Doctoral Dissertation

Neighborhood Planning based on Self-Containment: A Perspective of Travel Behavior with Social Network

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ABSTRACT

Background and motivations

Rapid urbanization can have positive effects on the economy, but has also brought a number of negative effects, such as congestion, housing shortages, high urban population density, and growth in energy consumption. The development of new neighborhoods and new towns in many countries has been considered an effective way to relieve a lack of housing and high density in urban areas. While these new neighborhoods were constructed in many developed countries about fifty years ago, the development of new neighborhoods and new urban areas has just emerged in the last decade in developing countries. In recent years, many new towns in developed countries have run into numerous problems. In addition, aging population is a current issue in developed countries, while the aging population and aging rate are predicted to become serious issues in developing countries in the next coming years.

In general, forms of neighborhood planning have changed over the years, reflecting the evolution of neighborhood planning over time. As an aspect of sustainable neighborhood planning, the concept of self-containment has been embodied in a variety of neighborhoods. It has beneficial for neighborhood development and management in developed cities, where it was conventionally interpreted as a balance between job locations and housing. However, in the developing countries of Asia, which are following their own paths of rapid urbanization and motorization, this notion of self-containment may not be appropriate, and thus may need to be adapted or expanded to reflect their particular contexts. . Besides, social goals have been the keystone of neighborhood design, and hence the social engagements or social capital of residents should be addressed in travel choice behavior models.

Research purposes

The purpose of this study is to shed light on people's travel choices for the sustainable development of new urban areas by expanding the notion of self-containment in a neighborhood and examining it empirically.

Data

Data was collected at two sites: an aging new town in Japan and several recently developed new towns in Vietnam. Data using a panel survey was collected in an aging new town in Japan in 2010 and 2011. During the two-week survey period at each wave, respondents were asked to fill out a paper-based travel diary and to record each trip trajectory using a GPS logging device. Around 50 households participated in each wave, with 38 households

common to both waves. To study a neighborhood society before population aging, a separate set of data was collected through a cross-sectional survey conducted in three new urban areas in Hanoi Metropolitan Area (Vietnam) in 2015, with a total of 462 individuals with 4,649 trips reported in travel diaries for two days (one weekday and one weekend day).

Contents of chapters and major findings

Chapter 1 includes the background, research motivation, research objectives and questions, and outline of the thesis.

Chapter 2 broadly reviews the literature on neighborhood planning, with a focus on the notion of self-containment. Generally speaking, a majority of urban planners have approached neighborhood design through physical design and attempted to build a sense of community via specific design elements. The idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process, and the process is primarily nurtured through the promotion of social solidarity and resident bonding, whereby existing problems are handled collectively. The conventional concept of self-containment was associated with job-housing balance embodied in neighborhood planning. However, with rapid motorization and the evolution of complex social networks and modern lifestyles, residents could not entirely conduct their activities inside the limited boundaries of neighborhoods and town. As a result, the notion of self-containment in a conventional sense would not be appropriate as a framework for analyzing new urban areas in developing countries.

Chapter 3 describes the study locations and surveys used in this study.

Chapters 4 and 5 then consider travel behavior from the perspective of travel mode choice.

Chapter 4 focuses on a travel mode choice model developed based on a panel mixed logit model by using the panel survey conducted in Japan. The results show that (1) altitude difference and maximum slope factors, among four topographical factors under the study, have significant impacts on elderly people's mode choice decisions; (2) owning non-motorized vehicles would further enhance the self-containment of the neighborhood; and (3) elderly-oriented personal mobility vehicles can be useful in mitigating the negative effects of topographical factors.

Chapter 5 focuses on travel mode choice in the Hanoi Metropolitan Area of Vietnam and develops a path model with multiple discrete choices. In the path model, a mediation model is proposed, in which the mediation effects of income on travel mode choice are captured via residential location choice being modelled as a discrete mediator which generates non-linear indirect effects of income on mode choice. The result shows that (1) income has both direct effects and indirect effects on travel mode choice behavior via a mediator: i.e., residential location choice behavior; (2) income has a non-linear indirect effect; (3) the relationship between motorcycle usage and income is quadratic with a minimum of motorcycle share at a certain income level.

Chapters 6 and 7 look at travel behavior from the perspective of destination choice. Chapter 6 explores the self-containment status of a new town for discretionary activities (shopping, volunteer, recreation and so on), by using the panel survey data collected in Koyo New Town located in Hiroshima, Japan. For this purpose, a panel mixed logit model of destination choice with a focus on the impacts of social networks is developed. The results show that (1) the status of social network significantly influences destination choice sets, and hence is an influential factor of the self-containment status of the new town; (2) the more friends the respondents have in the neighborhood, the more subjective well-being they would obtain.

Chapter 7 examines the impacts of social capital measured in two dimensions, social network and participating in local community activities, on travel choice for discretionary activities. For this purpose, using data collected in Hanoi, Vietnam, a logit model for destination choice and an ordered probit model for trip generation were developed. The results show that (1) social engagement at an individual level has more impact on travel choice compared with one at the community level; (2) having a more self-contained neighborhood enhances subjective well-being, and thus improves the quality of life for residents living there.

Chapter 8 focuses on the endogenous effect of social network on destination choice in the neighbourhood. For this purpose, a logit model for destination choice was developed, controlling for socio-demographic characteristics, trip context, mobility, accessibility, group fixed-effects, and expected probability of the individual's acquaintance choosing the destination inside the neighborhood area (i.e. endogenous social interaction effects). As an initial example, the model is estimated using data collected in three new neighborhood areas in Hanoi Metropolitan Area of Vietnam in 2015. The results show that (1) the endogenous effect of the social network is statistically significant with positive sign; (2) without controlling the group fixed-effects, the social interaction effects on destination choice are over-estimated.

Chapter 9 summarizes the main findings, limitations of this research as well as some suggestions for future studies.

Major contributions

This is one of the first attempts in the literature to expand the notion of self-containment in theory and examine it empirically using travel choice behaviors, taking into account different types of neighborhood societies in a consistent and comprehensive way. Major contributions are summarized as follows.

- Academic contributions: The concept of self-containment in neighborhood planning is expanded in theory both for developed and developing societies. In particular, this study could successfully:
  (i) Establish a theoretical approach of self-containment which can be used in quantitative analysis for neighborhood planning;

    (ii) Propose a framework to understand the mechanism of self-containment for neighborhood planning.

- Practical Contributions:
    (i) While neighborhood planning has been solved mainly based on neighborhood attributes, the previous studies did not handle income increase directly. Income is an important factor in developing cities, and also can be mediated by neighborhood attributes.
    (ii) This study found a fact that, even in its poor conditions, the development of social capital in neighborhood helps to increase the level of self-containment and thereby the quality of life for residents is improved.
    (iii) Endogenous effect is a non-negligible factor to make neighborhood more sustainable with a long-term aspect, to dispel the planning fallacy in neighborhood that conventional overestimation of exogenous market and social effects in a short-term aspect may reach to unstable or low-level equilibrium. Therefore, the concept of self-containment with a consideration of social interaction (i.e. non-market interaction) could be a key concept to design and plan the neighborhood in both developed and developing countries
- Contributions to policy implications:
    (i) Self-containment contributes to the improvement of the quality of life. Therefore, policy-makers should be pay more attention to the mismatch between social networks and activity locations, especially for those who have higher mobility constraints.
    (ii) Policy-makers can enhance social multiplier effects for residents living in neighborhoods by standing for the level of self-containment existing in each neighborhood.
    (iii) Local resources can be utilized to maintain or revitalize the neighborhood since residents tend to invest economically and socially in their neighborhood.
    (iv) For the neighborhood in aging society, one of the important factors is topography, pointing to the need to pay more attention to providing appropriate and user-friendly modes for the residents. For the neighborhood before aging population, it is important to pay more attention to the built environment of the neighborhood in order to have a self-contained neighborhood.

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Nguyen Thi Anh Hong
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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

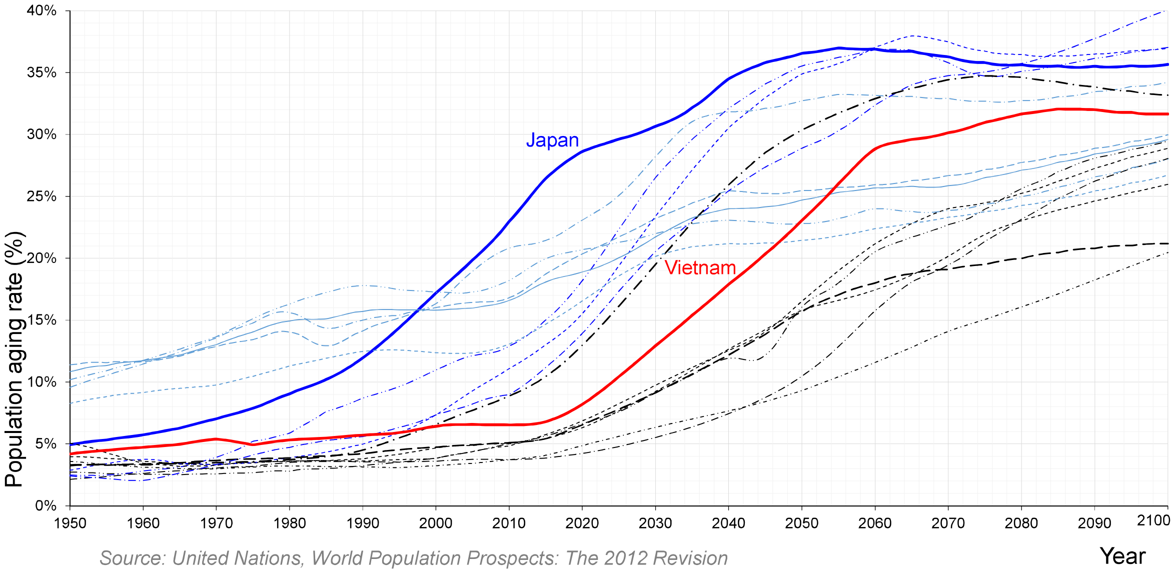
1.1 Background

According to the Asian Development Bank (2012), there has been rapid urbanization in the Asian region. While only 30% of Asia's 0.7 billion citizens lived in urban areas in 1950, it is predicted that about 60% - 4.9 billion people - will live in urban areas in 2030. On the one hand, this urbanization may contribute to higher rates of economic growth. On the other hand, there have been a variety of negative effects, such as worsening congestion, housing shortages, high population density, environmental pollution, and rapid growth in energy consumption.

In order to tackle these dilemmas, some governments have relied upon several different policies, including rural development, the development of medium-sized cities, and the development of "new urban areas" – new towns, new neighborhoods, and newly developed areas, usually located near or within commuting distance to nearby city centers. These areas have been developed in many countries as a way of relieving urban population density, and over the years their sizes and numbers have expanded considerably. While new towns have been built largely in developed countries for a long time, such as in the United States (1960s), the United Kingdom (1946), France (1960s), Sweden (1950s) and Japan (1970s)(Cervero, 1995a), such types of new urban areas have a much more recent history in developing countries. For example, the development of new towns and new urban areas emerged in Vietnam only in the 2000s.

In recent years, many developed countries have run into new challenges, especially rapidly aging populations, which are now raising questions about the wisdom of earlier urban development policies such as new town development. One of the attractions of these areas was their relatively low land prices, and many people moved there to live in detached houses. Land use was designed mainly for the working age population, who were physically fit and who could drive. However, now, as the populations in these areas have aged, and the number of new people moving into these areas has declined, the mobility of elder people and their access to basic shopping and social services has become difficult.

The current problems faced by developed countries are particularly important for those developing countries which will face a growing elderly population in the next coming years (see Figure 1.1). At present, the country with the highest proportion of elderly population is Japan, followed by China and the Republic of Korea, respectively. Some developing countries such as Vietnam, Thailand, and Malaysia will deal with this problem about 40 years to 50 years in the future. In addition, the rate of aging in Asian countries is significantly faster than in North America or Europe. For example, it took around 260 years in France, 44 years in Sweden, 63 years in the United Kingdom, 37 years in Germany and 76 years in the United State to increase the share of the elderly (aged 65 or over) from 7% to 14 % of the total population, while it took only 24 years in Japan, 18 years in Korea, 20 years in Singapore, and 29 years in China. For developing countries, aging is expected to progress even more rapidly, taking only 17 years in Vietnam, 18 years in Laos, 20 years in Thailand, 23 years in Indonesia and Cambodia, and 24 years in Malaysia (United, 2012). Developing countries will need to adjust or prepare their various systems, such as social security and infrastructure development, to handle changes in the total population and age structure within a short period.



Source: United Nations, World Population Prospects: The 2012 Revision

Figure 1.1: Change in population aging rate

As mentioned above, in many developing cities in Asia, rapid urbanization has lead to some unintended consequences, such as uncontrolled development of new neighborhoods. Coinciding with this, the aging population and aging rate are moving forward. The critical question is therefore how to mitigate the negative impacts of urbanization on the development of new neighborhoods.

Developed cities in Asia also face a new type of problem now. Marking the 50th anniversary of the New Towns Act, passed in 1996 in the United Kingdom, The Times newspaper featured the current reality of “Old New Towns”. It raised an alert that social exclusion has been caused by the aging facilities and residents in neighborhoods which had been developed around small villages along highways and railways. Similar to the United Kingdom, Japanese new towns are now becoming “old” new towns. The younger generation leaves the towns located in urban suburbs to downtown, and subsequently the whole new towns urgently ages, causing a collapse of communities and imposing transport constraints on the residents. Approximately 15 years behind the UK, the debate on how to break the negative chain reaction is spreading in Japan as well. Therefore, it is not possible to say conclusively whether the developing cities in Asia will also have to confront this issue in the future.

In the neighborhood planning field, the concept of self-containment has been embodied in the planning objectives of a variety of neighborhoods. Besides, in the transportation field, growing interest in the above issues has led to proposals for policies related to how transport and neighborhood planning affects household's and individuals' residential and travel choices. This study attempts to expand the concept of self-containment to travel behavior analysis in a neighborhood.

1.2 Research Motivation

Based on the above background, this study is motivated by the following five aspects.

First, forms of neighborhood planning have changed over the years, reflexing evolution of neighborhood planning over the time. Some typical forms are the neighborhood planning unit, urban renewal, community action, municipal neighborhood planning, community economic development planning, and traditional neighborhood design, transit-oriented development (Rohe, 2009).

In addition, there has been more attention associated with uncertainties. Neighborhood planning is often done before residents have actually lived in the neighborhood for a long time, while people have learned to live with day-to-day uncertainties and to make their decisions and choices in with their presence. Therefore, it is necessary to find a solution or a concept in neighborhood planning that can be adaptive over the time.

Second, the concept of self-containment has been embodied in the planning objectives of a variety of neighborhoods, especially in Europe and the United States. This concept was originally promoted by Ebenezer Howard via the Garden City Movement, in which was planned as self-supporting communities (Howard, 1898, cited Cervero, 1995a) were planned in order to relieve London from overcrowding in the post-World War II period. Conventionally, it is usually interpreted as the balance between jobs and housing (i.e., job-housing balance) in a community. However, with rapid urbanization and motorization, working places are no longer limited to residential neighborhoods and towns, and commuting has attracted attention as an environmental issue. As a result, the notion of self-containment in a conventional way would be not appropriate, and thus needs to be adapted to reflect current issues.

