home address to the working location. The axis structure of daily mobility in APPENDIX 2 shows us that the most of daily mobility activities originating from a district will end in a destination district along one of axes. Each district was therefore connected with a small constellation of axes directing to a small group of the destination districts in the same manner as the residential mobility.

The spatial structure of Hong Kong indeed shows a clear tendency towards increasingly polycentric urban structure, which is obvious in term of labors distribution. However, the CBD areas are still the centers of Hong Kong the perspective of job opportunities.

This kind of star-like link map where each district acts a hub in turn is confirmed by the link analysis. Actually, it is possible to see that the commuting flows are featured by the rankings calculated in terms of “Degree Centrality” and “Weight”. There is the symbol of the existence of urban structure where important districts which are well connected, while the link to the geographical far way districts become

weak. Less important districts are usually connected with the similar level districts by small commuting connections. The link analysis is capable to discover the characteristics of the urban structure of Hong Kong in a comprehensive and quantitative way.

6.3 RESEARCH FINDINGS FROM THE INTERACTION OF TWO TYPES OF MOBILITY

The research findings from the study of interaction of residential mobility and daily mobility confirmed the existence of "Axis Structure" of two types of mobility by adding the effect of spouses. Each district was connected by a constellation of districts geographically situated in different part of Hong Kong. The axis structures directly determined the residential mobility routes and the daily mobility activities. The interaction of residential mobility patterns and daily mobility patterns provided a map of a set of overlapping urban area boundaries, which revealed the radius of mobility behaviors. This map showed us that how residents changed their residence and how they conducted the daily mobility activities. The results also indicated that both household heads and their spouses played an important role in the decision process of residential mobility and daily mobility. Their mutual interaction and restriction effect made their mobility activities usually ended in the same area boundary.

It also discovered that the mono-centric theory with only one direction of the mobility pattern-an outward movement from the CBD to the periphery, had already been replaced by the polycentric model with various mobility patterns generated around the secondary sub-centers. The active intra-mobility along the axis contributed to the growth of secondary sub-centers in Hong Kong. These sub-centers were freed from the attraction of the central districts without totally being disconnected to them. The findings clearly showed that the central area no longer exerted an attractive power on its periphery, and only a small fraction of commuting flows were directed toward the CBD of Hong Kong.

For example, some new towns such as “Yuen Long (New Town)”, “North (New Town)” became own catchment places, where both residential mobility and daily mobility activities rarely interacted with the central districts and mostly happened within their own catchment areas. Residents performed most of their residential mobility behaviors and conducted most of their daily mobility trips especially for the working commuting activities near their home residence

Therefore, some sub-centers originated from the new towns emerged. The geographical locations and their unique urban structure of new towns made their residents had developed a fierce sense of location attachment, where most of them spent their residential life in or around new towns, and conducted most of their daily mobility activities around new towns as well. More and more residents of new towns found their job positions near their residence area rather than worked in the central district because of the decentralization effect of the labor market. In summary, the residences, work locations, and other destinations of many residents were within the same defined area boundary where a large part of their daily mobility trips and residential mobility behaviors occurred.

The mobility patterns indicated that residents displayed a deep attachment to their original residence, where they could keep their social networks and social status, although they might get the potential improvement of living standards through relocating their homes. Most of residential mobility activities and daily mobility behaviors especially the working commuting trips were conducted near the home, along one of axis of each district (APPENDIX3). The results showed that both residential mobility and daily mobility were deeply affected by local attachment and their identified territorial area boundaries. The explanation can be that each resident will wisely plan his or her commuting activities by considering the shortest route to

destinations given equal conditions. Therefore, it was not surprising to see there was a strong relationship between mobility and local attachment.

The phenomenon of local attachment tended to highlight the drawbacks of the polycentric structure in a different angle. For example, it was found that the peripheral districts such as the district “Sai Kung (Other Areas)”, the district “Yuen Long (Tin Shui Wan)”, the district “Yuen Long (Other Areas)”, the district “North (Other Areas)”, and the district “Sha Tin (Ma On Shan)” were becoming the representative cases of the isolated mono-residence places with bad public transport accessibility. However, not all the district share the same situation, such as the district “Sai Kung (Tseung Kwan O)”, which conducted in a more sustainable mobility pattern with good public transport accessibility, and became a success of the mixed-use (residence and work place) districts This mobility “lock-in” phenomenon of some new towns can be explained by three reasons-the location attachment to the new town, the decentralization of labor market, and the poor accessibility of the new town, which require the Hong Kong Government to pay much attention to.

The research also found the transportation network played an important role in the interactions between daily mobility and residential mobility. Since the evolution of the transportation network deeply modified the travelling distance, and consequently determined the direction of mobility activities. In other words, the underlying theory of this interaction can be explained like this: daily mobility as a reflection of different geographical location and corresponding transportation system will affect the accessibility of each district, which itself, together with long-term socioeconomic changes, affects residential mobility and location choice, which in turn impacts daily

mobility, the accessibility of each district. Therefore, the Hong Kong government needs to set up transport policies according to the mobility behaviors of resident.

6.4 IMPLICATIONS FOR HONG KONG GOVERNMENT

This research contributes to providing a quantitative framework on how to identify the axis structure of residential mobility and daily mobility by using link analysis. Such theoretical foundation is necessary for urban planning and housing policy making. It can help link potential policy interventions to intended outcomes. For example, the relationship between the transportation/land use pattern and the daily mobility, the relationship between housing policy and the residential mobility, and the urban structure and the mobility behaviors of residents. It helps us to build the city areas in light of more sustainable mobility patterns. The results can provide a map of residential mobility patterns and daily mobility patterns in Hong Kong. This framework is also valuable of reference for other cities, and can be applied in the similar setting in the world.

Mobility patterns of Hong Kong residents affect and are affected by land use patterns, travel demand, housing consumption, and urban landscapes, which provides a number of broader policy implications.

First, mobility behaviors are a fundamental basis of urban planning policies. It is necessary for policy makers to predict land use patterns based on the mobility behaviors, which is crucial to forecast their business activities and their travel demands in the future. This has generated a lot of concerns about the issue of urban planning, which should be addressed by the Hong Kong government, such as: how to accommodate their residents with different housing requirements according to their mobility behaviors. Does the transportation system in Hong Kong back up the travelling patterns of their residents? How the new town policy balances the

residential development in a sustainable way, without sacrificing the life quality and their environments.

Effective urban planning is very important to build Hong Kong sustainably. Policy makers usually make their decisions based on the experiences of the experts. For example, in order to understand residents' commuting behaviors, a series of research studies have been conducted by using the travel survey data. The information obtained through the surveys may not be enough and cannot be updated with the time. The big data implies rich knowledge about the development of the city and can assist urban planning when used correctly. This research can provide a relatively simplified solution with precise measurement and prompt responses in a very complex system.

This study can also help discover the real boundaries of urban area according to the interaction between residents based on their residential mobility behaviors and their daily mobility behaviors. This application can be obtained by firstly constructing a link map of Hong Kong based on the mobility patterns and then clustering the districts based on their links, where some district groups together with denser links between districts in the same cluster than between clusters. Actually, the defined boundaries of urban area by the government may not represent the real way how residents interact across the urban area. This research offered a visualization of the interaction between land supply, housing supply and mobility patterns in Hong Kong. It helps policy makers understand the evolution process of the Hong Kong area, which gives academic suggestions on defining the optimal boundaries in a subjective way.

Second implication is related with the new town policy. Apparently, the new town policy does succeed in alleviating the congestion condition of urban areas by dispersing the residents from urban areas to new towns. However, suffering from lack of attractiveness and poor accessibility, some new towns cannot play a critical role as expected in the sustainable development of urban areas. There are no enough job opportunities allocated in new towns. As a result, the mismatch of labors and the residence has created high cross-district commuting flows between new towns and urban areas and contributed a lot of the potential problems, which is contrary to the objectives of the new town policy which originally emphasizes on self-sufficiency.

The new town "Yuen Long (Tin Shui Wai)", which is portrayed as "City of Misery", has a lot of serious family and social issues, such as domestic violence, mental illness, and suicide because of its remote location, relatively limited employment opportunities, and high density of public houses. However, not all the new towns encounter the same problem with the district "Yuen Long (Tin Shui Wai)". Another new town "Tsueng Kwun O," as a representative of the success of the new town development, has been already connected by the MTR system's Tseung Kwan O Line. It has created a lot of service working opportunities in its own area, which leads to a balanced work-residence matching situation and highly improved its economic condition.

In order to build the new towns into balanced communities without spatial mismatch, the government should create enough job opportunities requiring various levels of skills in the local area so that their residents can find jobs near where they live, therefore cross-district mobility trips can be reduced and the burdens of the nearby urban area can be relieved. At the same time, the government can also promote the

"home-based office" mode in order to alleviate the traffic congestions along the busiest cross-district route.

Noticeable, it doesn't mean that the new towns with lower cross-district commuting flows don't have problems. The lower mobility rate may reflect a serious spatial lock-in problem with bad transportation condition among those new towns either because they are too poor to move out to pursue better housing condition.

Finally, this research calls for an improvement in public transport provision. It can give some advices on how to improve the public transportation network, subsequently to increase the mobility rate of residents in the spatial lock-in area. The new town policy has created a situation where most of the poorest residents cluster within public houses in new towns. Under such environments, many social problems, such as unemployment, economic poverty and social inequality, have emerged and most likely continue to be so.

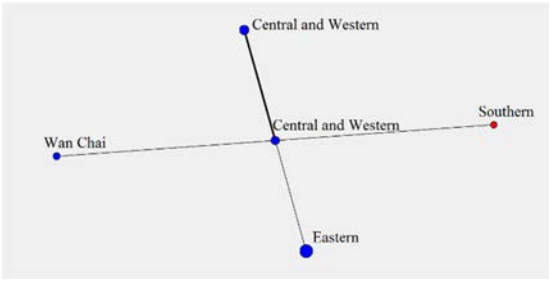
The mismatch of jobs and residence in Hong Kong cannot be solved only by creating job opportunities because of the economic transformation from manufacturing industry to service industry is inevitably associated with lower demand of less skilled labors. Many investors still prefer to settle in the CBD area, although the government has created sufficient infrastructure facilities and recreation facilities in the local area. This is the reason why many residents who live in new towns but still need to travel to the urban area for work. Therefore, an effective public transportation system, as another solution for spatial mismatch, is highly required and need the government pay much attention.