Third, from the planning perspective, neighborhood level is an important complement to comprehensive planning for the distinctive physical and social characteristics at the smallest geographical unit, providing an important mechanism for integrating public policy interventions. In other words, to tackle some problems facing towns, cities, nations, and even the world, handling the problems at the neighborhood scale is the most effective. In addition, with rapid urbanization, governments have paid attention to a variety of dilemmas at city and nation levels, and have been unable to address lower level, neighborhood issues. This has meant that the supply side has not caught up with demand side in the neighborhood. In this case, it seems better if the local resources can be utilized to reduce the burden for the government. Residents may contribute by investing economically and socially into the areas surrounding their houses, contributing to maintain or revitalize the neighborhood if they are more motivated to participate. Considering these things from the field of travel behavior analysis, it is thus necessary to focus on travel behavior of residents living in the neighborhood.

Fourth, a majority of neighborhood planners have approached pervasively physical design and attempted to build a sense of community via specific design elements (integrating residential and public spaces, careful designs and layouts of infrastructure in the neighborhood). In other words, social goals have been the key-stone of neighborhood design. Hence, social engagements or the social capital of residents living should also be reflected in travel choice behavior models.

Fifth, in the field of travel behavior analysis, with the four-step modeling approach, travel mode and destination choices remarkably depend on individual decision and assumed to be easily changed. In addition, residents' travel mode and destination choices seem to be an obvious measurement to assess the awareness handling the environmental issue. Thus, this study argues that travel mode choice and destination choice behavior in a neighborhood need to be considered jointly.

In this study, two key hypotheses regarding self-containment are included:

- The self-contained neighborhood may improve the quality of life for residents living there.
- Factors affecting the level of self-containment may different over neighborhood societies in terms of time and space.

1.3 Aims and Objectives

The aim of this study is to shed light on people's travel choices for sustainable development of new urban areas by to expanding the concept of self-containment in neighborhoods and examining it empirically.

Based on the key hypotheses mentioned in the previous section, there are several research questions related to travel choice and neighborhood in both developed and developing countries:

1) What is the concept of self-containment in neighborhood planning?
2) Is travel mode choice affected by topographical factors in a self-contained aging neighborhood?
3) Is travel mode choice affected by income level in a self-contained neighborhood, before aging population?
4) Is self-containment affected by social network distribution in an aging neighborhood?

5) Is self-containment affected by social capital in a neighborhood, before population aging?
6) Does self-containment enhance the subjective well-being of residents?
7) Does social interaction among residents in the neighborhood's network have an influence on residents doing activities inside the neighborhood area?

To answer these research questions, there are several specific tasks to be carried out, as follows:

i) To expand a concept of self-containment in neighborhood planning.
ii) To examine the relationship between travel destination choices and subjective well-being.
iii) To examine the influence of social network distribution on destination choice in an aging neighborhood.
iv) To examine the influence of social capital on destination choices in a neighborhood before population aging.
v) To examine the influence of topographical factors on travel mode choices in a self-contained aging neighborhood.
vi) To examine the income effects on travel mode choice in a self-contained neighborhood before population aging.
vii) To examine endogenous effect of social network on destination choice in the neighborhood.

1.4 Outline of the Thesis

The research framework and chapter structure of the dissertation are presented in Figure 1.2 and Figure 1.3, respectively. The research framework is to emphasize two ways of interactions (i.e., feedback effects) between travel behavior and three different factors (consist of neighbourhood, individual attributes and social effects). To highlight the importance of the feedback effects, two temporal dimensions as short-term and long-term should be mentioned. In particular, providing amenities and service inside the neighborhood are planned or designed by neighborhood' planners, and hence, these built environment and services whithin a neighborhood are considered as exogenous in the short-term period. Then, residents living in the neighborhood behave to neighbourhood, individual attributes and social effects in the long-term period, and thus, these factors become endogenous. For instance, aging new towns in Japan after 50 years of development (i.e., almost approaching the equilibrium stage) currently almost of neighborhood attributes and services have been gone, as a result of residents lived in may not tend to use these attributes and services. Therefore, since neighborhood planning is done for the long-term development of neighbourhood, it is essential to focus on the endogenous effects for neighborhood planning. In addition, subjective well-being (SWB) is to represent an evaluation part for the proposed framework in this study. Here, SWB may be a current satisfaction as a short-term measurement, may be accumulated satisfaction in a long term.

An individual's SWB also is obtained not only his/her behaviour but also others' behaviour. It should be noted that there are several indicators that can represent for the evaluation part for the framework, and SWB would be one of them.

The dissertation consists of eight chapters and appendices. The background, research motivation, and aim and objectives of this research are described in this chapter. The remainder of the dissertation is organized into the following chapters:

Chapter 2 broadly reviews the literature on neighborhood planning: a concept of self-containment. Generally speaking, a majority of urban planners have approached neighborhood design through physical design and attempted to build a sense of community via specific design elements. The idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process, and the process is primarily nurtured through the promotion of social solidarity and resident bonding, whereby existing problems are handled collectively. The conventional concept of self-containment was associated with job-housing balance embodied in neighborhood planning. However, with rapid motorization and the evolution of complex social networks and modern lifestyles, residents could not entirely conduct their activities inside the limited boundaries of neighborhoods and town. As a result, the concept of self-containment in a conventional sense would be not appropriate as a framework for analyzing new urban areas in developing countries.

Chapter 3 describes the study locations and surveys used in this study. Data employed in this study were primarily collected from paper-based questionnaire surveys, with some data also from GPS-based devices. In order to draw from both a developed country and a developing country context, the data were drawn primarily from two study sites: Koyo New Town in Hiroshima, Japan, and new urban areas in Hanoi, Vietnam.

Chapters 4 and 5 then consider travel behavior from the perspective of travel mode choice. Chapter 4 focuses on a hilly neighborhood called Koyo New Town in Hiroshima City, Japan, where a multi-period (two waves) and multi-day (two weeks) panel survey was conducted in 2010 and 2011. The survey consisted of a GPS-based survey and a paper-based travel diary survey. In addition, a travel mode choice model is developed based on a panel mixed logit model. Heterogeneities are captured by introducing random effects in parameters of topographical factors, which are measured in terms of altitude difference, intensity of up/down movement, maximum slope, and changing slope. Furthermore, effects of introducing personal mobility vehicles (PM) to mitigate negative impacts of topographical factors are also evaluated.

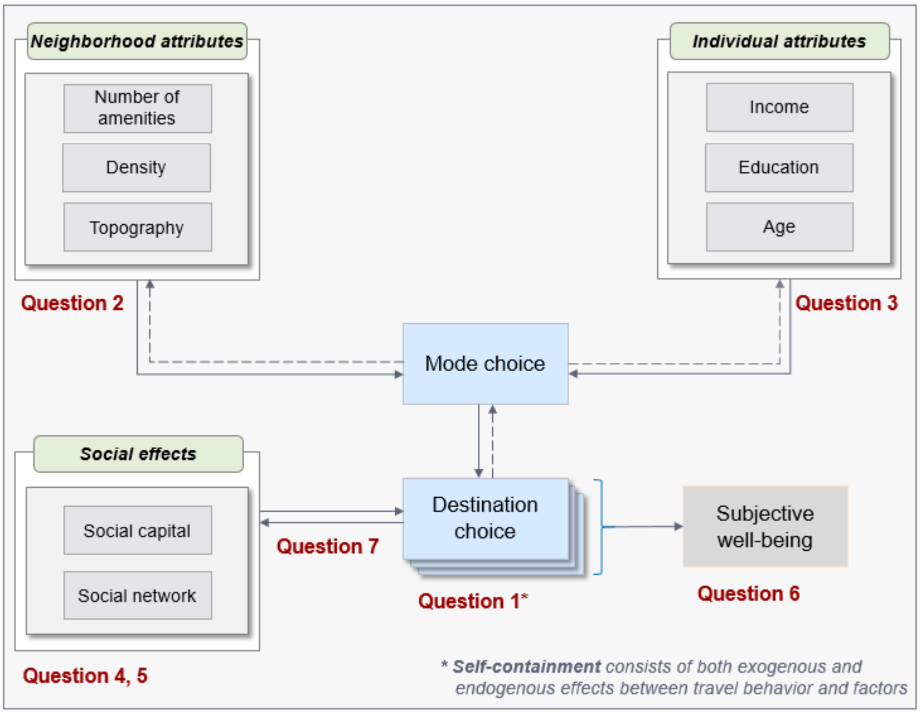
Chapter 5 focuses on travel mode choice in Hanoi Metropolitan Area of Vietnam and develops a path model with multiple discrete choices. In the path model, a mediation model is proposed, in which the mediation effects of income on travel mode choice are captured via residential location choice being modeled as a discrete mediator which generates non-linear indirect effects of income on mode choice. As a comparison, a joint model of residential location and travel mode choices is built with only direct effects of income on both choices. This model is then tested using data collected at three new urban areas in Hanoi in 2015.

Chapters 6 and 7 look at travel behavior from the perspective of destination choice. Chapter 6 explores the self-containment status of new town for discretionary activities (shopping, volunteer, recreation and so on), by using a multi-period (two waves) and multi-day (two weeks) panel survey data collected in Koyo New town located in Hiroshima, Japan. For this purpose, a panel mixed logit model of destination choice with a focus on the impacts of social networks is developed. The analysis also looks at the question of whether or not self-containment contributes to the improvement of residents' subjective well-being.

Chapter 7 explores the impacts of social capital measured in two dimensions, social network and participating in local community activities, on travel choice for discretionary activities. For this purpose, by using data collected in Hanoi, Vietnam, a logit model for destination choice and an ordered probit model for trip generation were developed, controlling for socio-demographic characteristics, mobility and accessibility, and built environment factors.

Chapter 8 examines the endogenous effect of social network on destination choice in the neighbourhood, is an example examining the feedback effects. A logit model for destination choice was developed, controlling for socio-demographic characteristics, trip context, mobility, accessibility, group fixed-effects, and expected probability of the individual's acquaintance choosing the destination inside the neighborhood area (i.e. endogenous social interaction effects). As an initial example, the model is estimated using data collected in three new neighborhood areas in Hanoi Metropolitan Area of Vietnam in 2015.

Chapter 9 is the final chapter, where the conclusions and limitations of the research are presented, as well as some suggestions for future studies.



Note: The dash lines show possible causal-relationships that are not examined in this study

Figure 1.2: Research framework

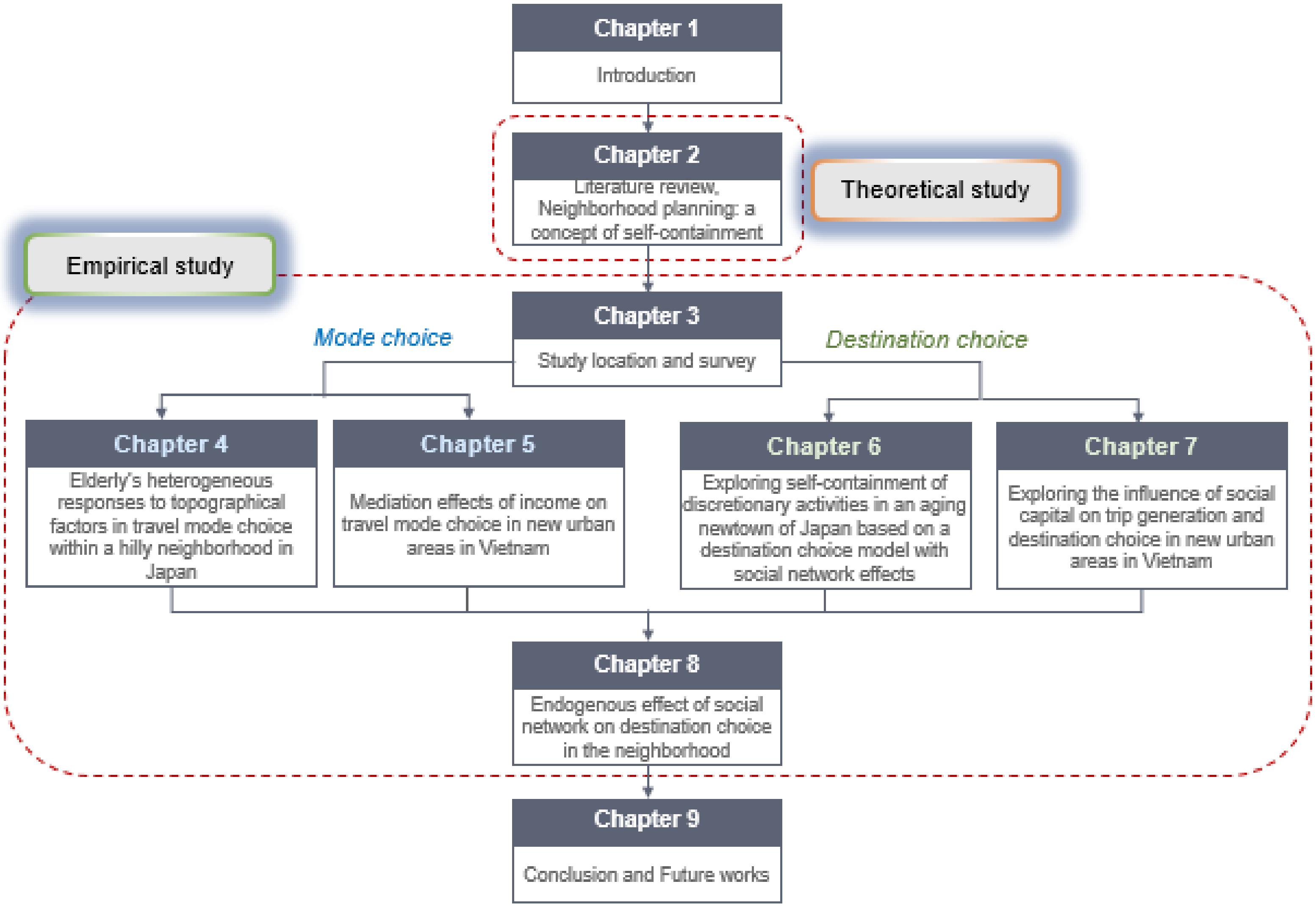


Figure 1.3: Chapter structure

2 LITERATURE REVIEW, NEIGHBORHOOD PLANNING: A CONCEPT OF SELF-CONTAINMENT

This chapter broadly reviews the literature on neighborhood planning with a focus on the concept of self-containment will be discussed. Then, a new concept of self-containment, in theory, will be newly proposed. To confirm the theory, an example of a shopping destination choice will be estimated.

2.1 Introduction

Rapid urban population growth around the world led many governments to promote the development of new urban areas, such as new towns or so-called "new neighborhoods" which are located outside the urban core, in order to relieve housing shortages in the city center. In some cases, these new urban areas fell into decline after several decades of neighborhood development. Some common issues associated with the decay are mobility problems (a reduction in the level-of-service of local public transport to central urban areas and the decline of physical abilities of the residents) and changes in spatial activities of residents living in the neighborhood. A typical example is the aging new towns in Japan, which are currently witnessing these problems after approximately 50 years of development.

Although there are many definitions of neighborhood (Kallus and Law-Yone, 2000; Minnery *et al.*, 2009), a common idea underlying these definitions is that the neighborhood is physically located in suburban areas of cities. The objectives of neighborhood planning typically are to achieve good physical and social environments. Rohe (2009) has discussed six forms of neighborhood planning that reflects the history and evolution of neighborhood planning over the last 100 years. They consist of (1) the neighborhood planning unit, (2) urban renewal, (3) community action, (4) municipal neighborhood planning, (5) community economic development planning, and (6) traditional neighborhood design, transit-oriented development (TND, TOD). Due to increasingly crowded and congested conditions in cities in the early days, Perry (1929) proposed the concept of neighborhood unit - a good neighborhood design embodied in neighborhood plans later - which could incite a sense of community and which should be nourished to bring civic benefits, moral and social values to residents. The latest form of neighborhood planning (TND, TOD) underlines building form, mixed land uses, higher density and walkability (Boarnet and Compin, 1999; Cervero, 1994). In general, a majority of neighborhood planners have focused on physical design, and attempted to build a sense of community via specific design elements, for example, by integrating residential and public spaces, careful designs and layouts of infrastructure in the neighborhood.

Some physical urban planners advocate that neighborhood forms affect social behavior, such as local social interaction. In other words, in their view, the notion of community is tied to physical design which is seen as fixed after neighborhoods are constructed. Talen (2000) has stated that the idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process and that this process is primarily nurtured through the promotion of social solidarity and resident bonding whereby existing problems are handled collectively. Madanipour (2001) notes that neighborhood planning is under severe criticism because it emphasizes the physical rather than the social setting. As a result, such planning may create physical proximity among residents, but it may not create social bonds among them – a benchmark of a community.

With an awareness of environmental issues, the concept of neighborhood emphasizes environmentally friendly forms in which the need for using motor vehicles is reduced, and walking/cycling is increased. New settlements which also provide employment and other services are considered as an environmentally positive form. The idea of this form is analogous to Ebenezer Howard's concept of self-containment via the Garden City Movement, in which self-supporting communities were planned in order to relieve London from overcrowding in the post-World War II period (Howard, 1898, cited Cervero, 1995a). The concept of self-containment was embodied in the planning objectives of many new towns, especially in Europe and the United States. A typical example of this form was the British New Towns program, self-sufficient new towns with almost everything needed for life in the town, allowing people to live, work, go shopping and enjoy recreational activities within new towns (Madanipour, 2001). However, with rapid motorization and complex social networks and modern lifestyles, residents could not entirely conduct their activities inside the limited boundaries of neighborhoods and town. As a result, the concept of self-containment in the conventional sense would be inappropriate as a model today.

Motivated by the above discussions, a new concept of self-containment is needed to consider the achievement of social goals as well as to handle environmental issues in neighborhood planning.

2.2 Theorized linkage between neighborhood planning and social capital

Social capital and the concept of a neighborhood are concerns of policy-makers today, due to a decline in the ability of local areas to handle local issues by themselves. It is therefore worth examining the association between neighborhood and social capital. Social capital is an original term used in the discipline of sociology, and is complicated because it has a variety of different definitions. Social capital refers to the advantages an individual can gain from social participation/networks, reciprocity and mutual trust (Putnam, 1993). Social capital can also be a dimension of neighborhood social environment associated with neighborhood services and physical environments which shape the health of residents (Hanibuchi *et al.*, 2012). In policy terms, in order to move from abstraction into implementation, there are eight domains socially linking with appropriate neighborhood policies (Forrest and Kearns, 2001). Social capital plays an important role in neighborhood stability, and neighborhoods with higher levels of social capital (measured by socio-cultural and institutional milieus) tend to remain stable over time (Temkin and Rohe, 1998). Residents with high levels of social capital are more likely to be politically active, to be engaged socially, to meet more frequently with friends and neighbors, and to trust others (Coleman and Coleman, 1994; Putnam, 1993).

Theoretically, different forms of neighborhood design will tend to promote or discourage social capital development since built environment factors influence social participation. Well-designed neighborhoods, where facilities are within walking distance and do not require the use of cars, enable residents to conduct their daily activities easily (e.g. daily shopping, doing exercise, taking children to kindergartens or schools, and so on), and hence, foster resident interaction (Cohen *et al.*, 2008; Leyden, 2003; Lund, 2002; 2003; Podobnik, 2002; Rogers *et al.*, 2011; Talen, 1999; Wood and Giles-Corti, 2008). However, some studies have found that there is no relationship among walkability and social capital. For example, from a survey in Australia, Du Toit *et al.* (2007) found no relationship between walkability and local social interaction, although there was a weak relationship between their walkability index and sense of community. Based on data from a Japanese sample, Hanibuchi *et al.* (2012) also found that the relationship between walkability score and any social capital indices is not significantly positive.

In the transportation field, the association between social capital and travel choice behavior can be shown in Figure 1. Self-containment - collectively individual behavior within neighborhood – is a platform representing the relationship between neighborhood planning and social capital.

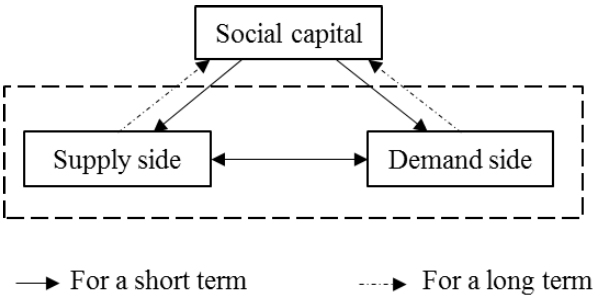


Figure 2.1: The relationship between transport and social capital

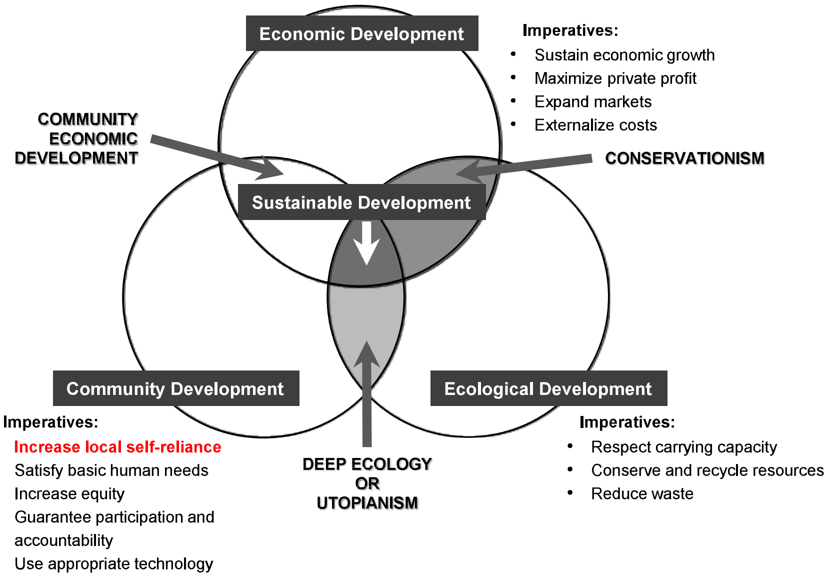
2.3 Self-containment

2.3.1 Foundation theories

City size has been a research and policy concern for a long time. According to Plato (ca. 350 BC), the optimal city size is determined by the exact number of citizens (7! = 5040 males). Aristotle (ca. 340 BC) set the optimal city size by *self-sufficiency:* “A city only comes into being when the community is large enough to be self-sufficing. If then self-sufficiency is to be desired, the lesser degree of unity is more desirable than the greater” (Ioannides, 2013). Ioannides adopts a market-based approach to optimal city size that results from individuals seeking to maximize their utilities as the equilibrium city size.

The concept of self-containment was embodied in the planning objectives of many new towns, especially in Europe and the United States. This concept was first promoted by Ebenezer Howard via the Garden City Movement, in which self-supporting communities were planned in order to relieve London from overcrowding in the post-World War II period (Howard, 1898, cited Cervero, 1995a). Conventionally, it is usually interpreted as a balance between jobs and housing (i.e., job-housing balance) in a community. Taking a broader perspective, self-containment is considered as a form that allows people to live, work, go shopping and enjoy recreational activities within a community (Burby & Weiss, 1976, cited fromCervero, 1995a). In other words, a self-contained area physically contains all necessary aspects of community life, including employment. A typical example of this form was the British New Towns program, where self-sufficient new towns had almost all things needed for life in the town that allows people to live, work, go shopping and enjoy recreational activities within the town (Madanipour, 2001). However, due to the nagetive consequences of motorization, there has been an increase in attention on environmental issues. In the fields of transport and neighborhood planning, environmental issues are often handled by reducing vehicle travel miles. In other words, environmentally friendly neighborhoods are where residents use environmetally friendly travel modes (i.e. the need for using motor vehicles is reduced, and walking/cycling is increased). New settlements which provide employment and other services are also considered as an environmentally friendly form.

According to Newman and Kenworthy (2009), the concept of sustainability is a global political process including three distinct development processes: economic development, community development and ecological development (see Figure 2.2). Each process has its own distinct imperatives. One of the key imperatives for community development is increased local self-reliance.



Source: International Council on Local Environmental Initiative (1996)

Figure 2.2: The concept of sustainability

2.3.2 Existing studies

From a planning and policy perspective, a high rate of self-containment level indicates that local residents are satisfied with a set of land use and transport conditions, contributing to reduced automobile use and thus devoted to regional environmental sustainability (Yigitcanlar *et al.*, 2008). Healy and O'connor (2001) suggest that "smart urbanization could really mean self-contained suburb development, and a smart policy could be one that enhanced suburban self-containment". This stream has resulted in a number of studies discussing self-contained neighborhoods with regard to commuting trips (Cervero, 1995a; Curtis and Olaru, 2010; Hui and Lam, 2005; Merlin, 2014; Miller, 2011; Yigitcanlar *et al.*, 2008). In terms of self-containment arguments of new towns, some researchers focus on non-work trip patterns (Lee and Ahn, 2005; Merlin, 2014), while others address both work and non-work trips (Jun, 2012; Pakzad *et al.*, 2007). Especially in non-work trips, availability and attractiveness of travel modes within new towns would affect destination choices, which eventually determine the level of self-containment.

2.3.3 The concept of self-containment in this study

From the above-mentioned discussion, the concept of self-containment should be further examined (see Figure 2.3). First, this concept should be adopted from a market-based approach. This means that the concept should be considered from both supply side and demand side. Second, unlike new towns in Western countries, newly developed neighborhoods in Asian cities have not developed together with industrial areas, and thus the original concept of keeping a job-housing balance within the neighborhood seems not possible. Instead, the level of self-containment may be better understood by looking at non-working activities, rather than working activities, and shifting the focus to the availability and attractiveness of travel modes within new towns and how these affect destination choices. Third, as mentioned in the previous section, community development should be a fluid process, which is primarily nurtured through the promotion of social solidarity and resident bonding whereby existing problems are handled collectively. Therefore, in order to address the process, endogenous effects should be included in the concept of self-containment in a neighborhood. It should be noted that this study does not focus on a clarification of the causal relationship between travel behavior and self-containment. In other words, travel behavior is correlated with self-containment in this study. The concept of self-containment for neighborhood planning is a broad concept, and it may be defined differently in different fields. From a viewpoint of travel behavior, the level of self-containment is defined through the travel choice behavior in the final stage of equilibrium with a consideration of endogenous effects. Concretely speaking, the concept of self-containment is defined by considering not only traditional way (i.e. ratio of collective behavior of destination choices to inside and outside the neighborhood) but also endogenous social networks at the final stage of equilibrium. It should be noted that this study does not target to show level of self-containment of a neighborhood by a spectific number (i.e., how many percentage of travel choice behavior inside the neighborhood). As a simple example about what is level of self-containment of a neighborhood. In case of destination choice of shopping behavior, there is 60% of shopping activities within the neighborhood. Then, as a traditional way, 70% of the activities is higher self-contained, and 50% of the activities is lower self-contained. However, it comes to the case that the neighborhood with 60% of the activities within and 40% of the activities done outside by socially support via friends' network or social media service, leading to that level of self-containment would increases compared to the case of 70% activities. Therefore, the level of self-containment of the neighborhood needs be examined by endogenous effects of the factors (neighborhood, individual attributes and social effects) on travel choice behavior rather than showing the targeted percentage of travel behavior inside the neighborhood.

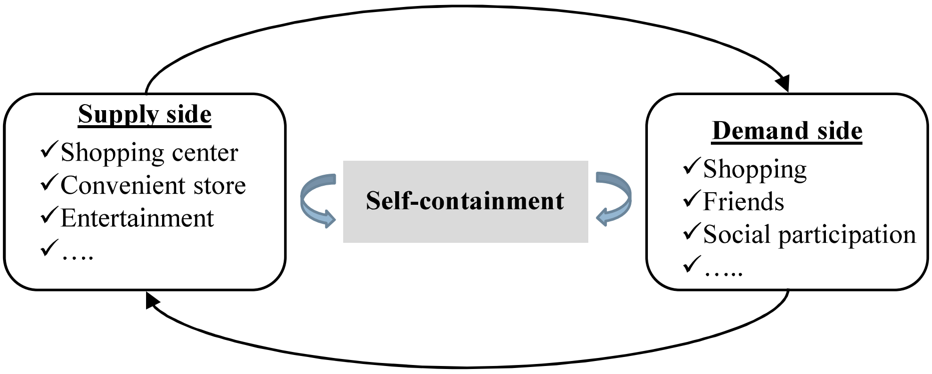


Figure 2.3: The concept of self-containment

2.4 Equilibrium

One fundamental approach for presenting supply-demand interactions is equilibrium. Although equilibrium is usually examined at the city level, the equilibrium also needs to be investigated at the neighborhood level. From the planning perspective, neighborhood level is an important complement for comprehensive planning, given the distinctive physical and social characteristics of the smallest geographical unit, providing an important mechanism for integrating public policy interventions. In other words, to tackle some of the biggest problems facing our towns, cities, nations, and even the world, handling the problems at the neighborhood scale is required. In addition, residents may be interested in investing economically and socially in the areas surrounding their houses. Thus, they can maintain or revitalize the neighborhood if they are more motivated to participate in it.

The utility $U_{in(i)}$ that an individual i in a population $N_{n(i)}$ living in a neighborhood $n(i)$ chooses a destination within the neighborhood with regard to discretionary activities, can be written as

$$\begin{aligned} U_{in(i)} &= V_{in(i)} + \varepsilon_{in(i)} \\ &= \alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + J_1 S_{n(i)} + J_2 W_{n(i)} + \varepsilon_{in(i)} \end{aligned} \tag{2-1}$$

where $V_{in(i)}$ denotes deterministic or observable portion of the utility function, X_i denotes a set of individual-specific controls, $Y_{n(i)}$ denotes a vector of neighborhood-specific controls (often called contextual effects), $SC_{n(i)}$ denotes social capital in neighborhood $n(i)$, $S_{n(i)}$ denotes attractiveness of neighborhood's non-market and can be taken as representing non-market interaction (social capital interaction) in neighborhood $n(i)$ (often called endogenous effects), $W_{n(i)}$ denotes attractiveness of a neighborhood's market and can be taken as representing market interaction in neighborhood $n(i)$ (often called endogenous effects), and $\alpha_{in(i)}$, β, γ, φ, J_1, J_2 are unknown parameters; $\varepsilon_{in(i)}$ is a random utility term, independently and identically distributed across individual i.