APPENDICES

APPENDIX 1 – AXIS STRUCTURE OF RESIDENTIAL MOBILITY

APPENDIX 2 – AXIS STRUCTURE OF DAILY MOBILITY

APPENDIX 3 – COMPARISON AND CONVERGENCE OF AXIS STRUCTURE OF TWO TYPES OF MOBILITY



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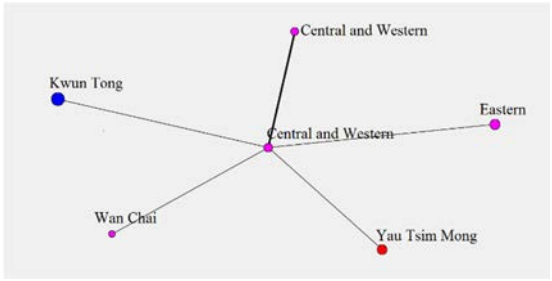

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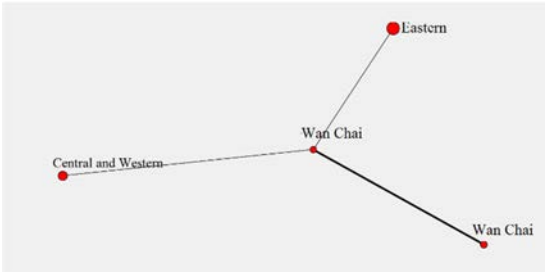

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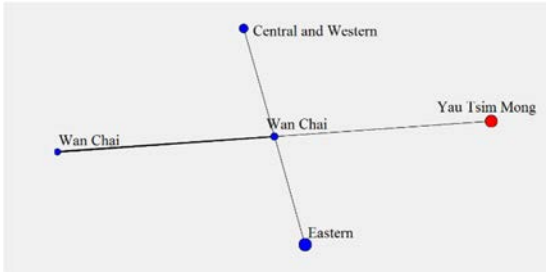

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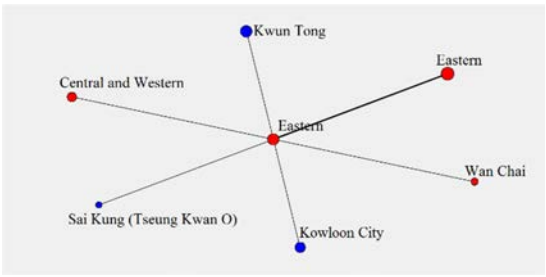

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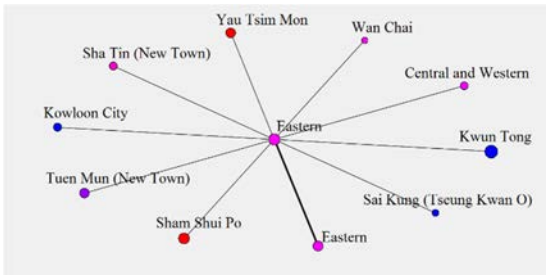

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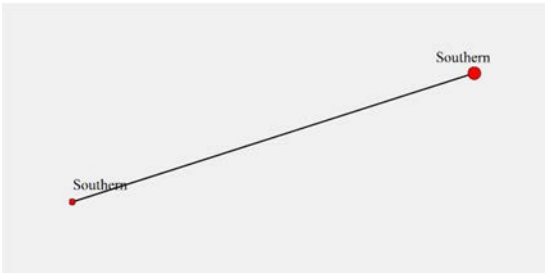

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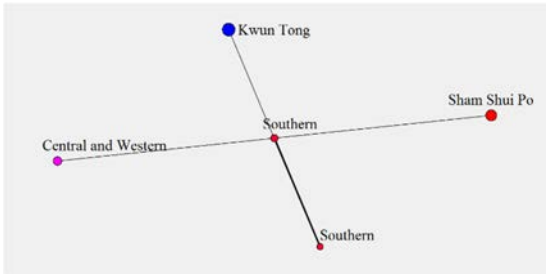

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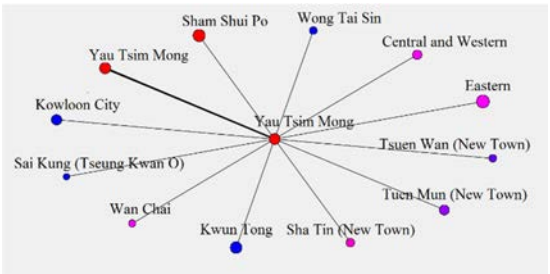

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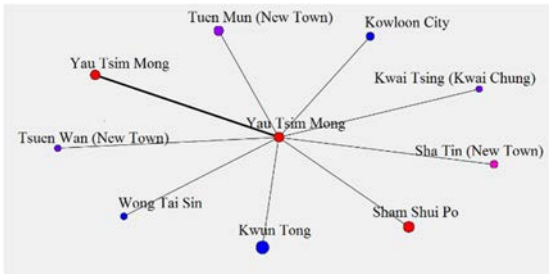

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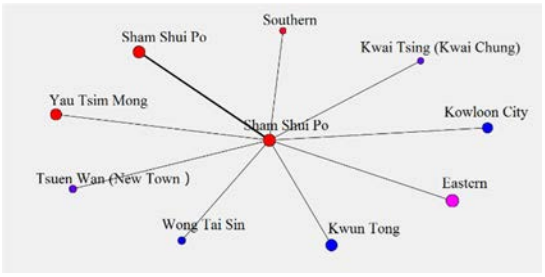

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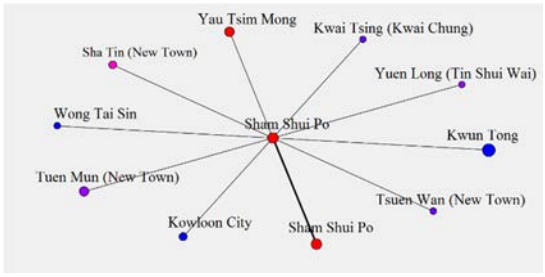

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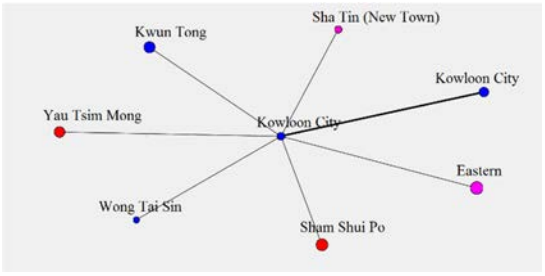

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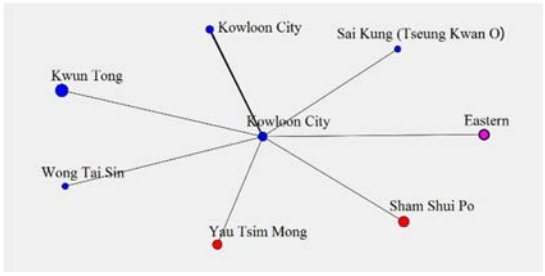

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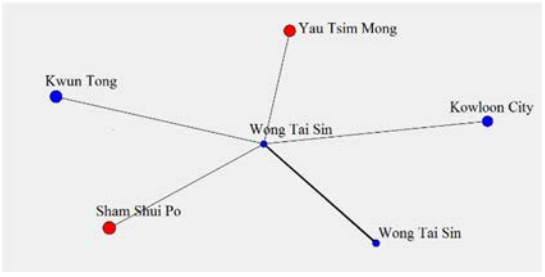

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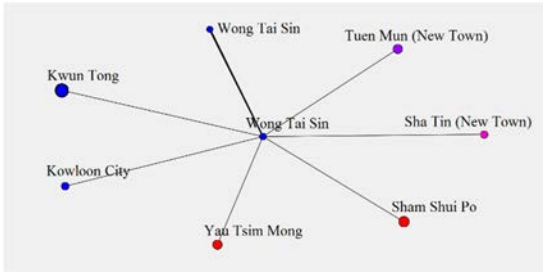

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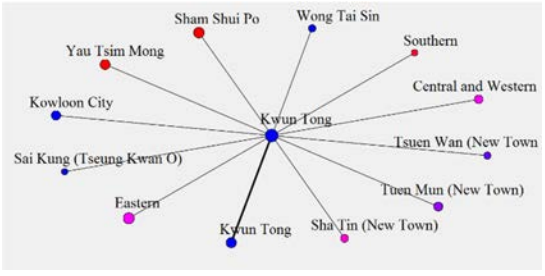

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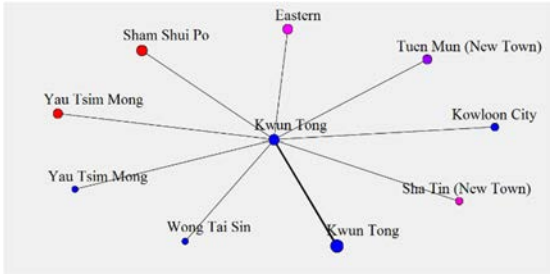

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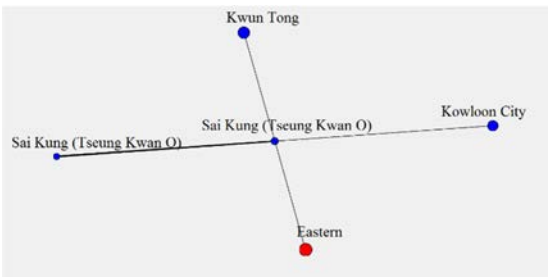

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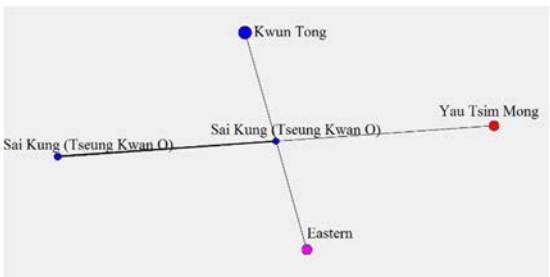

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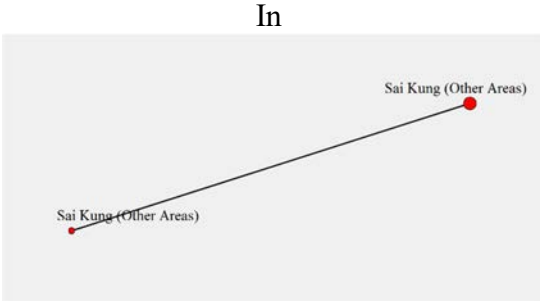

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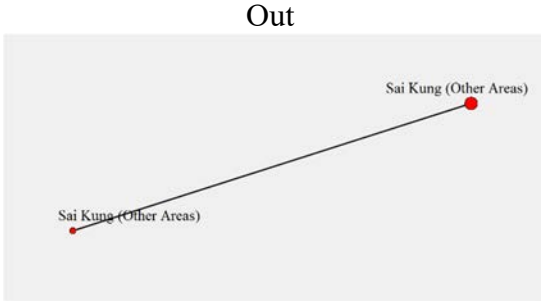

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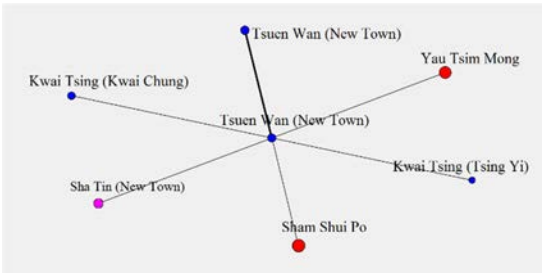

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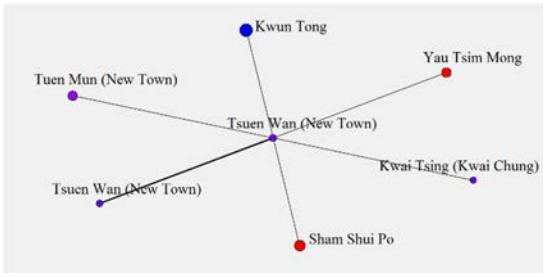

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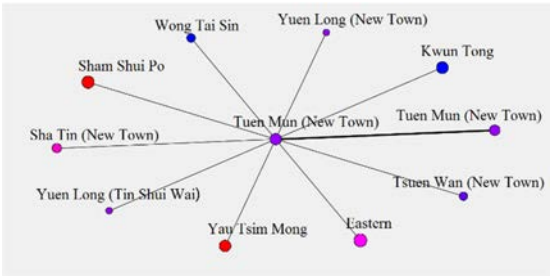

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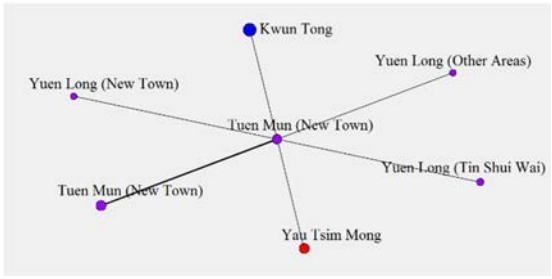