The probability P_i of individual i choosing destination inside the neighborhood is

$$P_{in(i)} = \frac{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + J_1 S_{n(i)} + J_2 W_{n(i)}\right)}{\sum_m \exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + J_1 S_{n(i)} + J_2 W_{n(i)}\right)} \tag{2-2}$$

2.4.1 Market interaction

Harris and Wilson (1978) have suggested that $W_{n(i)}$ is usually interpreted as the attractiveness of a neighborhood's market and is measured as a function of market capacity $A_{n(i)}$

$$W_{n(i)} = f(A_{n(i)}) \tag{2-3}$$

From the supply side, a producer may be a private entrepreneur or a public authority, and a differential equation $\partial A_{n(i)} / \partial t$ is taken to represent profit-maximization of producer's behavior

$$\partial A_{n(i)} / \partial t = a.\Pi_{n(i)} = a\left(bR_{n(i)} - p_{n(i)}A_{n(i)}\right) \tag{2-4}$$

where, $\Pi_{n(i)}$ represent *profit* (assuming that a producer can obtain a profit), a is positive constant, b is nonzero constant, $p_{n(i)}$ denotes cost per unit of market capacity, $R_{n(i)}$ is total revenue in neighborhood $n(i)$.

At equilibrium, $\partial A_{n(i)} / \partial t = 0$, and so equation (2-4) implies that

$$A_{n(i)} = \frac{b}{p_{n(i)}} R_{n(i)} = \frac{b}{p_{n(i)}} D_{n(i)} \tag{2-5}$$

Inserting (2-5) into (2-3)

$$W_{n(i)} = f\left(D_{n(i)}\right) \tag{2-6}$$

2.4.2 Non-market interaction

Individuals living and doing activities in the neighborhood have numerous opportunities of communication with their neighbors or acquaintances, creating a number of interactions. It is assumed that rising interactions leads to a need to increase the capacity of facilities in the neighborhood.

The attractiveness of neighborhood's non-market can be taken as representing non-market interaction (social capital interaction) in neighborhood $n(i)$ and is assumed as a function of demand for facilities in the neighborhood:

$$S_{n(i)} = g\left(D_{n(i)}\right) \tag{2-7}$$

To explain the common phenomenon that an individual tends to behave similarly with other members of his/her reference group, Manski (1993) has developed a social interaction model with three hypotheses (endogenous effect, exogenous effect, and correlated effect). Since only endogenous effect generates social multiplier among these effects, studies about a social interaction have often attempted to capture the endogenous effect.

The demand of an individual i doing discretionary activities within the neighborhood can be written as

$$D_{in(i)} = P_{in(i)}\, Fre_i \tag{2-8}$$

where Fre_i denotes the frequency of individual i doing discretionary activities.

The total demand of residents doing discretionary activities within the neighborhood is

$$D_{n(i)} = \frac{\sum_i P_{in(i)}}{N_{n(i)}} \sum_i^{N_{n(i)}} Fre_i = \overline{P_{n(i)}} \sum_i Fre_i \tag{2-9}$$

where $\overline{P_{n(i)}}$ is average probability in neighborhood *n(i)*

Substituting (2-6) and (2-7) into (2-2), there is a detailed form expression for probability of individual choice,

$$P_{in(i)} = \frac{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + J_1 g\left(D_{n(i)}\right) + J_2 f\left(D_{n(i)}\right)\right)}{\sum_m \exp\left(\alpha_{im(i)} + \beta X_i + \gamma Y_{m(i)} + \varphi SC_{m(i)} + J_1 g\left(D_{m(i)}\right) + J_2 f\left(D_{m(i)}\right)\right)} \tag{2-10}$$

2.4.3 Identification

Under plausible assumptions, identification of parameters is an important issue for a model concerning social capital, endogenous effect, and interaction. Meanwhile, whether equation (2-10) is economically identified is also important. The potential for identification has been established in the context of neighborhood effects or endogenous effects or social capital effects in the literature (Brock and Durlauf, 2001a; 2001b; Durlauf, 2002; Durlauf, 2004; Manski, 1993). To focus attention on this question, there are three assumptions:

(a) Residents' destination choices for discretionary activities are binary choices (inside or outside the neighborhood), simplifying to derive an equilibrium analysis;

(b) Only residents living in the neighborhood are consumers of the neighborhood's facilities, enabling data collected from residents in the neighborhood to be used;

(c) The relationship between attractiveness (both market and non-market of neighborhood) and demand for neighborhood's facilities is assumed to be linear, since it would be difficult to analyze if the relationship is a non-linear relation.

Based on these assumptions, probability of individual choice (2-10) can be revised as

$$P_{in(i)} = \frac{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + J_1 k_1 D_{n(i)} + J_2 k_2 D_{n(i)}\right)}{1 + \exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta D_{n(i)}\right)} \tag{2-11}$$

where $\delta = \left(J_1 k_1 + J_2 k_2\right)$ denotes an unknown parameter.

In this case, the probability of an individual's choice takes on the value 1 for the activities inside the neighborhood, and 0 for the activities outside the neighborhood.

The total demand of residents doing discretionary activities within the neighborhood with number of sample size $n_{n(i)}$ is extrapolated as

$$D_{n(i)} = \overline{P_{n(i)}} \frac{N_{n(i)}}{n_{n(i)}} \sum_i^{n_{n(i)}} Fre_i = \overline{P_{n(i)}} Fre_{n(i)} \tag{2-12}$$

Inserting (2-12) into (2-11)

$$P_{in(i)} = \frac{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta \overline{P_{n(i)}}\ Fre_{n(i)}\right)}{1 + \exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta \overline{P_{n(i)}}\ Fre_{n(i)}\right)} \tag{2-13}$$

Brock and Durlauf (2001a; 2001b) has proposed equilibrium under proportional spillovers of the model. This means that the individual makes his/her choices given an expectation of the average choice level. In particular, $\omega_{in(i)}$ individual's choice (taking on the value 1 for the activities inside the neighborhood, and the value -1 for the activities outside the neighborhood), can be written as

$$\omega_{in(i)} = 2P_{in(i)} - 1 \tag{2-14}$$

The expected value of individual's choice, conditional on his/her decisions regarding the behaviors of others in the neighborhood, can be written as

$$\begin{aligned} \mathrm{E}\left(\omega_{in(i)}\right) &= \frac{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + cD_{n(i)}\right) - 1}{\exp\left(\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta D_{n(i)}\right) + 1} \\ &= \tanh\left(\frac{\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)}}{2} + \frac{\delta D_{n(i)}}{2}\right) \end{aligned} \tag{2-15}$$

Inserting (2-14) into (2-12)

$$D_{n(i)} = \frac{Fre_{n(i)}}{2} + \frac{Fre_{n(i)}}{2}\mathrm{E}\left(\omega_{in(i)}\right) \tag{2-16}$$

Inserting (2-16) into (2-15)

$$\mathrm{E}\left(\omega_{in(i)}\right) = \tanh\left(\frac{\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta Fre_{n(i)}}{2} + \frac{\delta Fre_{n(i)}}{4}\mathrm{E}\left(\omega_{in(i)}\right)\right) \tag{2-17}$$

In the equation(2-17), $\alpha_{in(i)}$, β, γ, φ, k_1, k_2, J_1, J_2 are unknown parameters

With $A = \frac{\alpha_{in(i)} + \beta X_i + \gamma Y_{n(i)} + \varphi SC_{n(i)} + \delta Fre_{n(i)}}{2}$; $B = \frac{\delta Fre_{n(i)}}{4}$, the final equation of existence of equilibrium for individual's choice can be reduced as

$$m^* = \tanh\left(A + B\,m^*\right) \tag{2-18}$$

Multiple equilibria are not possible unless there is the existence of multiple average choice levels in equilibrium in Equation (2-18). Conditions for the existence can be based on the properties of the tanh(.) function

(1) If $B < 1$ and $A = 0$, there exists a unique root to equation (2-18)
(2) If $B > 1$ and $A = 0$, there exists three roots to equation (2-18)
(3) If $B > 1$ and $A \neq 0$, there exists a threshold H, such that
    (a) $|B| < H$, there exists three roots to equation (2-18)
    (c) $|B| > H$, there exists a unique root to equation (2-18)

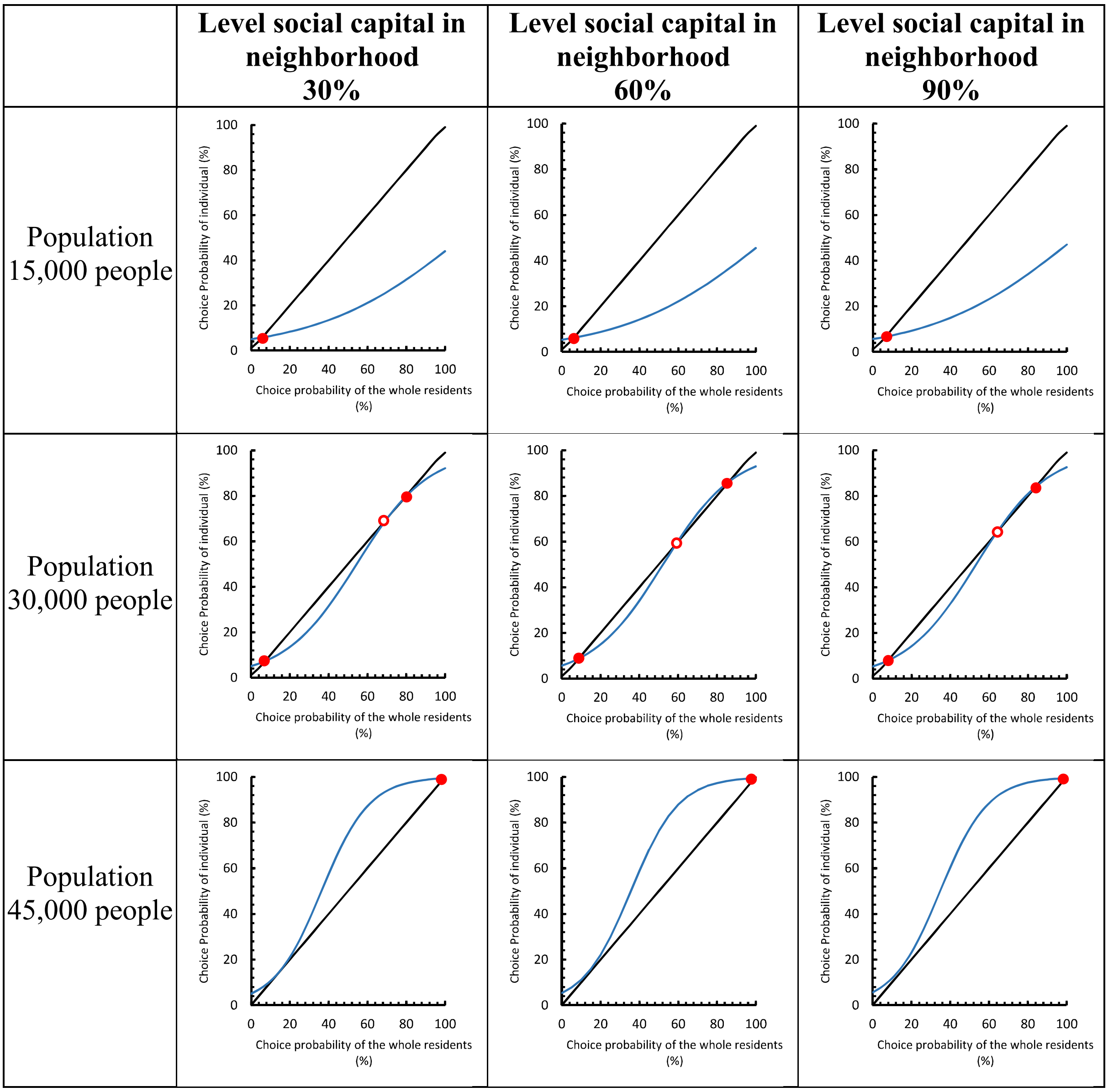
There is a potential for multiple average equilibrium choice levels when $Fre_{n(i)}$, the total demand of residents doing discretionary activities within the neighborhood, is bigger than $4/(J_1k_1+J_2k_2)$.

2.5 Simulation

An example is taken to confirm the behavior of the model and examine the change of equilibrium with different factors, where all parameters are assumed to be applicable. Particularly, the behavior of the model is dropped in terms of shopping activities since the model can be broadened to apply to other cases with the same formal model (Harris and Wilson, 1978), and shopping is a typical activity among discretionary activities within the neighborhood.

Focusing attention on equilibrium status over social capital levels, some factors, such as X_i individual-specific controls and $Y_{n(i)}$ denotes a vector of neighborhood-specific controls, are omitted in this proof analysis in order to simplify the calculation process. It is assumed that: an individual's frequency for shopping in the neighborhood is fixed to 2 trips per day; there are three levels of social capital and frequency; there are a set of parameters $\alpha_{in(i)} = -3.0$, $\varphi = 0.2$, $\delta = 0.9$.

The behavior of the model under the above-mentioned parameters and setting values can confirm that equilibrium significantly depends upon the population and social capital level in the neighborhood (see Figure 2.4), which is consistent with previous studies (Chikaraishi *et al.*, 2016; Nishikawa, 2017). In particular, if there are 15,000 people, the number of residents shopping inside the neighborhood slightly increases when there is an increase in social capital of the neighborhood. When the population triples (45,000 people), the probability of residents shopping in the neighborhood is extremely high without depending upon the social capital level. For the neighborhood with 30,000 people, it is interesting that the probability possibly falls into a low equilibrium (having low probability among two stable equilibrium points).



Note: ● : Stable equilibrium point; ○ : Unstable equilibrium point

Figure 2.4: Change of equilibrium with different levels of social capital and frequencies in the neighborhood

2.6 Conclusion

The majority of neighborhood planners tend to focus on physical design and thereby attempt to build a sense of community via specific design elements (integrating residential and public spaces, careful designs and layouts of infrastructure in the neighborhood). Such planners advocate that neighborhood forms affect social behavior such as local social interaction, and thereby can create a sense of community. The idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process. This process is primarily nurtured through the promotion of social solidarity and resident bonding whereby existing problems are handled collectively. The conventional concept of self-containment was previously associated with job-housing balance embodied in neighborhood planning. However, with rapid motorization and complex social networks and modern lifestyles, residents could not entirely conduct their activities inside the limited boundaries of neighborhoods and town. As a result, the concept of self-containment in the conventional sense is inappropriate.

This study examines the concept of self-containment with a focus on three elements: (1) from the perspective of a market-based approach, (2) with emphasis on non-working activities, instead of working activities, and (3) examined with endogenous effects. To handle this concept, conditions for identification of equilibrium is established. Then, a shopping destination choice is simulated to confirm the equilibrium again.

3 STUDY LOCATION AND SURVEY

Data employed in this study are primarily collected from paper-based questionnaire surveys and a minor part from GPS-based devices. Firstly, a panel survey was conducted in a new town in a developed country – with an aging population – in 2010 and 2011. During the two-week survey period at each wave, respondents were asked to fill out a paper-based travel diary and to record each trip trajectory using a GPS logging device. This part of data will be used in Chapter 4 and Chapter 6. Secondly, focusing on travel choice behavior in newly developed neighborhoods in a developing country - with a population before aging - a cross-sectional survey was conducted in three new urban areas in Hanoi Metropolitan Area (Vietnam) in 2015. This dataset was obtained only from the paper-based questionnaire and will be analyzed in Chapter 5 and Chapter 7.

3.1 Study location

3.1.1 Study in the developed country

Koyo New Town (current population: 17,000) is located in the north-east part of Hiroshima City, Japan, about 11 kilometers away from the city center. Koyo New Town is a typical aging new town in Japan and is characterized by steep slopes (i.e., the community center is located on the top of the hill) and a high proportion of elderly residents (i.e., currently the ratio of the elderly, who are 65 years old and over, to total population is around 26.7%). While there are railway and bus services to the city center, public transport services within the new town are relatively poor. The new town has a higher level of self-containment than others in Japan, in the sense that the community hall, shopping center, post office, banks, hospital, and sports club are all located in the community center.