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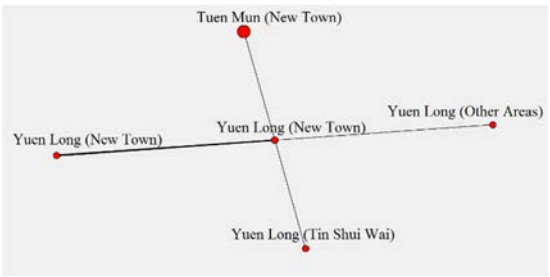

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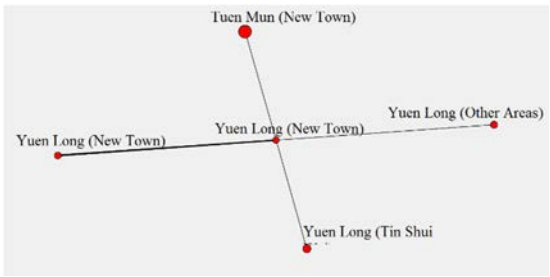

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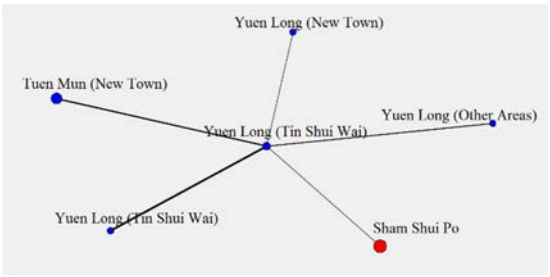

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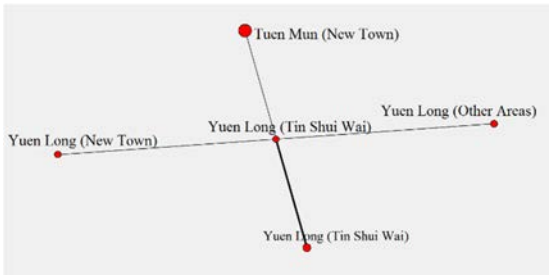

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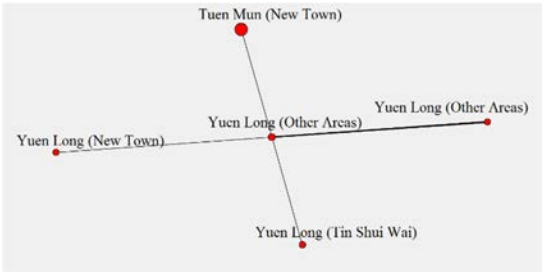

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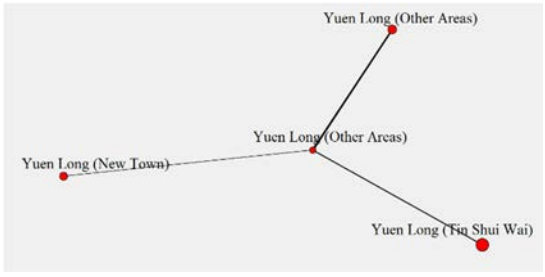

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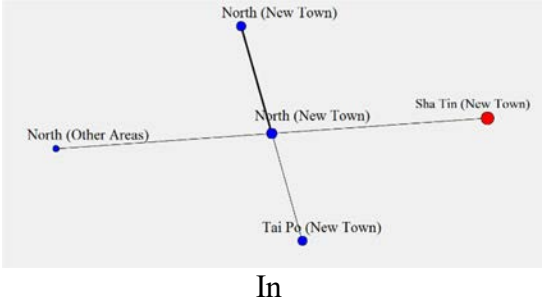

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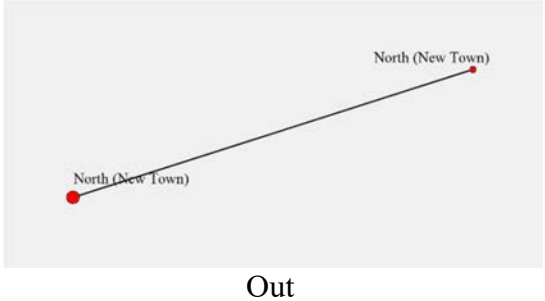

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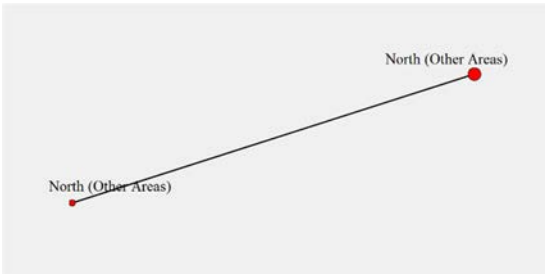

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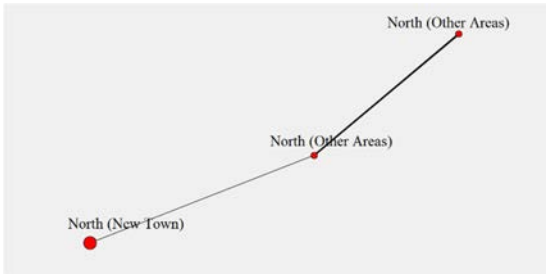

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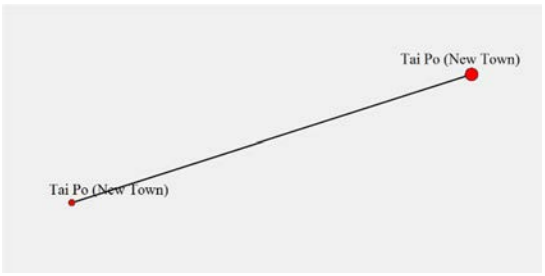

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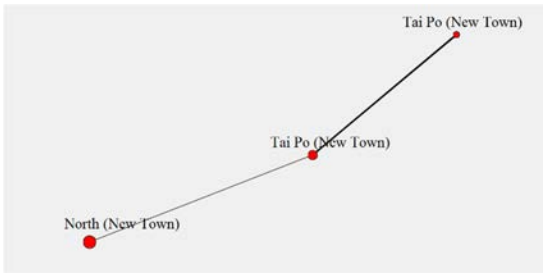

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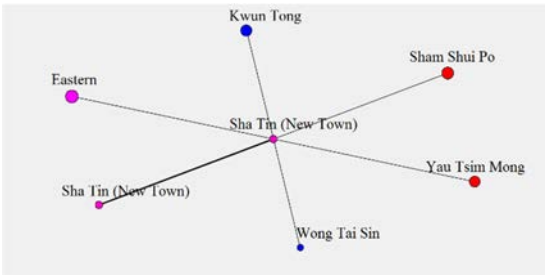

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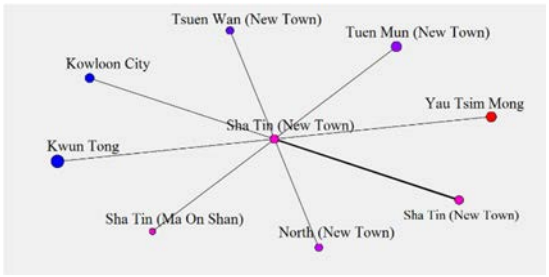

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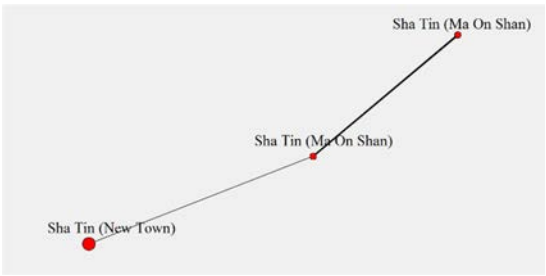

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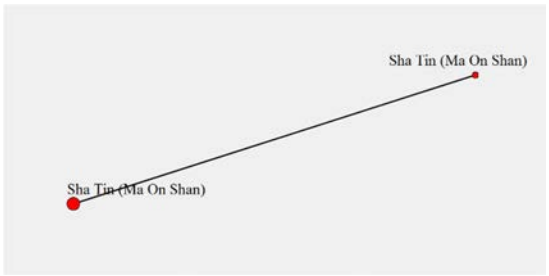

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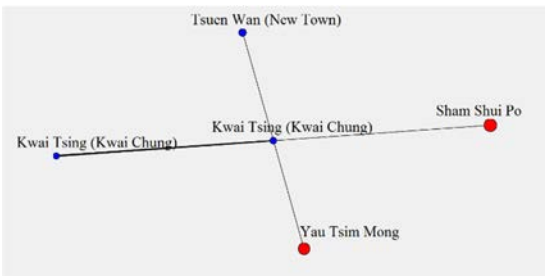

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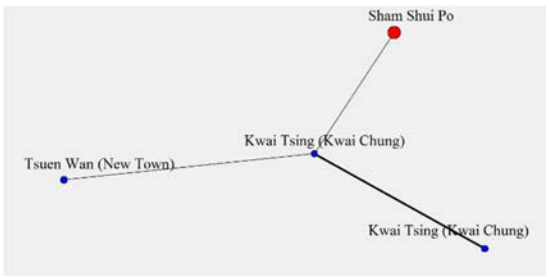

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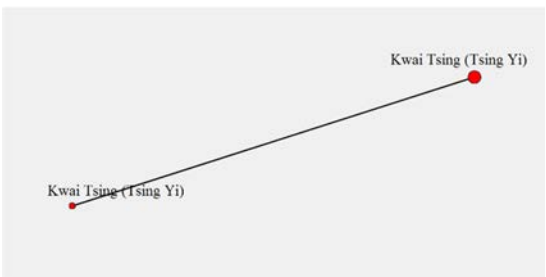

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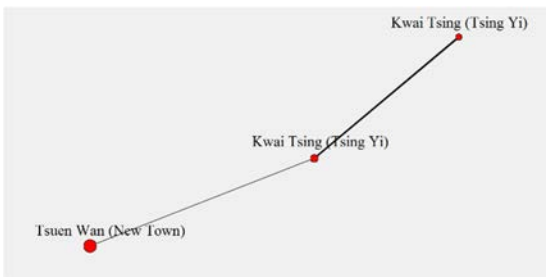

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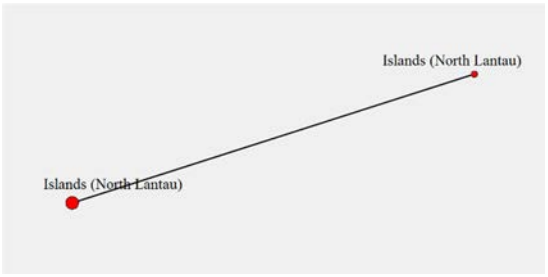
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Islands (North Lantau)

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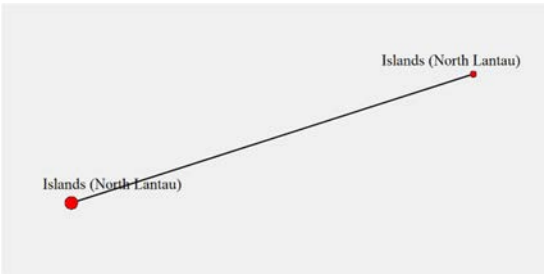
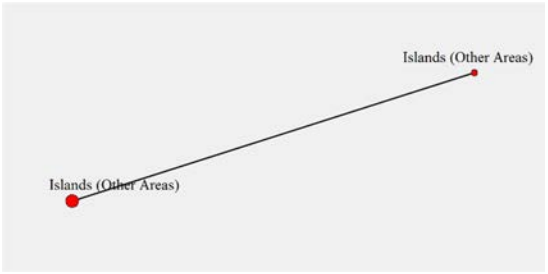
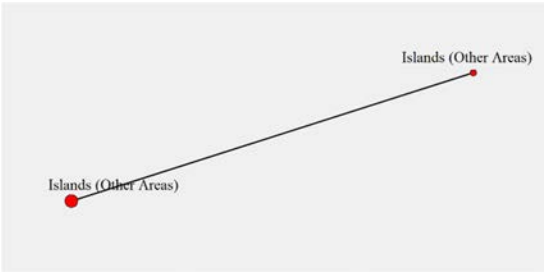

Islands (North Lantau)
Islands (North Lantau)

Out


Islands (Other Areas)
Islands (Other Areas)

In


Islands (Other Areas)
Islands (Other Areas)

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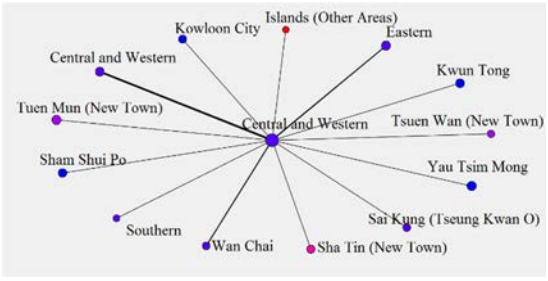

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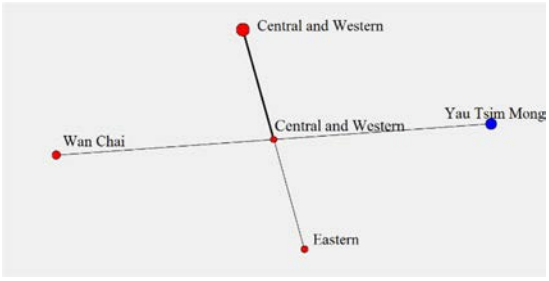

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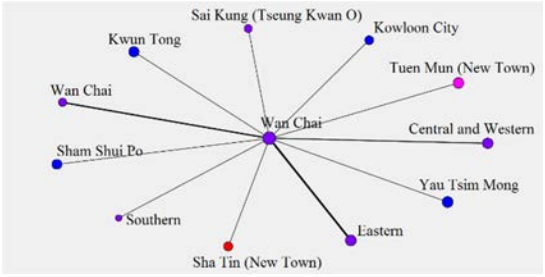

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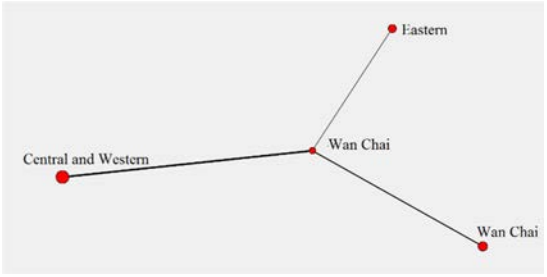

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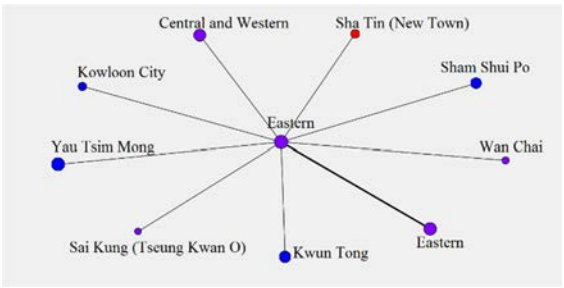

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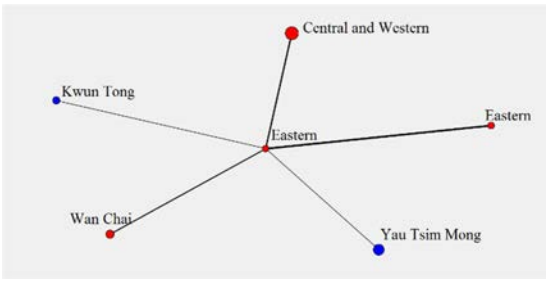

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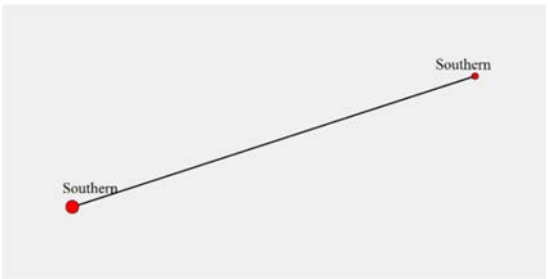

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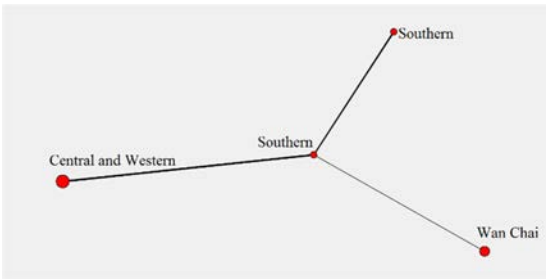

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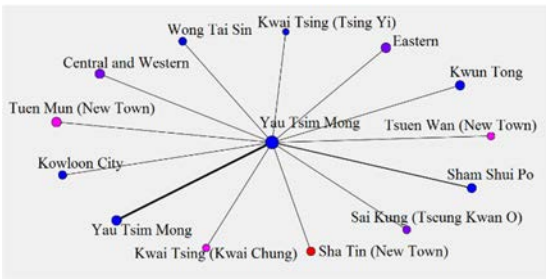

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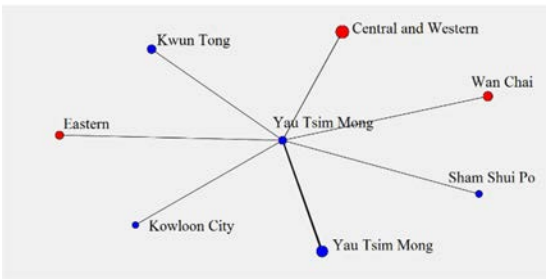

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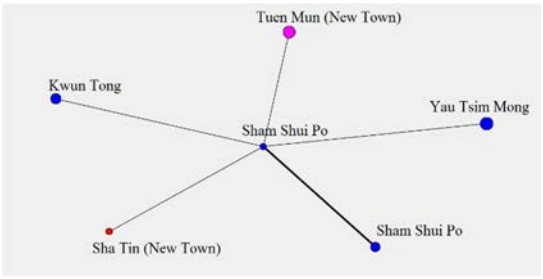

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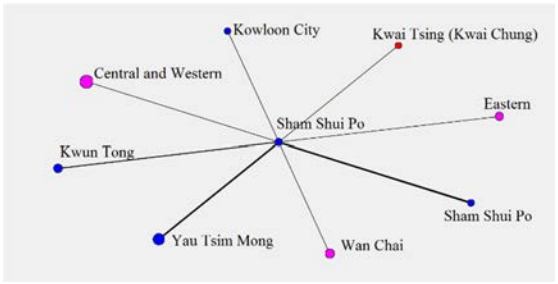

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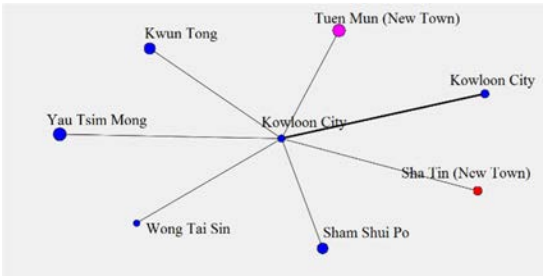

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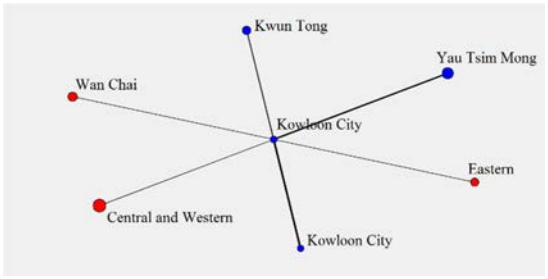

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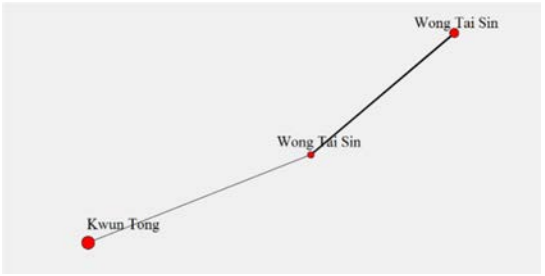

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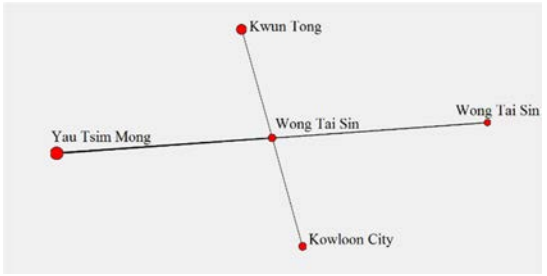

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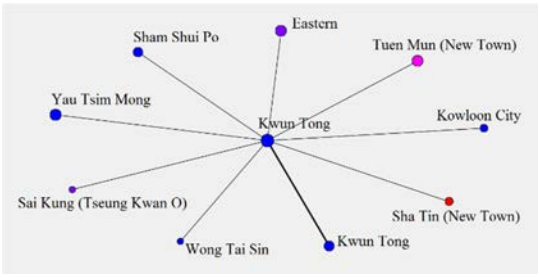

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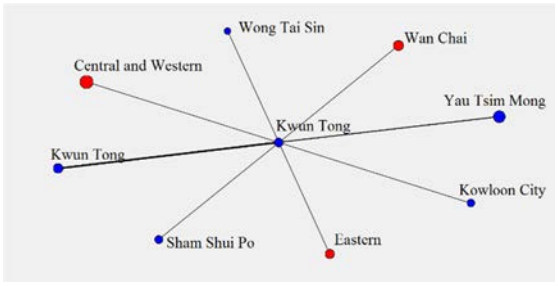

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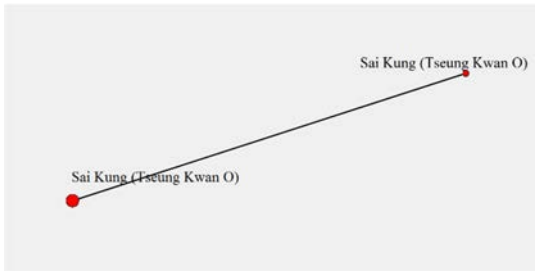

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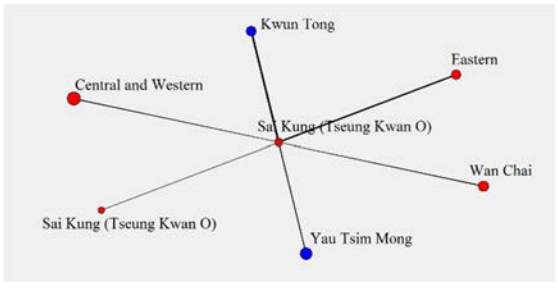

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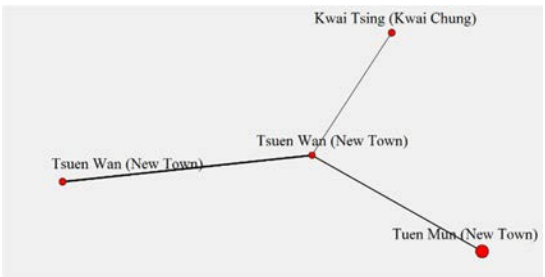

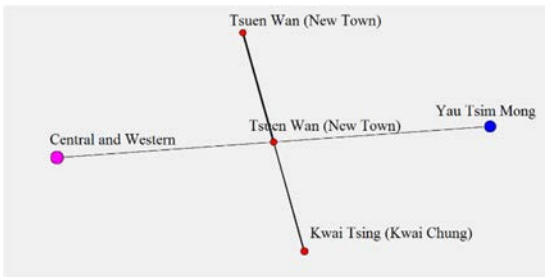

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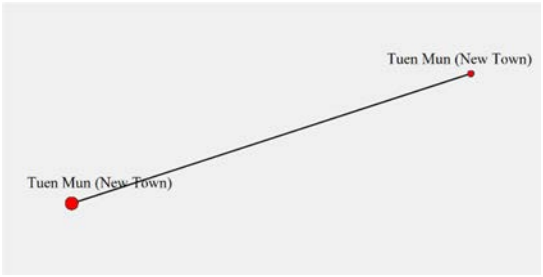