Although Koyo New town administratively consists of four districts (Magame, Kamezaki, Ochiai, and Kurakake), the survey was conducted only in Magame and Kamezaki where the new town center is situated (Figure 3.1). As can be seen in Figure 3.1, where some examples of trips from the survey (O_1-D_1, O_2-D_2: blue lines) are also shown, the community center is located at the top of a hill. Such geographical features force the residents to move up and down to go to the center.

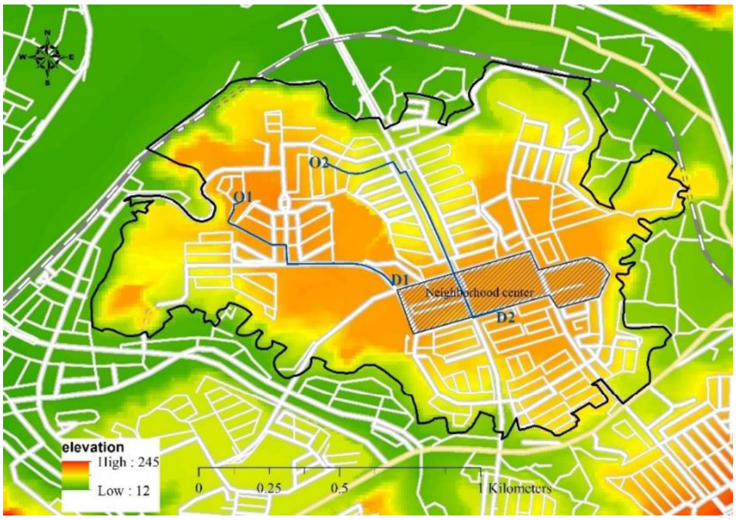
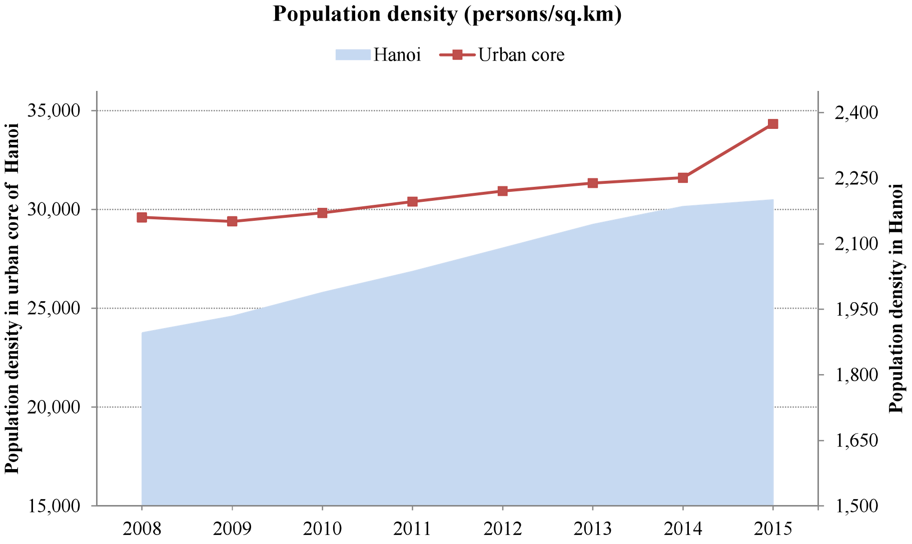


Figure 3.1: Study area: Koyo New Town in Hiroshima City, Japan

3.1.2 Study in the developing country

Hanoi is the capital city of Vietnam and is located in the north of the country. Before the expansion of its administrative boundary, Hanoi city was divided into four districts in the urban core, four districts in the urban fringe and four districts in the suburban area (JICA, 2007). The administrative boundary of Hanoi city was expanded towards the west in 2008. Hanoi now has ten inner districts mainly concentrated in the South of the Red River (Construction, 2009), one town at urban grade 3 and 20 townships at urban grade 51. A large number of migrants have moved to Hanoi in the last ten years, leading to the gradual increase in the population of Hanoi (WorldBank, 2011). As a result, the population density in the urban core in Hanoi is higher approximately 15 times than that in the whole of Hanoi, while population density of the whole of Hanoi increased by approximately 300 persons per square kilometer from 2008 to 2015 (see Figure 3.2).



Source: (Hanoi Statistical Office, 2008, 2010, 2011, 2013, 2015)

Figure 3.2: Population density in Hanoi city

3.2 Survey

3.2.1 Panel survey

A panel survey was carried out in Koyo New Town in 2010 and 2011. Considering that the elderly may tend not to make regular daily trips after retirement, a longer period was needed to trace their trip-making. As a result, a multi-day travel diary was adopted for capturing infrequent and irregular trips. To examine the effects of personal mobility vehicles or PM, to mitigate the topography-induced burden on the elderly, a social experiment was also conducted, where a newly developed PM on mitigating, as shown in Figure 3.3, was provided to residents. In principle, PM was given to respondents who wanted to use it, and in total ten respondents used such a vehicle in the second wave. Each wave covered two weeks.

	 (a) power-assisted two-wheeled bicycle	 (b) power-assisted three-wheeled bicycle	 (c) mobility scooter
Vehicle size (length × width × height [mm])	1,875×580×1,025	1,755×600×1,120	1,090×550×1,070
Engine	Electric power assist		Electric motor
Maximum speed	-	-	6.0 km/h
Distance per charge	Around 15km	Around 25km	
Driving license	Not required		

Figure 3.3: Personal mobility vehicles (PM) used in the experiment

With the support of Hiroshima City government and social welfare councils in Magame and Kamesaki, the survey was conducted on households with at least one elder member (60 years old and over). During the two-week survey period at each wave, household members were asked to fill out a paper-based travel diary, while one elderly member of each household was requested to record each trip trajectory using a GPS logging device. Particularly, the two-week travel diary in the first wave was designed based on the German Mobility Panel. It was found that some respondents answered the diary survey incorrectly in 2010. Most participants also gave critical comments on the diary design. To reflect these issues and concerns, the travel diary in the second wave was revised based on the Survey in Time Use and Leisure Activities implemented by the Ministry of Internal Affairs and Communications in Japan. More specifically, the paper-based questionnaire included questions relating household structure (number of household members, members' individual attributes, their relationship with household head, etc.), social networks (number of friends inside and outside the new town, number of relatives), vehicle ownership (number and type of vehicles owned), travel behavior (trip purpose, departure/arrival time, destination, and travel mode), and especially in 2011 the level of respondents' happiness measured by the Likert scale (0 to 10) was asked to report. As a result, around 50 households participated in each wave, with 38 households common to both waves. The population pyramid of the the people surveyed is shown in Figure 3.5, while the questionnaire used in this survey is given in Appendix 1.

3.2.2 Cross-sectional survey

A travel diary survey was conducted at three new urban areas in Hanoi Metropolitan Area, Vietnam. They are Van Quan, Viet Hung and Ecopark located in the inner and outer city of Hanoi (see Figure 3.4). These three areas were selected by considering the timing of the first group of residents moving into these locations and locations relative to Hanoi's Central Business District (CBD). Residents living in these different types of areas may have significantly different residential behaviors, which may be attributable to their travel mode choices. Of these new urban areas, only Ecopark is located outside of Hanoi City, about 11 kilometers away from the CBD. While Van Quan is a typical community of the first generation of urban development in Hanoi, Ecopark is one of the newly developed areas. Table 3.1 provides more detailed information about characteristics of the three new urban areas.

A face-to-face interview was adopted for this survey in October 2015. With the support of the University of Transport and Communications and the local community, the survey was conducted in households with at least one member aged 15 years old and over. The survey contents included three categories of information: (i) household attributes and individual characteristics; (ii) frequency to access facilities per month, people's satisfaction with current living area in term of transport environment and traffic safety; (iii) social network; and (iv) travel diary in two days (one weekday and one weekend day).

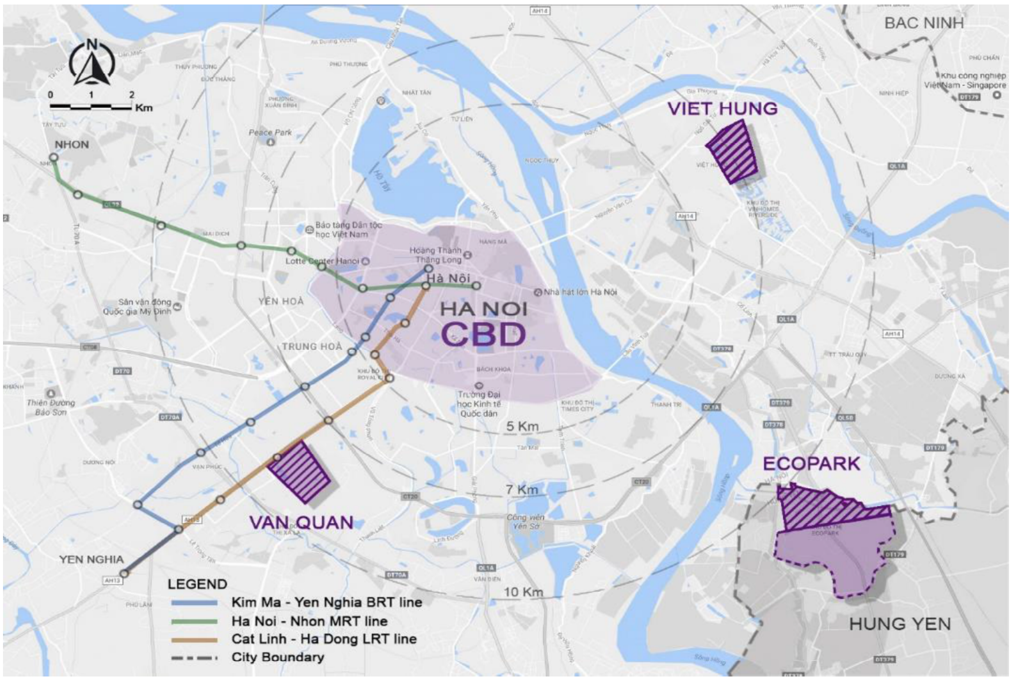


Figure 3.4: Locations of the three new urban areas

Table 3.1 Characteristics of the three new urban areas

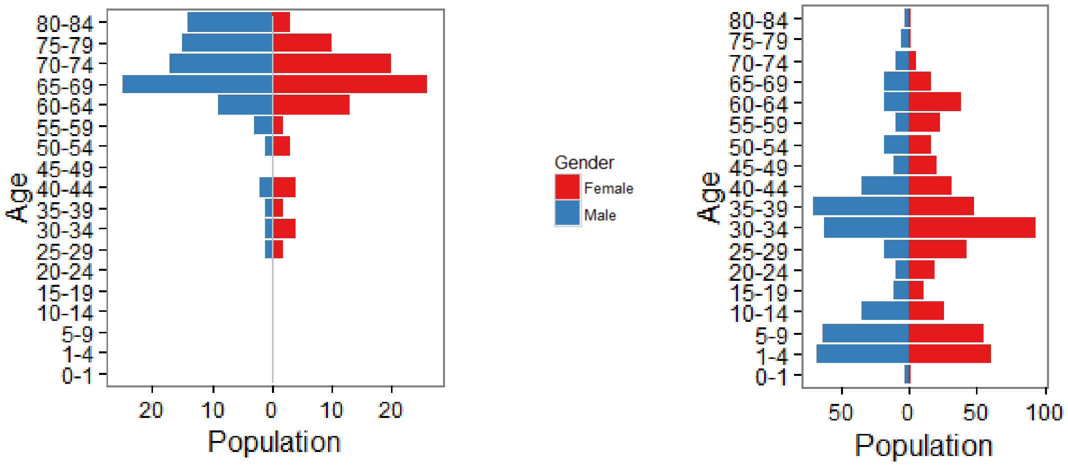
Characteristics of the three new urban areas	Van Quan	Viet Hung	Ecopark (1st stage)
Area (ha)	61.5	119.4	53.9
Distance to CBD (km)	9	7	11
The first phase of residents moving in	2005	2007	2013
Land use (percentages within each area)			
Residential	39.2	49.7[a]	50.0
Administration and public	9.2	20.5[a]	10.0
Open space	21.0	8.3[a]	12.1
Transport	30.6	21.5[a]	27.9
Number of bus stop	0	8	6[b]

Note: The above information was collected based on the area planning, obtained by interviewing the area investors

[a] Constructed areas of Residential, Administration and public, Open Space & Transport account for about 70%, 55%, 90% of their planned areas in 2015, respectively.

[b] There are two types of bus systems in Ecopark: one is public bus and the other is the investor's bus

A total of 469 respondents, from 243 households, participated in the survey. Some respondents had to be excluded due to missing data (incomplete daily travel diaries, unwillingness to provide some individual characteristics and household attributes). As a result, the final sample includes a total of 462 individuals with 4,649 trips reported in their travel diaries. The population pyramid of the people surveyd is shown in see Figure 3.5, and the questionnaire used in this survey is given in Appendix 2.



(Japan) (Vietnam)

Figure 3.5: Population pyramid of survey areas

4 ELDERLY PEOPLE'S HETEROGENEOUS RESPONSES TO TOPOGRAPHICAL FACTORS IN TRAVEL MODE CHOICE WITHIN A HILLY NEIGHBORHOOD IN JAPAN

Elderly people's mobility is more vulnerable to topographical factors than younger population groups, because of the decline of their physical abilities. However, topographical factors have been neglected in studies on travel behavior, and elderly people's heterogeneous responses to topographical factors remain unknown. To fill this research gap, this chapter will focus on a hilly neighborhood called Koyo New Town in Hiroshima City, Japan, where a multi-period (two waves) and multi-day (two weeks) panel survey was conducted in 2010 and 2011. The survey consisted of a GPS-based survey and a paper-based travel diary survey. In addition, a travel mode choice model will be developed based on a panel mixed logit model. Heterogeneities will be captured by introducing random effects to parameters of topographical factors, which are measured in terms of altitude difference, intensity of up/down movement, maximum slope, and changing slope. Furthermore, effects of introducing personal mobility vehicles (PM) to mitigate negative impacts of topographical factors are also evaluated.

4.1 Introduction

The aging phenomenon and its serious impacts on the elderly people's mobility and daily life have been observed in developed countries. People's physical abilities usually decline with age and impacts of such decline on the elderly's life are more serious in hilly and mountainous areas. In Japan, the target country of this study, the rapid population growth which took place in Japan from the 1950s to the 1980s led to the appearance of new neighborhoods, or so-called "new towns", in suburban areas. Many of these new towns were developed in hilly or mountainous areas. The aging of the population in Japan is more rapid than other developed countries. The elderly share in Japan (i.e., the share of population aged 65 years old or above) has reached 26% and the share even exceeded 30% in some prefectures. The elderly share is even higher in mountainous areas. Many mobility problems have emerged in the aging new towns: the decrease in the number of commuters has led to a reduction in the level-of-service of local public transport to central urban areas. Due to the decline of physical abilities, it is difficult for some elderly people to drive by themselves. Hilly/mountainous geographical features may further restrict elderly people's activity participation via trip generation, mode choice, route choice and so on, because of difficulties to walk and abilities to use motorized travel modes. As a result, their daily mobility has to rely on other people's pick-up and drop-off. After retirement, the elderly living in new towns may not need to make long distance trips to working places, their activity space may tend to be smaller and there are probably more shorter-distance trips within new towns. Such mobility issues have been under-researched and consequently insights into transport policy decisions are very limited, especially in hilly and mountainous new towns. Therefore, there is an urgent need for greater research attention to travel patterns within aging new towns. Such research is further motivated by the fact that traffic accidents of elders have happened mainly within about 500-meter periphery of their houses. A better understanding of travel behavior within such a neighborhood may allow policy makers not only to make better decisions on policies relating to elderly people's mobility, but also to build self-contained neighborhoods for maintaining necessary facilities and services for the elderly people's daily life.