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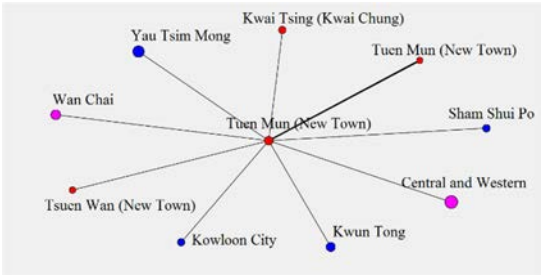

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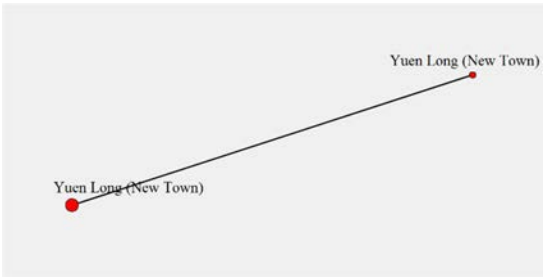

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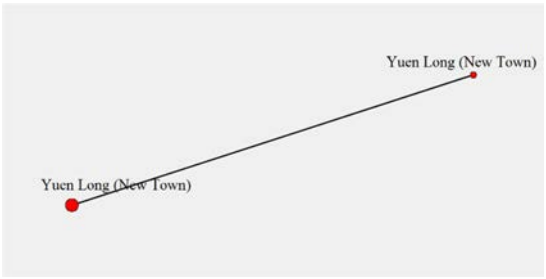

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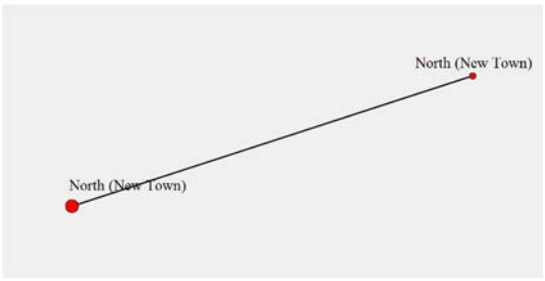

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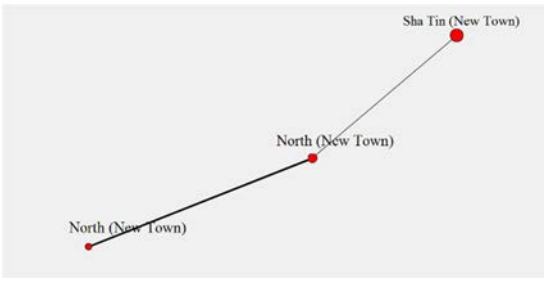

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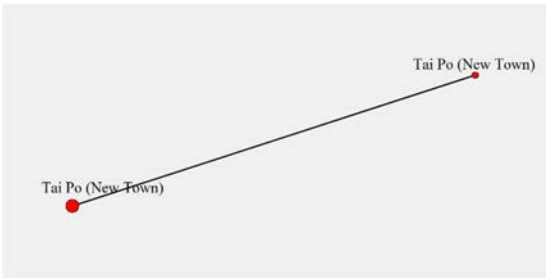

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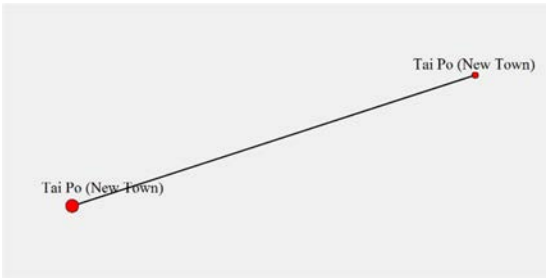

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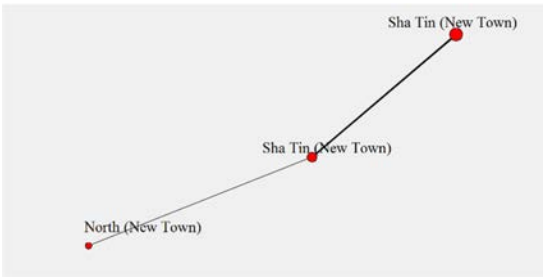

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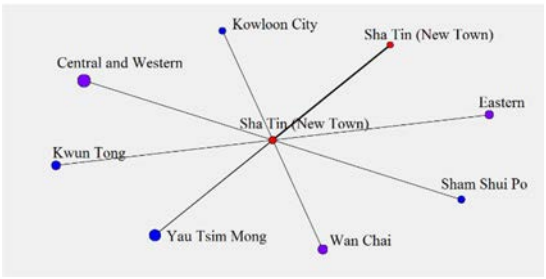

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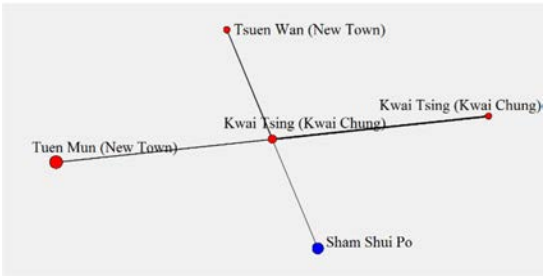

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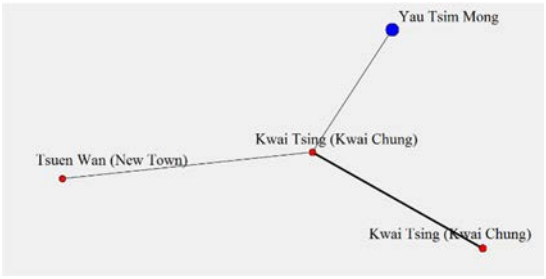

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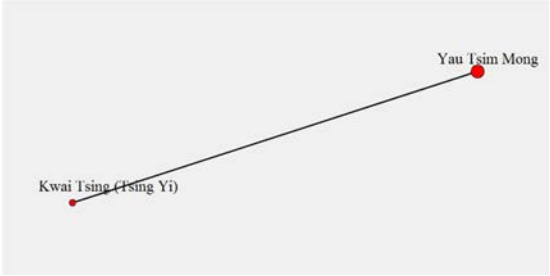

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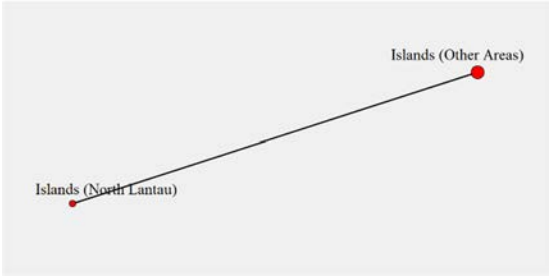

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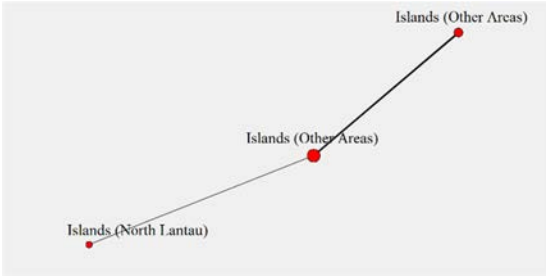
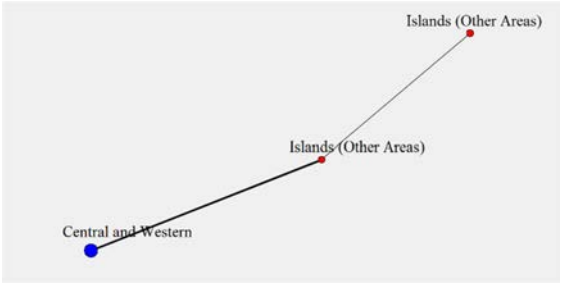
Out

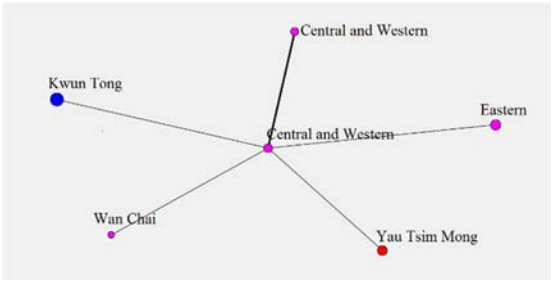


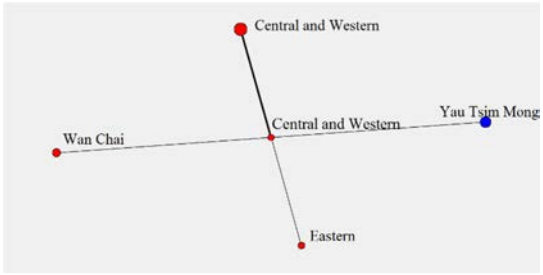


In

Out

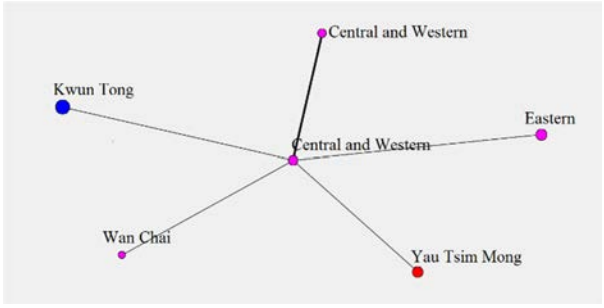
APPENDIX 3 – COMPARISON AND CONVERGENCE OF TWO TYPES OF MOBILITY

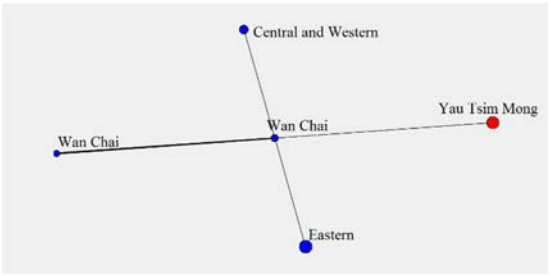


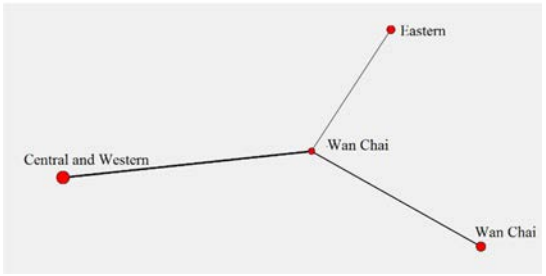


Residential Mobility Daily Mobility

"Central and Western-Central and Western", "Central and Western-Wan Chai", "Central and Western-Eastern", "Central and Western-Yau Tsim Mong"