The concept of self-containment was embodied in the planning objectives of many new towns, especially in Europe and the United States. This concept was first promoted by Ebenezer Howard via the Garden City Movement, in which self-supporting communities (Howard, 1898, cited Cervero, 1995a) were planned in order to relieve London from overcrowding in the post-World War II period. Conventionally, it is usually interpreted as a balance between jobs and housing (i.e., job-housing balance) in a community. Especially in non-work trips, availability and attractiveness of travel modes within new towns would affect destination choices, which eventually determine the level of self-containment. Bearing this in mind, we conducted an experiment to confirm the impacts of personal mobility vehicles (PM) in a new town on travel mode and destination choices (Chikaraishi *et al.*, 2015).

The literature on the relationship between travel behavior and local geographical environment has grown considerably over the last two decades (e.g., Badoe and Mille, 2000; Crane and Crepeau, 1998; Ewing and Cervero, 2001). In these studies, the local geographical environment is understood as natural and built environments, such as local topography, street characteristics, availability of sidewalks, sidewalk width and so on. Travel mode choice studies have illustrated this relationship. If the local geographical environment supports the use of a travel mode, then such a mode can be provided adequately for the neighborhood (Rodríguez and Joo, 2004). Recent studies have shown that certain attributes of the local physical environment can affect the attractiveness of travel modes, especially for non-motorized modes (Cervero and Duncan, 2003; Handy and Xing, 2011; McGinn *et al.*, 2007; Olszewski and Wibowo, 2005; Rodríguez and Joo, 2004). For example, Rodríguez and Joo (2004) argue that the slope does not influence the attractiveness of travel mode by adding the time difference without and with slope information into a mode choice model. They find that the slope information has a significant impact on non-motorized mode choice. Cervero and Duncan (2003) introduce a slope variable, defined as rise/run ratio between origin and destination, to a mode choice model, and find that it significantly affects walking. Sousa *et al.* (2014) consider a slope effect on bicyle usage, where the slope was evaluated by respondents using a seven-point Likert scale as a perception of barriers. By using a shank-mounted inertial measurement unit, slope is computed by horizontal and vertical displacements, and the slope affects walking speed (Li *et al.*, 2010). Socharoentum and Karimi (2016) simulate the route choice for walking with considering an impact of slope defined as a slope for each context-aware walking segment, while Broach *et al.* (2012) examine an effect of 10-meter increments along each link for cycling route choice. A hypothetical binary route choices for bicycling based on an experiment with an attribute of route slope has also been developed (Motoaki and Daziano, 2015). Mohanty and Blanchard (2016) also examine the impacts of slope on bicycle/walking access to transit, where slope is calculated along the shortest path between origin and destination. However, most studies focus only on walking and bicycle, and it has remained unclear how PM can alleviate physical burden of slope. Thus, topographical factors have been under-researched in the literature of travel behavior. More seriously, the elderly's heterogeneous responses to topographical factors has remained unknown.

To fill the above research gap, as an initial step to explore the comprehensive travel behavior in a neighborhood, this study focuses on a hilly neighborhood, called Koyo New Town, Hiroshima City, Japan, and attempts to examine the effects of topographical factors (e.g., altitude and slope) on the elderly travel mode choices, including a new short-distance travel model, i.e., PM. For this research purpose, a multi-period (two waves) and multi-day (two weeks) panel survey was conducted in 2010 and 2011, which consists of a GPS survey and a paper-based travel diary survey. The GPS survey records travel behavior trajectories (coded by latitude and longitude) through GPS devices. Such GPS survey allows us to examine the impacts of topographical factors on travel mode choices, including PM choice under actual situations.

4.2 Data and descriptive analysis

Here, panel data from elderly respondents are used. Among the 38 respondents remaining in the two waves, 31 provided valid GPS data and 26 recorded paper-based data. While paper-based data provide trip purpose and travel mode information that cannot be collected through GPS devices, GPS data provide precise activity location information. To make full use of the advantages of the two sets of surveys, GPS data and paper-based data were merged.

For GPS data processing, first, trip ends are detected within GPS data stream by searching for time periods of non-movement. The GPS data (decomposed into trips) and paper-based data are then merged based on departure and arrival time information. There are numerous studies which have identified thresholds in detecting trips and merging GPS data with paper-based data. These thresholds vary primarily depending on the characteristics of local activities. Wolf *et al.* (2001) state that the two-minute threshold yielded the best prediction of the true trip ends. It is considered as a gap whenever the time interval or the distance between consecutive points is greater than two minutes or 250 meters (Chen *et al.*, 2010). A trackpoint is removed when the distance between two consecutive trackpoints is less than 10 meters (Bohte and Maat, 2009). Schüssler and Axhausen (2008) also use a two-minute threshold to record stopped activities. Based on the findings of existing studies, this study considers that a movement is regarded as a trip when it is more than 100 meters within two minutes, and uses a time-interval condition with 30 minutes threshold to merge the two kinds of data. As a result, a total of 1,684 trips is identified in the two waves.

This study only uses trip data, in which origins and destinations are located within the boundary of Koyo New Town (created by adding a 200-meter buffer to the administrative boundary). As a result, 1,015 trips are identified. The share of trips within the new town is 60.3%, indicating that more elders tend to make a trip inside the new town.

The shortest route was used to obtain topography information (i.e., slope and elevation) in this study. The survey area is Koyo New Town where the route network follows by the layout of the new town, where there are few of route choices. To some extent, once an origin and a destination are selected, then the route choice of the trip is automatically decided. The road network employed in this study is a digital road map of Japan released by the Digital Road Map Association. Specifically, to calculate the new town topography data, (1) a shortest path as a polyline is divided into continuous points with a 10-meter segment, and (2) the slope of each segment is measured by the changes of altitude position data at 10-meter grid cell obtained from the Fundamental Geospatial Data of the Geospatial Information Authority of Japan. Out of the total, 55 trips were excluded because of missing information about travel modes and inabilities to calculate shortest routes. As a result, the total number of trips in this study is 960 trips. Note that, ideally, it would be better to estimate a route choice model with slope information and then add the expected minimum travel cost (including the cost of slope) into a mode choice model so that all potential routes with different slopes can be considered in the mode choice model. On the other hand, in order to do it, at least the path enumeration problem is needed to be solved. Although recent studies indicate the possibilities to overcome this limitation (Fosgerau *et al.*, 2013; Mai, 2016; Mai *et al.*, 2015), since it lies outside of the scope of this study, the shortest-path information is used in the current paper is used. Note that a number of trips actually using the shortest paths is checked. The results indicate that around 62% of observed paths are matched with the shortest paths.

Figure 4.1 shows some examples of changes in elevations during trips. As can be seen, there is a stable altitude during the trip O_1-D_1, while the altitudes of the O_2-D_2 trip first decrease by about 15 meters to the lowest altitude, then rise by approximate 20 meters to the peak, and finally stablizes. In this case, topography information calculated only from the location of the origin and destination information would not reflect the up-down movement of the trip. This is one of the merits in merging GPS and paper-based data. In this study, four indicators are introduced to capture topographical features: altitude difference (*AD*), maximum slope (*MS*), intensity of up/down movement (*IUD*), number of changing slopes (*CS*).

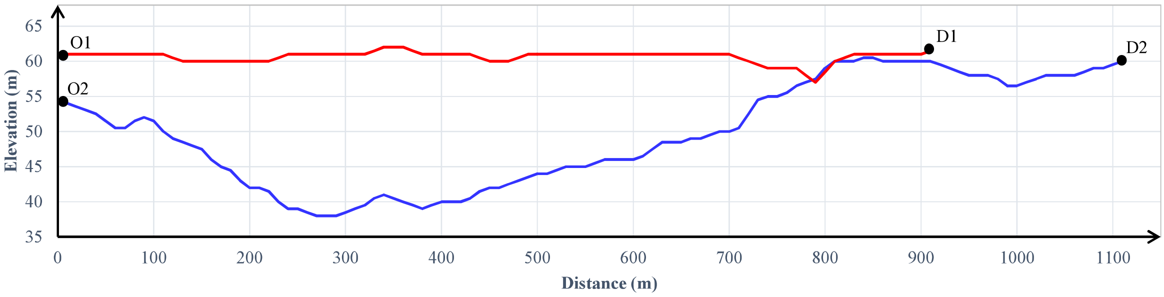


Figure 4.1: Some examples of changes in elevations during trips

Suppose that a *t*-th trip (*t* = 1, 2, ..., *T*) has consecutive lines *k* (*k* = 1, 2, ..., *K*), where each line was created by merging 10-meter continuous segments with the same slope s_k (see Figure 4 for the graphical visualization). Thus, the total number of lines *K* indicates the number of changing slopes (*CS*). Denoting that the elevation at a point changing slope is h_k (k = 1, 2, ..., K+1), where k = 1 and k = K + 1 indicate origin and destination points respectively, other topographical features can be defined as follows:

$$AD_t = \max\left(h_{tk}\right) - \min\left(h_{tk}\right) \qquad ;(k = 1, 2, ..., K+1) \qquad (4\text{-}1)$$

$$MS_t = \max\left|s_{tk}\right| \qquad ;(k = 1, 2, ..., K+1) \qquad (4\text{-}2)$$

$$IUD_t = \frac{\sum_k \left|s_{tk}\right|}{CS_t} \qquad ;(k = 1, 2, ..., K+1) \qquad (4\text{-}3)$$

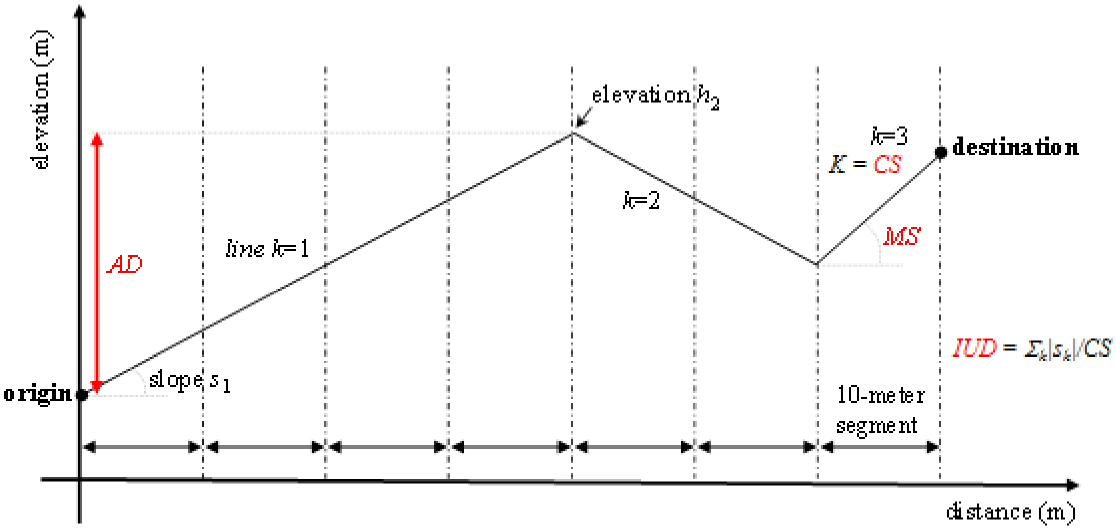


Figure 4.2: Illustration of four topographical indicators used in this study

Figure 4.2 describes these four indicators graphically. The four topographical variables indicate different aspects/phenomena of topography, which share some physical aspects. Therefore, multicollinearity should be of concerned. The severity of multicollinearity is quantified by a variance inflation factor (VIF) to measure how much the variance of an estimated regression coefficient is increased because of multicollinearity. According to the recommendations of several studies (Hocking, 2013), individual VIF values greater than 10 and/or average VIF greater than 6 suggest strong collinearity. In our study, individual VIFs range from 2.45 to 5.29, with an average VIF of 3.99, suggesting that there is no serious problem of multicollinearity.

Table 4.1 shows basic statistics on share of travel modes. Car and non-motorized modes (walking and bicycling) are the two biggest modes with the respective shares being 42% and 40.6 %, followed by PM mode with 12.3%. In contrast, the share of public transport just accounts for 2.2%. This may point to poor public transport services in the new town. Non-motorized modes, PM, and car are thus selected in the mode choice model, with 911 trips for the three alternatives.

Table 4.1 Share of travel mode

Travel mode	Number	Share (%)
Non-motorized mode	390	40.6
Personal mobility (PM) mode	118	12.3
Car	403	42.0
Public transport	21	2.2
Motorbike	25	2.6
Others	3	0.3
Total	*960*	*100*

It should be noted that health condition and physical abilities were considered in both waves of the survey. This is because these aspects may have implications for elderly travelers (Hildebrand, 2003; Su and Bell, 2009; Wasfi *et al.*, 2012). Particularly, aggregation analyses show that over 90% of the respondents can walk more than 200 meters without taking a rest and consequently do not need someone's help in daily life. It is also revealed that respondents going to hospital less than twice a month account for around 70%. Considering the small variations in these results, the elderly's health and physical conditions are approximated by an age variable in this study.

4.3 Modeling travel mode choice

In order to examine the impacts of topographical factors on mode choice while controlling for other influential factors, a mode choice model is developed based on a panel mixed logit model (also called random-parameter logit) to account for unobserved heterogeneities among respondents who repeated choices over a certain period. For non-random (or observed) factors, individual characteristics, distance, and topography are considered. A number of studies have proven that individual socio-demographic factors relatively affect mode choice decision (e.g., Kitamura *et al.*, 1997, Susilo, 2007). Additionally, topography (e.g., slope information) is widely used, because it can be directly associated with policy discussions, especially to support walk and bicycle (Rodríguez and Joo, 2004). To the authors' knowledge, there was only one study examining topographical impacts on mode choice based on a mixed logit model (Mohanty and Blanchard, 2016).

The utility U_{njt} that an individual n (n = 1, 2, …, N) traveling on a t-th trip (t = 1, 2, …, T) chooses a travel mode j (j = 1, 2, 3) may be written as follows.

$$U_{njt} = \alpha_j + \eta_{nj} + \boldsymbol{\beta X}_{njt} + \left(\boldsymbol{\gamma}_j + \boldsymbol{\varphi}_{nj}\right)\boldsymbol{Z}_{njt} + \varepsilon_{njt} \tag{4-4}$$

Here, α_j is a fixed constant term, and η_{nj} is a random component that is assumed to be normally distributed with mean 0 and variance $(\sigma_{\eta j})^2$. η_{nj} is used to capture individual-specific unobserved heterogeneity. $\boldsymbol{\beta}$ is a vector of coefficients associated with explanatory variables ($\boldsymbol{X}_{njt}$), $\boldsymbol{\gamma}_j$ and $\boldsymbol{\varphi}_{nj}$ are a vector of fixed coefficients and a vector of random coefficients respectively, both of which are associated with topographical variables ($\boldsymbol{Z}_{njt}$). The m-th element of $\boldsymbol{\varphi}_{nj}$, i.e., $\boldsymbol{\varphi}_{njm}$, is assumed to be normally distributed with mean 0 and variance $(\boldsymbol{\sigma}_{\gamma jm})^2$, which capture individual-specific unobserved heterogeneities with respect to topographical factors. ε_{njt} is an error term with a Gumbel distribution.