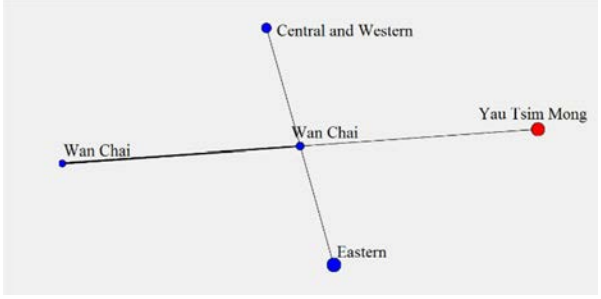


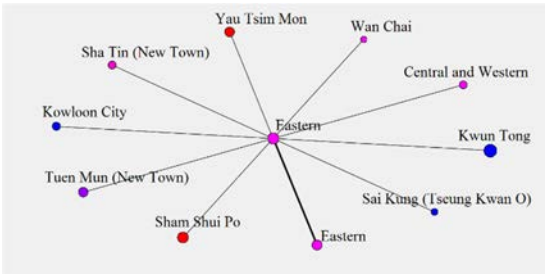


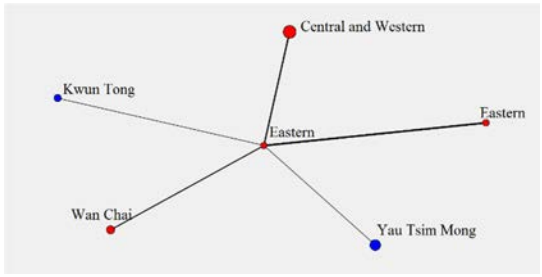


Residential Mobility Daily Mobility

"Wan Chai-Wan Chai", "Wan Chai-Central and Western", "Wan Chai-Eastern"

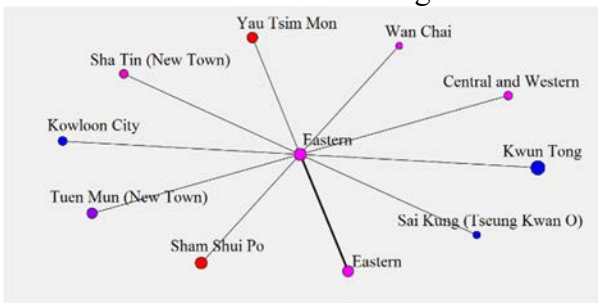


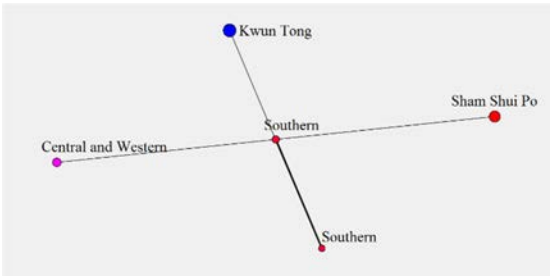


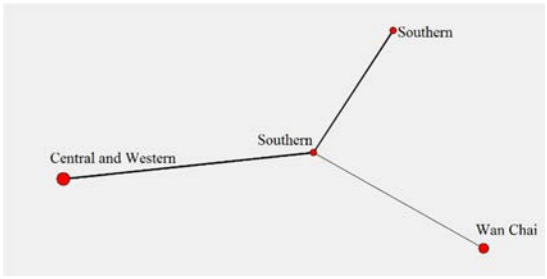


Residential Mobility Daily Mobility

"Eastern-Eastern", "Eastern-Central and Western", "Eastern-Wan Chai", "Eastern-Yau Tsim Mong",
"Eastern-Kwun Tong"

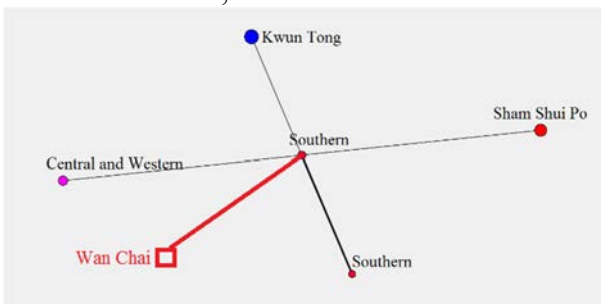


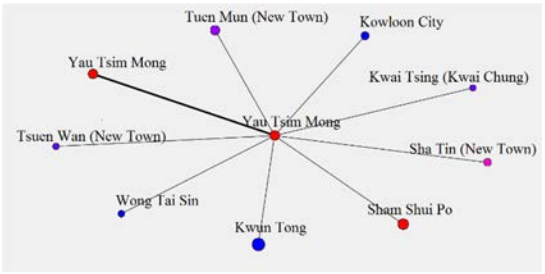


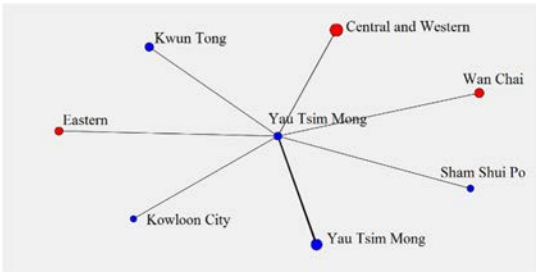


Residential Mobility Daily Mobility

"Southern-Southern", "Southern-Central and Western"

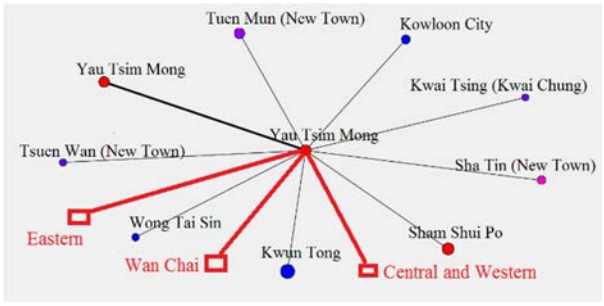


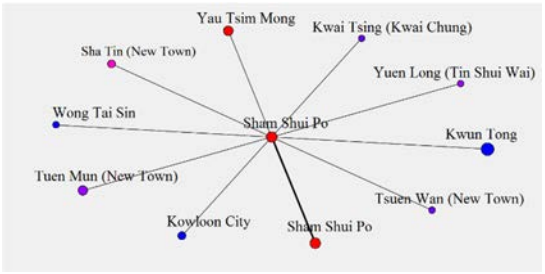


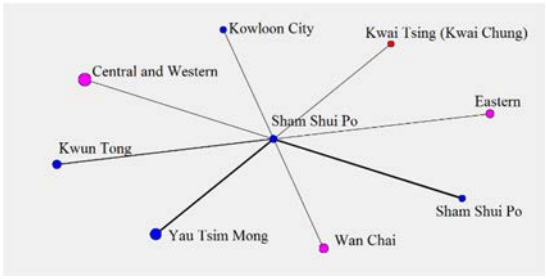


Residential Mobility Daily Mobility

"Yau Tsim Mong-Yau Tsim Mong", "Yau Tsim Mong-Central and Western", "Yau Tsim Mong-Wan Chai", "Yau Tsim Mong-Sham Shui Po", "Yau Tsim Mong-Kowloon City", "Yau Tsim Mong-Kwun Tong"

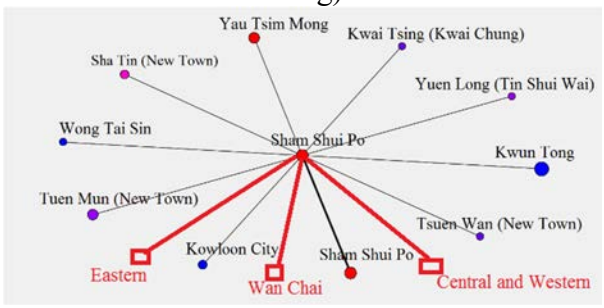


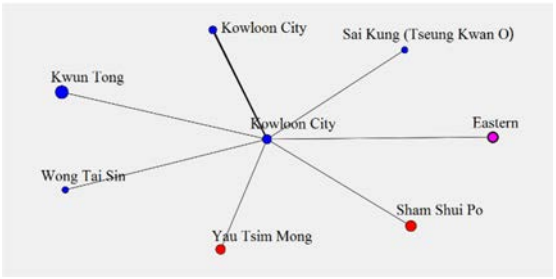


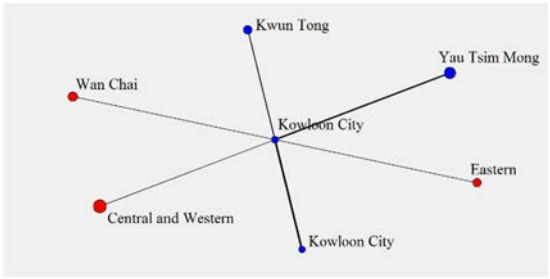


Residential Mobility Daily Mobility

"Sham Shui Po-Sham Shui Po", "Sham Shui Po-Yau Tsim Mong", "Sham Shui Po-Kowloon City", "Sham Shui Po-Kwun Tong", "Sham Shui Po-Kwai Tsing (Kwai Chung)"

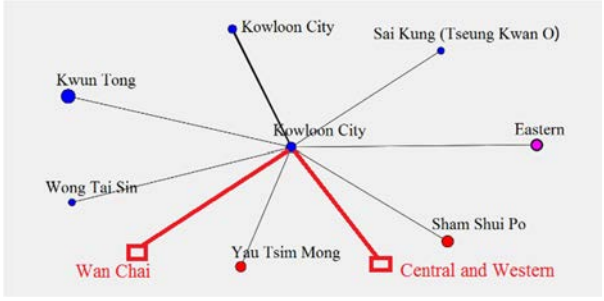


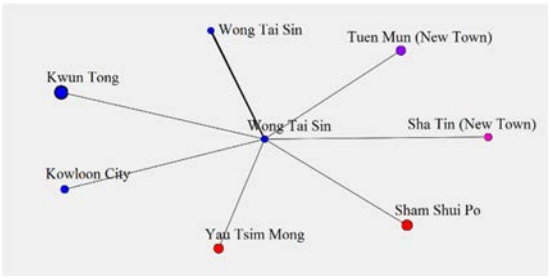


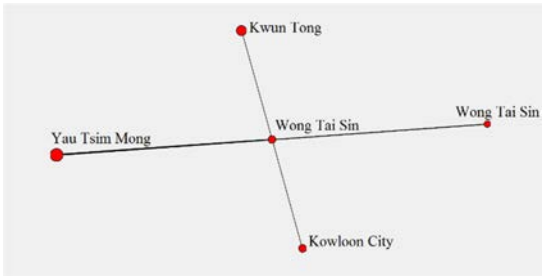


Residential Mobility Daily Mobility

"Kowloon City-Kowloon City", "Kowloon City-Eastern", "Kowloon-Yau Tsim Mong", "Kowloon-Kwun Tong"

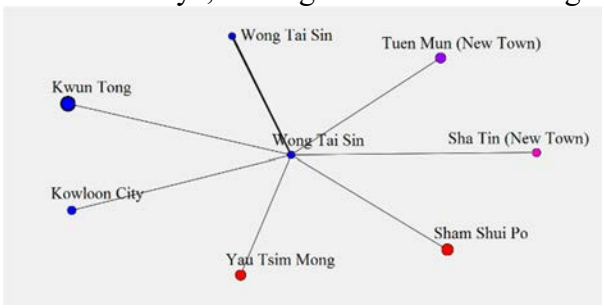


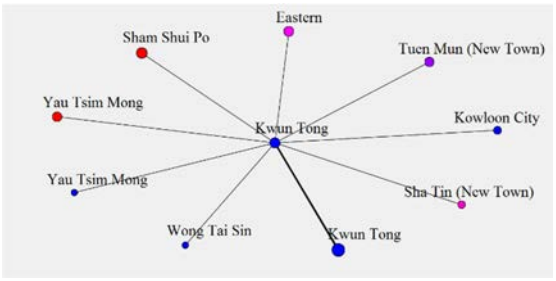


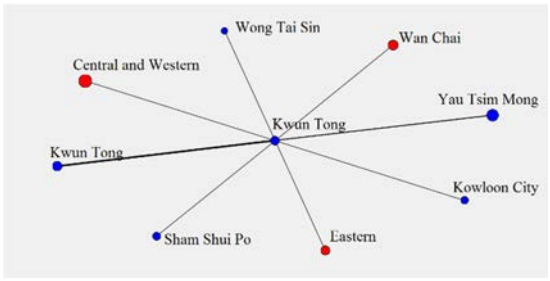


Residential Mobility Daily Mobility

"Wong Tai Sin-Wong Tai Sin", "Wong Tai Sin-Yau Tsim Mong", "Wong Tai Sin-Kowloon City", "Wong Tai Sin-Kwun Tong"

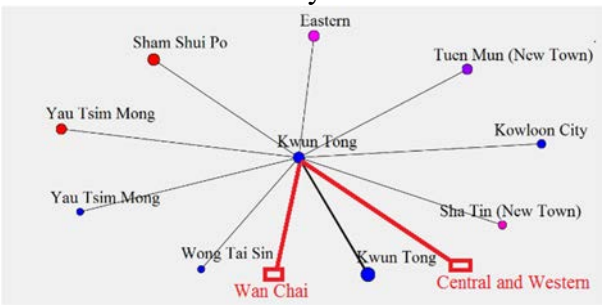


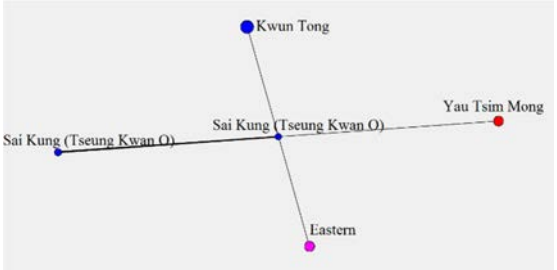


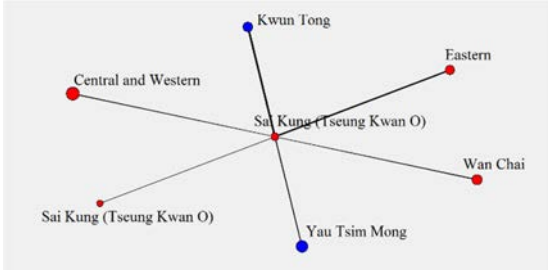


Residential Mobility Daily Mobility

"Kwun Tong-Kwun Tong", "Kwun Tong-Eastern", "Kwun Tong-Yau Tsim Mong", "Kwun Tong-Sham Shui Po", "Kwun Tong-Wong Tai Sin", "Kwun Tong-Kowloon City"



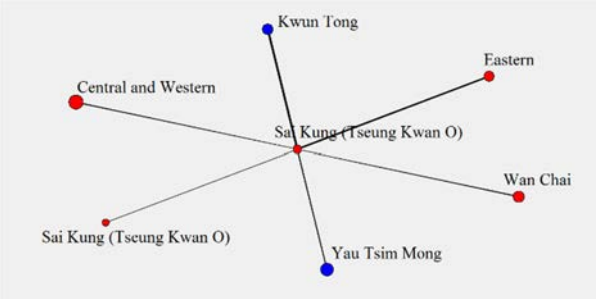


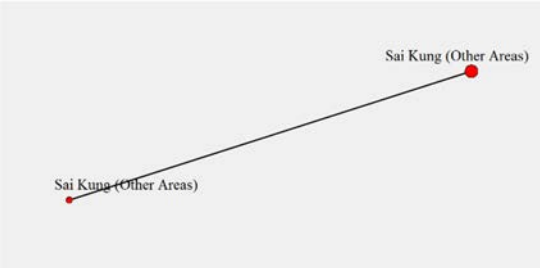


Residential Mobility Daily Mobility

"Sai Kung (Tseung Kwan O)-Sai Kung (Tseung Kwan O)", "Sai Kung (Tseung Kwan O)-Eastern", "Sai Kung (Tseung Kwan O)-Yau Tsim Mong", "Sai Kung

(Tseung Kwan O)-Kwun Tong”





Residential Mobility

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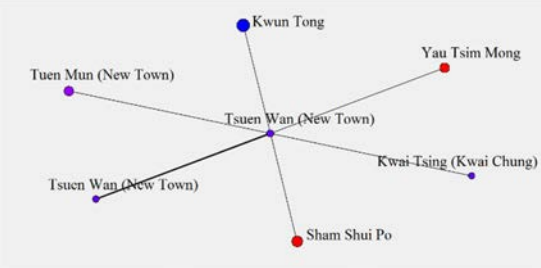
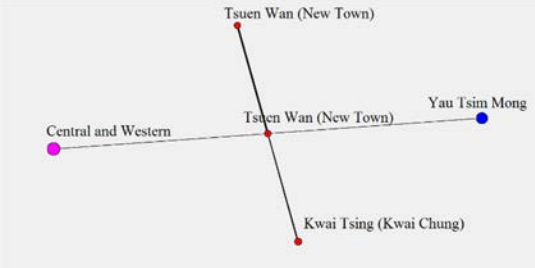
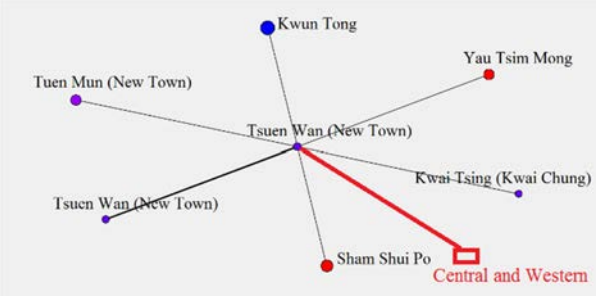


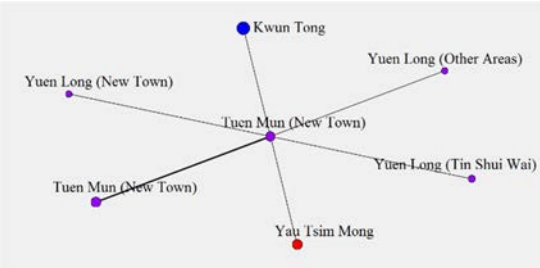


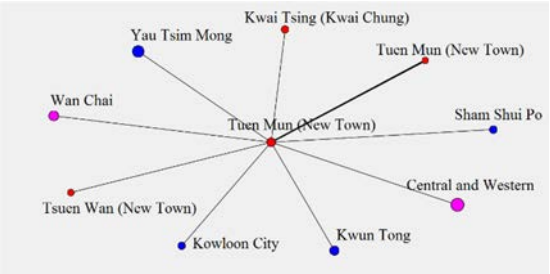
Residential Mobility

Daily Mobility

“Tsuen Wan (New Town)-Tsuen Wan (New Town)”, “Tsuen Wan (New Town)-Yau Tsim Mong”, “Tsuen Wan (New Town)-Kai Tsing (Kwai Chung)”



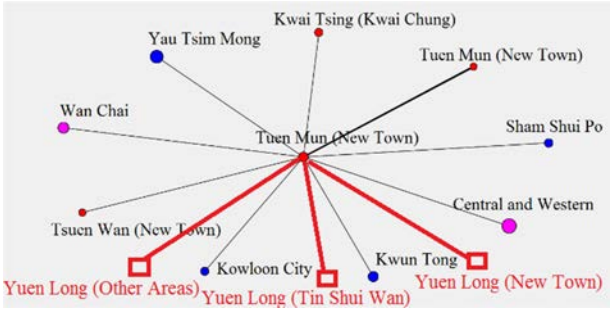


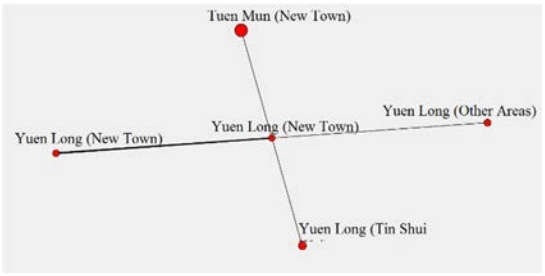


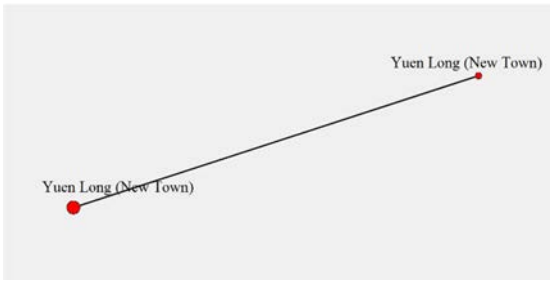
Residential Mobility

Daily Mobility

“Tuen Mun (New Town)-Tuen Mun (New Town)”, “Tuen Mun (New Town)-Yau Tsim Mong”, “Tuen Mun (New Town)-Kwun Tong”

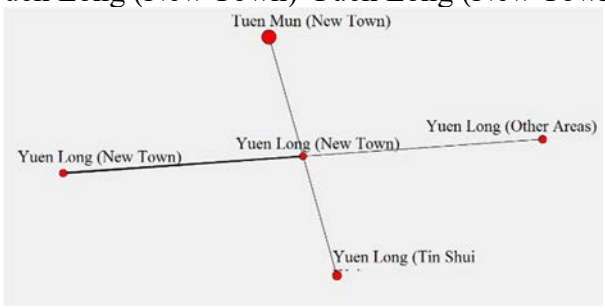


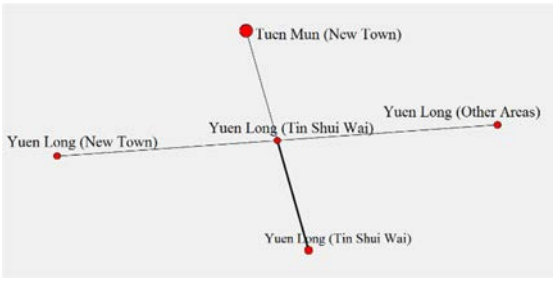




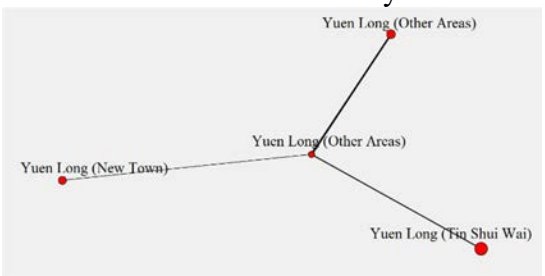
Residential Mobility Daily Mobility

"Yuen Long (New Town)-Yuen Long (New Town)"

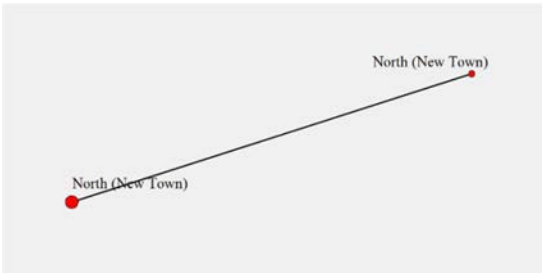




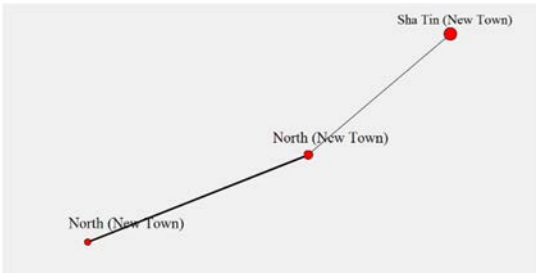
Residential Mobility Nill



Residential Mobility Nill

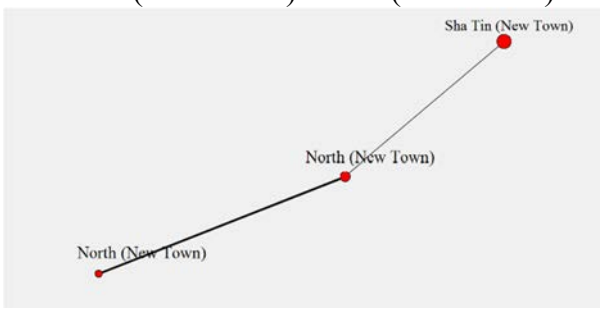


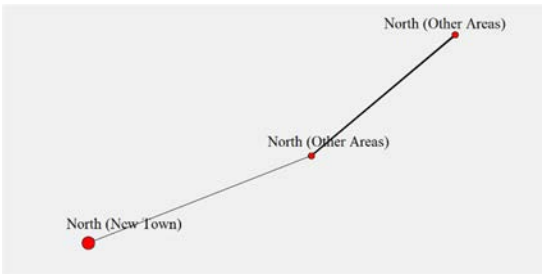
Residential Mobility



Daily Mobility

"North (New Town)-North (New Town)"