Conditional on η_{nj} and $\boldsymbol{\varphi}_{nj}$, the probability that individual n chooses mode choice j can be written as the following standard logit formulation. The dummy variable ρ_{njt} is equal to 1 if j is non-motorized mode/car. When j is PM, ρ_{njt} is equal to 1 if PM owned by individual n who travels on a t-th trip, and 0 otherwise.

$$P_{njt}\left(\boldsymbol{\beta},\boldsymbol{\gamma}_j \mid \eta_{nj},\boldsymbol{\varphi}_{nj}\right) = \prod_t \frac{\mathrm{e}^{\boldsymbol{\beta X}_{nit} + \left(\boldsymbol{\gamma}_i + \boldsymbol{\varphi}_{ni}\right)\boldsymbol{Z}_{nit}}}{\sum_j \rho_{njt}\mathrm{e}^{\boldsymbol{\beta X}_{njt} + \left(\boldsymbol{\gamma}_j + \boldsymbol{\varphi}_{nj}\right)\boldsymbol{Z}_{njt}}} \tag{4-5}$$

The likelihood function is formulated as,

$$L_{njt}\left(\boldsymbol{\beta},\boldsymbol{\gamma}_j \mid \eta_{nj},\boldsymbol{\varphi}_{nj}\right) = \int\int \prod_N \prod_j P_{njt}\left(\boldsymbol{\beta},\boldsymbol{\gamma}_j \mid \eta_{nj},\boldsymbol{\varphi}_{nj}\right)^{\delta_{njt}} f\left(\eta_{nj} \mid \sigma_{\eta j}\right) f\left(\boldsymbol{\varphi}_{nj} \mid \boldsymbol{\sigma}_{\gamma j}\right) d\eta_{nj} d\boldsymbol{\varphi}_{nj} \tag{4-6}$$

where N (=911) is the number of samples. The dummy variable δ_{njt} is equal to 1 if j is chosen by individual n who travels on a t-th trip, and 0 otherwise.

Simulation methods are often used to estimate a mixed logit model (e.g., Bhat, 2001; Chikaraishi *et al.*, 2011; Train, 2009). In this study, a hierarchical Bayesian procedure based on Markov Chain Monte Carlo methods is employed (Train, 2009). In particular, the posterior distribution is written as,

$$K_{njt}\left(\boldsymbol{\beta},\boldsymbol{\gamma}_j,\sigma_{\eta j},\boldsymbol{\sigma}_{\gamma j} \mid \eta_{nj},\boldsymbol{\varphi}_{nj}\right) = \prod_N \prod_j L_{njt}\left(\boldsymbol{\beta},\boldsymbol{\gamma}_j \mid \eta_{nj},\boldsymbol{\varphi}_{nj}\right)^{\delta_{njt}} f\left(\eta_{nj} \mid \sigma_{\eta j}\right) f\left(\boldsymbol{\varphi}_{nj} \mid \boldsymbol{\sigma}_{\gamma j}\right) \phi\left(\sigma_{\eta j}\right) \phi\left(\boldsymbol{\sigma}_{\gamma j}\right) \phi\left(\boldsymbol{\beta}\right) \phi\left(\boldsymbol{\gamma}_j\right) \tag{4-7}$$

where an inverted Gamma distribution N(0.001, 0.001) is assumed for $\phi(\sigma_{\eta j})$ and $\phi(\boldsymbol{\sigma}_{\gamma j})$, and a normal distribution N(0, 1e-6) for $\phi(\boldsymbol{\beta})$ and $\phi(\boldsymbol{\gamma}_j)$ as a prior distribution. The terms $f(\eta_{nj}|\sigma_{\eta j})$ and $f(\boldsymbol{\varphi}_{nj}|\boldsymbol{\sigma}_{\gamma j})$ generate hierarchical procedures in the sampling process.

The model estimation is done by using WinBUGs (1,000,000 interactions with 500,000 interactions for burn-in, and 20,000 draws). The stationary distribution of the estimation results reported in this study was tested in several ways, including (1) checking the trace plot and correlation in each parameter chain, and (2) using the Geweke diagnostic (Geweke, 1992). All results of the above ways show that the model reported in this study is converged.

4.4 Estimation results and discussions

Table 4.2 shows the explanatory variables introduced in this study. *Socio-demographic* variables include age, gender, car ownership, and job. With regard to *distance* variables (the distance is used for all mode choices), it is the actual distance extracted from GPS logging device for each route is used. The following *topographical* variables are determined by shortest paths with a 10-meter segment, and altitude with 10-meter grid cell as mentioned above.

Table 4.2 Explanatory variables

Explanatory variables	Definition	Mean	SD
Socio-demographic			
Age	< 65 years of age (1= yes; 0 = no)	0.189	0.392
Car ownership	Car ownership (1 = yes; 0 = no)	0.807	0.395
Male	Gender (1 = male; 0 = female)	0.759	0.428
Non-worker	Job (1 = retirement/jobless; 0 = otherwise)	0.833	0.373
Distance	Distance, *km*	0.825	1.401
Topographical factors			
Altitude difference	Maximum elevation - minimum elevation: *m*	16.730	14.138
Intensity of up/down movement	Intensity of up/down movement: *degree*	4.494	2.330
Maximum slope	Maximum slope: *degree*	12.660	9.235
No. of changing slopes	Number of changing slopes	43.970	35.475

The selection of explanatory variables was done step by step as follows. First, a multinomial logit model (MNL) only with *socio-demographic* variables is estimated, and the insignificant variables are excluded from the model (at the 90% significant level). Next, distance variables by dropping insignificant variables are introduced. Finally, the four topographical variables are added to the model. Both the MNL and a panel mixed logit (ML) models with the selected variables based on the above procedure are estimated. It should be noted that the MNL results are the same as the ML model without η_{nj} and $\boldsymbol{\varphi}_{nj}$. The results only with the 2nd wave data are similar to ones with data from both waves' data, while some of the variables are not statistically significant presumably due to the relatively small sample size.

Table 4.3 summarizes the estimation results of MNL and ML models. The results are considerably different in terms of statistical significance of parameters. All *socio-demographic* variables, except car ownership, become insignificant after adding random components. This is because of the existence of unobserved heterogeneities among respondents that were not captured in the MNL model. This indicates that the significance of *socio-demographic* parameters in the MNL model is overestimated. Looking at the ML results, as expected, the *distance* variables are statistically significant with negative signs as expected, implying that respondents traveling longer distance are less likely to choose non-motorized modes and PM. This result is consistent with the fact that people prefer traveling by car for longer distance than walking and cycling. For *socio-demographic* variables, only the car ownership variable is statistically significant with a positive sign, indicating that travelers having a car are more likely to use it in comparison with other modes. This result is similar to a range of previous studies. Regarding the *topography* variables, altitude difference (*AD*) and maximum slope (*MS*) variables are statistically significant. Concretely, higher altitude difference results in higher PM use and lower non-motorized mode use, indicating that PM is the preferable mode in the hilly neighborhood. On the other hand, the higher maximum slope may reduce PM use, presumably because PM has limited power assistance. In this sense, PM could be particularly useful in areas which are hilly, but not in areas which have very steep slopes. The random component of topographical variable φ_{nj} is introduced to capture the intensity of up/down movement variable; however, it is estimated insignificant. The random parameters of constant terms are statistically significant. Since variance $(\sigma)^2$ is always positive, some studies state some other ways to assess statistical meaning for variance of random effect (Chikaraishi *et al.*, 2009; Pinheiro and Bates, 1995). Goodness-of-fit was assessed with both Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) shows that the ML model is far better than the MNL model.

The findings mentioned above are also supported by respondents' satisfaction with local geographical environment. From the travel diary in 2010, it is found that approximately 85% of respondents were dissatisfied with traveling by foot and bicycle due to many slopes. This assessment demonstrates that topographical factors such as slopes may be a major barrier to restrict elderly' trip-making.

Table 4.3 Estimation results of the mode choice model

Variables	Mode Alternatives	Multinomial Logit (MNL)		Mixed Logit (ML)	
		Parameter	t - value	Mean	Pseudo t - value
Constant term	Non-motorized	3.447	10.286	5.317	4.726
Constant term	PM	0.547	0.803	3.663	1.279
Socio-demographics (β)					
Age	Non-motorized	-1.245	-5.615	-2.003	-1.446
Car ownership	Car	0.986	4.200	1.146	2.904
Male	Non-motorized	-0.277	-1.213	-1.755	-1.519
Male	PM	2.482	4.025	-0.169	-0.056
Non-worker	Car	1.116	3.898	0.826	0.717
Distance variables (β)					
Distance	Non-motorized	-1.775	-8.732	-2.158	-7.999
Distance	PM	-1.095	-3.058	-2.210	-3.780
Topographical factors (γ)					
Altitude difference (AD)	PM	0.115	4.184	0.123	2.909
Altitude difference (AD)	Car	0.020	2.707	0.031	3.009
Intensity of up/down movement (IUD)	PM	0.124	1.477	-0.086	-0.339
Maximum slope (MS)	PM	-0.018	-1.821	-0.140	-2.294
No. of changing slopes (CS)	PM	-0.100	-2.613	-0.005	-0.332
Random effects (σ)					
Individual $(\sigma_\eta)^2$	Non-motorized			6.789	2.262[a]
Individual $(\sigma_\eta)^2$	PM			12.100	0.542[b]
Intensity of up/down movement $(\boldsymbol{\sigma_\gamma})^2$	PM			0.225	0.496[c]
Sample size		911			
Initial log-likelihood		-1000.84			
Log-likelihood for model with only constant terms		-737.96		-737.96	
Log-likelihood for estimated model		-563.28		-372.32	
AIC		1154.56		778.64	
BIC		1167.99		794.95	

4.5 Conclusion

In Japan, new towns were built around 40 years ago mostly during the period of rapid population growth. A shrinking and aging population have recently been observed in these new towns. This phenomenon is creating new challenges for mobility due to the reduction of level-of-services of local public transport and the limitations in elderly residents' capacities to drive and walk. A large proportion of residents in these new towns are not commuters. Such a characteristic may increase the demand for activities inside new towns. Considering the decline of elders' physical abilities, local geographical environment (e.g., local topography, street characteristics, availability of sidewalks, sidewalk width) needs to be taken into account in analyzing their travel behavior.

This study has examined the impacts of new town topographical factors (altitude difference, intensity of up/down movement, maximum slope, and changing slopes) on elderly' mode choices within a hilly new town in Japan. A mode choice model was developed by using a multi-period and multi-day panel survey data collected in a typical hilly new town located in Hiroshima, Japan. It is found that the altitude difference and maximum slope factors, among four topographical factors under the study, have significantly impacts on elderly's mode choice decisions. The usefulness of elderly-oriented personal mobility vehicles (PM) in mitigating the negative effects of topographical factors is also revealed. The study suggests that policies to introduce PM into hilly new towns can potentially contribute to the mobility of elderly residents.

The current study has provided useful insights into future urban and neighborhood planning. However, there are a number of unresolved research issues. First, for capturing a more general picture of travel behavior in a neighborhood, route choice should be targeted. This is because different parts of a route may have different topographical elements as discussed in Section 2. Second, topographical factors may affect the elderly's car ownership, which may be further affected by their car ownership and usage when they were young, and residential location choices, which are usually influenced by residential environment (including topographical factors). These also suggest the potential existence of self-selection. Thus, there are probably complicated relationships between the current car ownership and topographical factors, which need data covering on a longer period. Third, this study has only treated four topographical factors. Other topographical factors may also be relevant: e.g., street characteristics and availability of sidewalks. Future studies should explore a comprehensive set of topographical factors. Last but not least, it is important to reflect behavioral insights derived from the above efforts into re-design of elderly-friendly new towns and mobility services.

5 MEDIATION EFFECTS OF INCOME ON TRAVEL MODE CHOICE IN NEW URBAN AREAS IN VIETNAM

Effects of income on travel behavior have been widely examined in literature; however, a majority of existing studies have mainly focused on its direct effects and neglected its indirect effects. This is especially true in the context of developing countries where income per capita is increasing rapidly. Effects of income on travel behavior may be observed via its impacts on other life choices. Such indirect effects are called mediation effects in this study. To fill the above research gap, this study will focus on travel mode choice in three new urban areas in Hanoi Metropolitan Area of Vietnam in 2015 and develop a path model with multiple discrete choices. In the path model, mediation effects of income on travel mode choice are captured via residential location choice being modeled as a discrete mediator which generates non-linear indirect effects of income on mode choice (the proposed model is called the mediation model). As a comparison, a joint model of residential location and travel mode choices is built with only direct effects of income on both choices.

5.1 Introduction

Travel mode choice is usually affected by various socio-demographic attributes, among which income is one of the key attributes. Effects of income on mode choice is not homogenous: income could be correlated with other attributes (Jara-Díaz, 1991; Jara-Díaz and Videla, 1989); and travel time and cost, two core variables representing levels of transportation services, are often defined as a function of income to reflect changes in the value of travel time associated with income increase (Zhang *et al.*, 2008). Capturing income effects on travel behavior in a comprehensive way is important, especially when predicting travel demand in developing countries where income per capita is growing rapidly. Studies of examining effects of income on mode choice can be classified into the following four groups.

The first group of studies directly introduces income as an explanatory variable into mode choice models. This is the most dominant approach in literature in the context of both developed and developing countries (Abane, 1993; Alpizar and Carlsson, 2003; Enam and Choudhury, 2011; Pan *et al.*, 2009; SrinivasanBhargav *et al.*, 2007; SrinivasanPradhan *et al.*, 2007; Srinivasan and Rogers, 2005). Generally speaking, high-income travelers are more likely to use faster and more comfortable travel modes such as taxis and private cars, and less likely to use public transport (Abane, 1993; Alpizar and Carlsson, 2003; Enam and Choudhury, 2011; Pan *et al.*, 2009; SrinivasanPradhan *et al.*, 2007), while ones with low income depend heavily on non-motorized transport and transit for both work and non-work trips (SrinivasanBhargav *et al.*, 2007; Srinivasan and Rogers, 2005).

The second group represents both direct and indirect effects of income on mode choice, where the indirect effects are measured as an interaction effect between income and other factors. In particular, the interaction effects between income and travel cost/time are evaluated in a number of studies (Bhat, 1998; Dissanayake and Morikawa, 2007; Koppelman and Bhat, 2006; Kumar and Rao, 2007; Saha, 2010; Stephanedes *et al.*, 1984; Tuan, 2015; Yagi and Mohammadian, 2008), in which influence of travel cost/time on mode choice are assumed to be different among income groups. The interaction effects are often understood as moderated effects in the sense that income would modify/moderate the magnitude/direction of the impacts of travel time/cost on mode choice decisions.

The third group not only treats mode choice models with the features of the second group, but also relate them to other choice decisions, especially residential location choice. This approach assumes that a mode choice decision was associated with other choice decisions, bearing in mind that self-selection effects may exist (Mokhtarian and Cao, 2008). For example, residential self-selection effects, i.e., “the tendency of people to choose locations based on their travel abilities, needs, and preferences” (Litman, 2005), have been intensively explored in literature. Mokhtarian and Cao summarized seven methodologies dealing with self-selection effects: direct questioning, statistical control, instrumental variables models, sample selection models, joint discrete choice models, cross-sectional structural equations models, and longitudinal models-single equation (Mokhtarian and Cao, 2008). For example, Gou and Bhat develop a joint model to examine the interdependencies between residential location choice and auto ownership choice (Bhat and Guo, 2007). There are a number of similar models to treat, for example, joint choices of residential location, work location, and commuting mode (Tran *et al.*, 2016), and joint choices of residential location, work location, vehicle ownership, and commute tours (Paleti *et al.*, 2013). In summary, these studies deal with preference-induced or attitude-induced self-selection effects by introducing correlated random components into sub-models. However, the causal relationship has not been explicitly specified in this group of studies (Mokhtarian and Cao, 2008). As a consequence, the direction of causality among choices is not clear, even though joint choice modeling may be useful to reduce estimation biases caused by the existence of self-selection effects.