Residential Mobility

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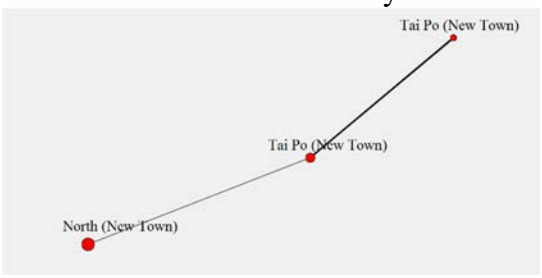
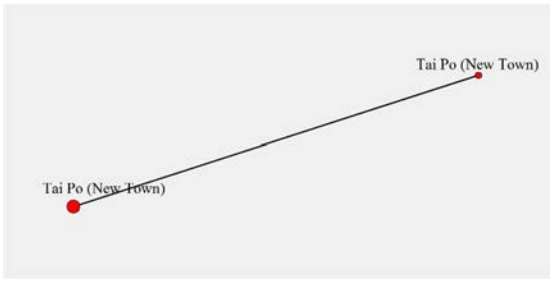
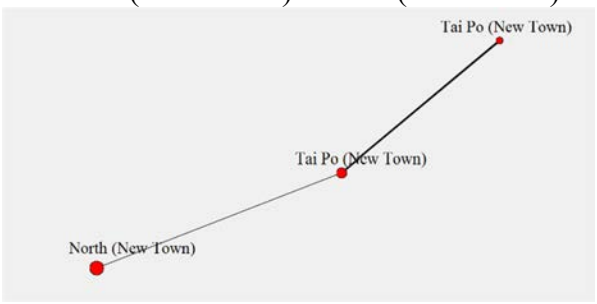


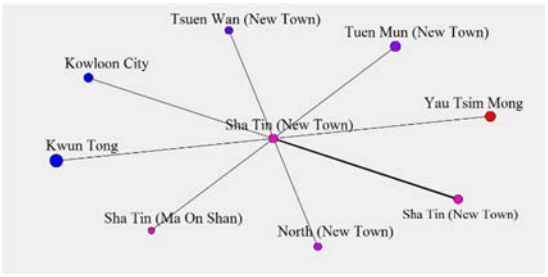
Residential Mobility



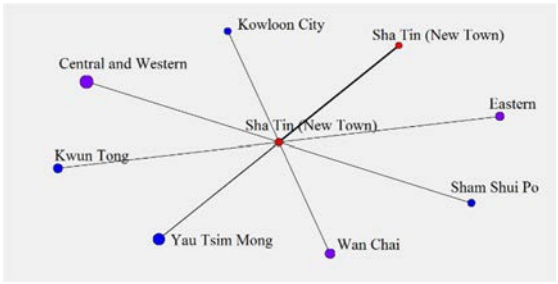
Daily Mobility

"Tai Po (New Town)-Tai Po (New Town)"



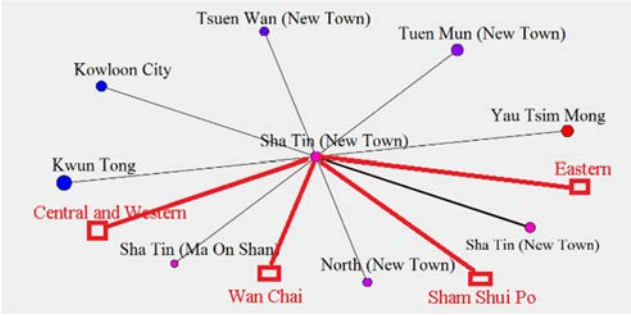


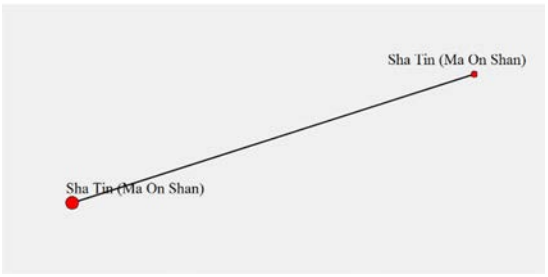
Residential Mobility



Daily Mobility

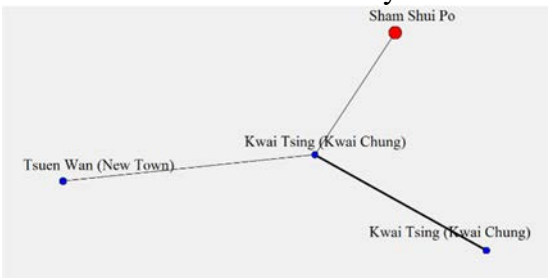
"Sha Tin (New Town)-Sha Tin (New Town)", " Sha Tin (New Town)-Yau Tsim Mong", "Sha Tin (New Town)-Kowloon City", "Sha Tin (New Town)-Kwun Tong"



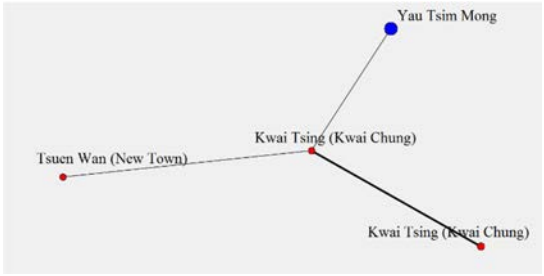


Residential Mobility

Nill

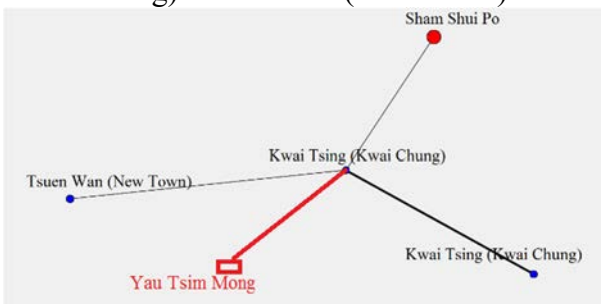


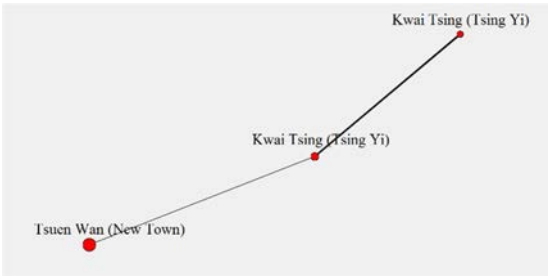
Residential Mobility

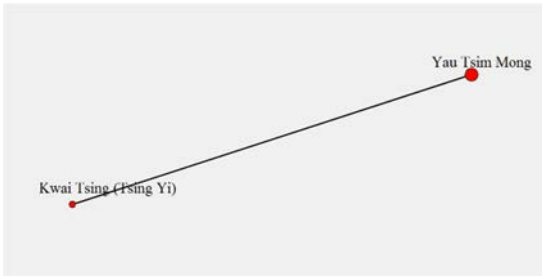


Daily Mobility

"Kwai Tsing (Kwai Chung)-Kwai Tsing (Kwai Chung)", "Kwai Tsing (Kwai Chung)-Tsuen Wan (New Town)"

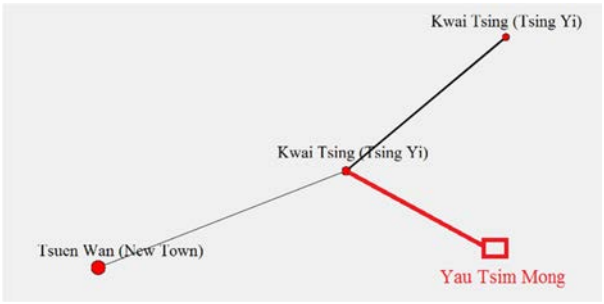


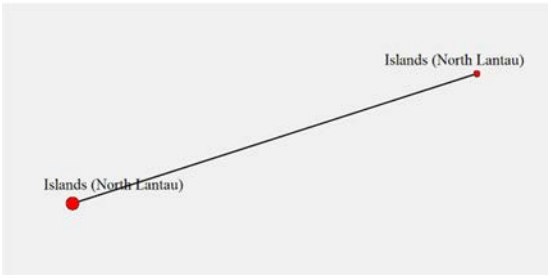


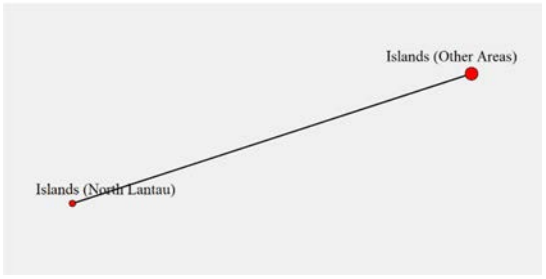


Residential Mobility Daily Mobility

0

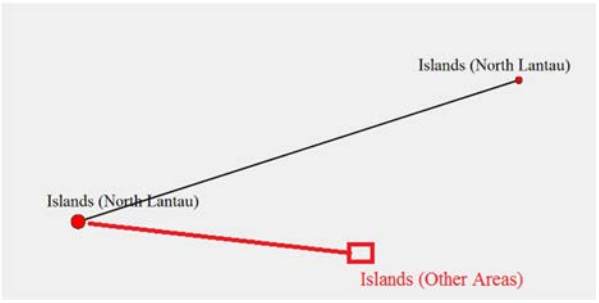


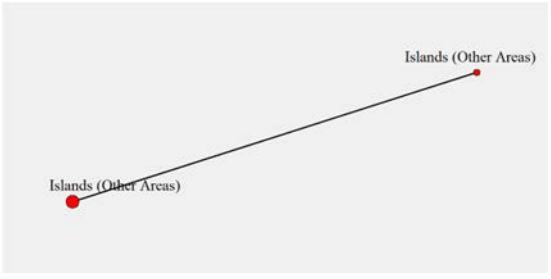


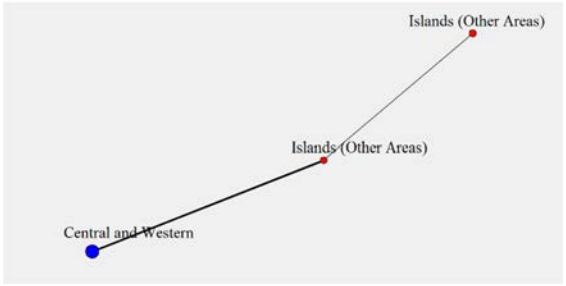


Residential Mobility Daily Mobility

0

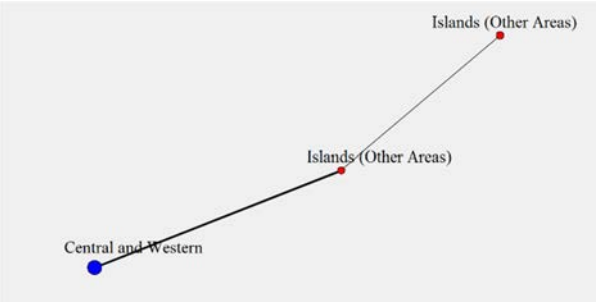






Residential Mobility Daily Mobility

"Islands (Other Areas)-Islands (Other Areas)"


Islands (Other Areas)
Islands (Other Areas)
Central and Western

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