The last group assumes that income has both direct and indirect effects, where the indirect effects are modeled through other decision variables. For example, income may directly influence residential location, car ownership, and education level, which may further influence the mode choice decision. Such direct and indirect effects of income can be handled under the framework of structural equation modeling (SEM), in which other decision variables *mediate* the effects of income on the mode choice decision. The main difference between this type of mediation models and the joint model of the above third group is in the assumption of the causal relationship: the cause-effect relationships are explicitly assumed in the mediation model, while the joint model does not. There are a number of studies employing such a mediation modeling framework. For example, indirect effects of income on the mode choice, mediated by activity duration, travel time, and car ownership, have been analyzed (Acker and Witlox, 2010; Yang *et al.*, 2013). Note that most existing studies only handle continuous variables as mediators. Although there is an approach called a hybrid discrete choice model in which latent variables are incorporated into a discrete choice model by using SEM (Atasoy *et al.*, 2013; Ben-Akiva and Lerman, 1985; Politis *et al.*, 2012; Temme *et al.*, 2008), this approach is mostly for continuous latent variables and continuous indicators. A few studies use ordered logit/probit latent variable models in the hybrid model (Daly *et al.*, 2012; Dekker *et al.*, 2014; Muthén, 1984; Soto *et al.*, 2014).

The selection process of cause-effect relationships is not simple because a number of plausible assumptions can be made (as mentioned above), though each of them would lead to different results. Thus, in many cases, an appropriate model has been selected in a trial-and-error manner. This indicates that (1) it is important to have a wider range of methodological options to identify how different assumptions about the cause-effect relationship could lead to different conclusions, and (2) it is important to look at the comparison of results among different cause-effect relationships by confirming with existing studies in the final model selection.

Motivated by the above shortcomings of existing studies on income effects in the context of travel mode choice behavior and lack of studies in developing countries, this study attempts to capture mediation effects of income on travel mode choice via a mediator, i.e., residential location choice. As a result, discrete choices of travel mode and residential location are jointly modeled, where both mediation effects and direct effects of income are further incorporated. Concretely speaking, mediation effects are represented by introducing the probability of residential location choice into the sub-model of travel mode choice and direct effects of income are introduced to sub-models of both travel mode and residential location choices. The above modeling tasks are realized based on a path analysis approach with multiple discrete choices. This model is simply called the mediation model. As a comparison, a joint choice model without mediation effects is also estimated. Data used in this study were collected in 2015 from a travel diary survey of 469 respondents who reported 2,094 trips made within their neighborhoods at three new urban areas in Hanoi Metropolitan Area of Vietnam.

5.2 Descriptive Analysis

A total of 469 respondents, from 243 households, participated in the survey. Some respondents had to be excluded due to missing data (incomplete daily travel diaries, unwillingness to provide some individual characteristics and household attributes). As a result, the final sample includes a total of 462 individuals with 4,649 trips reported in their travel diaries.

Survey results show that there are significant differences between Ecopark and the two areas (Van Quan, Viet Hung) in terms of individual income, vehicles ownership, activities distributions and travel modes. In particular, with regard to individual income level, the share of high-income residents living in Ecopark (greater than 9 million *VND*) accounts for about 66% of the total Ecopark residents, while that in the two other urban areas the share is just around 45% in its total citizen. The income difference becomes more remarkable when the threshold defining high-income group increases to 13 million *VND* (Ecopark: 49%; Viet Hung: 22%; Van Quan: 17%). (see Figure 5.1). As for vehicle ownership, the share of car ownership (more than a half) is higher and that of motorcycle ownership (around fourth-fifths) is lower in Ecopark than in the other two areas. Regarding the activity location and travel modes, over a half of activities are performed inside the Ecopark; in contrast, less than 50% of activities are done within the other two areas (Van Quan: 45%; Viet Hung: 39%). Specifically, the number of trips inside Ecopark is primarily done by walking/cycling, while motorcycle and non-motorized mode are preferred choices at the other areas (see Figure 5.2). The trips outside these areas are traveled by car and motorcycle, excepted for Ecopark where an additional mode - bus (approximate 27% of the total modal share for trips outside Ecopark) is available.

In summary, Ecopark residents, who are at a higher income level and show a higher car ownership level, prefer to walk or cycle for trips inside Ecopark and use buses for trips outside Ecopark. In other words, income positively affects use of walking or cycling for short-distance trip and buses for long-distance trips. This finding is not consistent with existing studies on developing countries, which usually state that high-income travelers tend to use cars, but not buses. Such inconsistency may be due to various reasons, such as data collected, the contexts under study, and the models adopted. Here, the methods to represent effects of income may be more attributable to such inconsistency, because different models reflect different decision-making mechanisms associated with income. Methodologically, the mediation model developed in this study has more logical behavioral features than existing models and it is expected to produce more logical and convincing findings about income effects on travel mode choices.

There is a substantial disparity in the modal share between trips inside and outside the new urban areas. Since a number of residents living in the new urban areas commute to their workplaces located in the CBD, their daily activity spaces are not limited to their neighborhood. The analysis results in this study also confirm this disparity. Hence, it might be appropriate to look at travel mode choice inside and outside areas, separately. To simplify the discussion, this study only focuses on trips made within respondents' residential neighborhoods. In total, there are 2,134 intra-area trips in the three areas. It is found that non-motorized modes (walking/cycling) and motorcycle are the two main travel modes for these intra-area trips, and these are thus selected for this study. After omitting unselected travel modes, 2,094 intra-area trips were obtained from the above data. Table 5.1 shows the shares of residential location and travel mode choices.

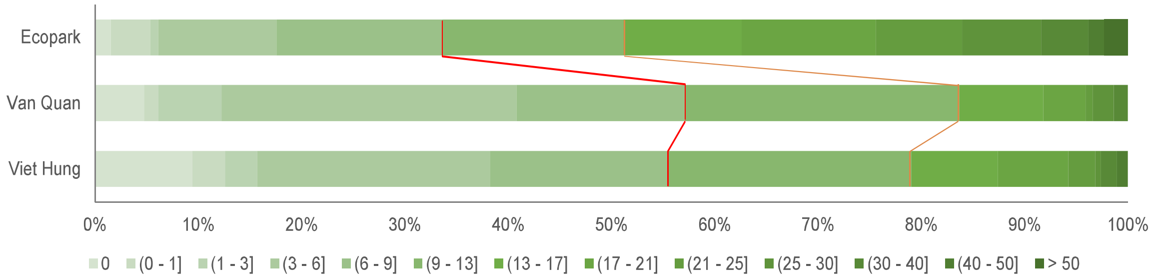


Figure 5.1: Individual income *(mil. VND/month)*

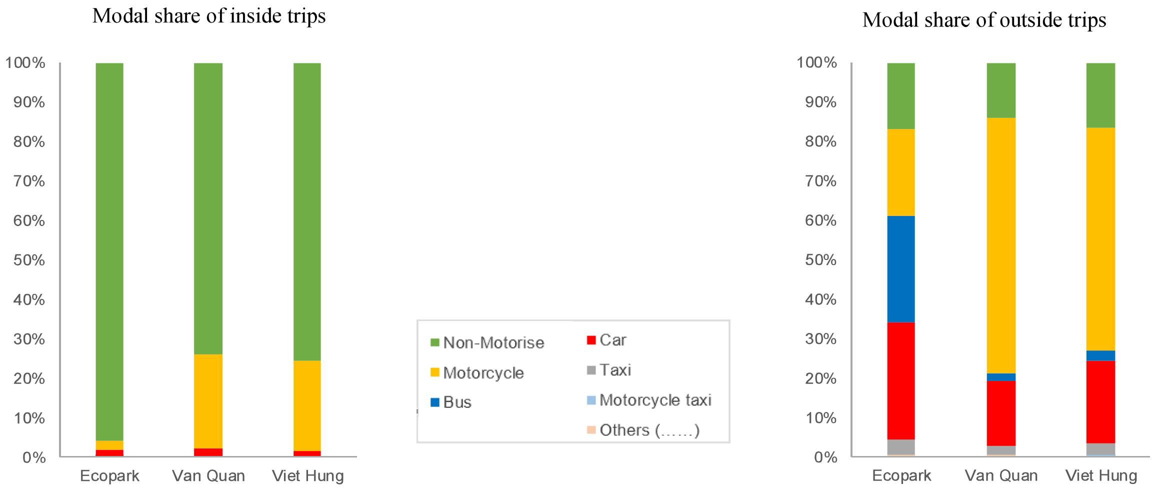


Figure 5.2: Modal share

Table 5.1 Shares of residential location and travel mode choices

Variables	Travel mode		
	Non-motorized	Motorcycle	*Sub-total*
Residential location			
Ecopark	736 *(35.15%)*	18 *(0.86%)*	754 *(36.01%)*
Non-Ecopark	1016 *(48.52%)*	324 *(15.47%)*	1340 *(63.99%)*
Sub-total	1752 *(83.67%)*	342 *(16.33%)*	2094 *(100.00%)*

5.3 Modeling methodology

5.3.1 The typical joint discrete choice model in the literature

In the literature, a joint discrete choice model with error term correlations across different choice decisions is usually adopted to evaluate effects of income on travel behavior (Bhat and Guo, 2007; Paleti *et al.*, 2013; Pinjari *et al.*, 2011; Tran *et al.*, 2016). Figure 5.3a shows the diagram for the joint model. Let the indices i $(i=1,2,\ldots,I)$, r $(r=1,2,\ldots,R)$, and m $(m=1,2,\ldots,M)$ denote a decision-maker, an alternative of residential location choice, and an alternative of travel mode, respectively. In our empirical study, two residential locations and two travel modes are considered, and thus the differences in utilities for residential location and mode choices can be defined as follows:

$$\begin{bmatrix} U_{ri}(r=1)-U_{ri}(r=2) \\ U_{mi}(m=1)-U_{mi}(m=2) \end{bmatrix} = \begin{bmatrix} \boldsymbol{\beta}_r \boldsymbol{X}_{ri} + \varepsilon_{ri} \\ \boldsymbol{\alpha}_m \boldsymbol{X}_{mi} + \varepsilon_{mi} \end{bmatrix} \sim MN\left(\begin{bmatrix} \boldsymbol{\beta}_r \boldsymbol{X}_{ri} \\ \boldsymbol{\alpha}_m \boldsymbol{X}_{mi} \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right) \tag{5-1}$$

where U_{ri} and U_{mi} are the utilities corresponding to alternatives r and m, respectively; ε_{ri} and ε_{mi} are error terms; MN is a bivariate normal distribution with correlation parameter ρ; $\boldsymbol{X}_{ri}$ and $\boldsymbol{X}_{mi}$ are vectors of explanatory variables consisting of individual and household characteristics (including income) and trip attributes; $\boldsymbol{\beta}_r$ and $\boldsymbol{\alpha}_m$ are vectors of parameters corresponding to explanatory variables $\boldsymbol{X}_{ri}$ and $\boldsymbol{X}_{mi}$. The choice probability of choosing the 1st alternatives of residential location and travel mode can be written below. The probability of choosing other combinations can also be defined in a similar way.

$$\begin{aligned} & P_{ri}(U_{ri}(r=1)>U_{ri}(r=2))\times P_{mi}(U_{mi}(m=1)>U_{mi}(m=2)) \\ & \qquad = \int_{-\boldsymbol{\alpha}_m \boldsymbol{X}_{mi}}^{\infty} \int_{-\boldsymbol{\beta}_r \boldsymbol{X}_{ri}}^{\infty} MN\left(\begin{bmatrix} \varepsilon_{ri} \\ \varepsilon_{mi} \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right) d\varepsilon_{ri} d\varepsilon_{rm} \end{aligned} \tag{5-2}$$

The corresponding likelihood function is formulated as

$$L(\boldsymbol{\beta}_r, \boldsymbol{\alpha}_m) = \prod_i \prod_m \prod_r (P_{ri} P_{mi})^{\omega_{ri}\omega_{mi}} \tag{5-3}$$

where ω_{ri} (ω_{mi}) is a dummy variable (equal to 1 if individual i chooses alternative r (m), and 0 otherwise).

Though the joint choice model is defined under the framework of probit model where the normal distribution is assumed for its error terms, the logit-based joint model can also be defined in a similar way (Bhat and Guo, 2007; Paleti *et al.*, 2013; Pinjari *et al.*, 2011; Tran *et al.*, 2016).

5.3.2 Mediation model

As a discussed in the Introduction, the above defined joint choice model describes interdependencies across choices, not the cause-effect relationship. The joint choice model is useful when the cause effect relationship is difficult to be pre-specified. However, if this is not the case, it is preferable to explicitly model the cause-effect relationship, because policy implications derived from the model could be substantially different. The mediation model is a causal model that interprets "why" and "how" a cause-effect relationship happens, and a mediator is a third variable that links a cause and an effect (Fairchild and MacKinnon, 2008; Rose *et al.*, 2004; Wu and Zumbo, 2008). Generally speaking, in a mediation model, an independent variable is presumed to cause a mediator, and in turn, the mediator causes a dependent variable. As a result, a mediation effect is also termed an indirect effect, intermediate effect, or intervening effect (MacKinnon *et al.*, 2002). Comprehensive reviews can be found in previous studies (Baron and Kenny, 1986; Edwards and Lambert, 2007; Fairchild and MacKinnon, 2008; Frazier *et al.*, 2004; Hayes, 2013; MacKinnon *et al.*, 2002; Rose *et al.*, 2004; Wu and Zumbo, 2008). A mediator plays dual roles in a causal relationship. Particularly, a mediator (*Me*) is the dependent variable for *X*, while it acts as an independent variable for *Y*. A conventional approach by Baron and Kenny (Baron and Kenny, 1986) is still the most prevalent one and is regarded as the default paradigm for modeling mediation (Spencer *et al.*, 2005). This approach can be summarized in four steps as follows:

Step 1, there is an overall direct effect that may be mediated

$$Y = \boldsymbol{\alpha}_o + \boldsymbol{\alpha} X + \varepsilon_1 \tag{5-4}$$

Step 2, the independent variable (*X*) is correlated with the mediator (*Me*)

$$Me = \boldsymbol{\beta}_o + \boldsymbol{\beta} X + \varepsilon_2 \tag{5-5}$$

Step 3, the mediator *M* affects the dependent variable (*Y*), and *Y* is affected by both *X* and *Me*

$$Y = \gamma_o + \boldsymbol{\alpha}' X + \boldsymbol{\gamma} Me + \varepsilon_3 \tag{5-6}$$

where, α_o, β_o, γ_o are regression intercepts; $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, $\boldsymbol{\alpha}'$, and $\boldsymbol{\gamma}$ are parameters corresponding to explanatory variables *X* and *Me*; ε_1, ε_2, ε_3 are error terms assumed normally distributed.

Step 4, Compare $\boldsymbol{\alpha}$ in *step 1* and $\boldsymbol{\alpha}'$ in *step 3*

If the partially direct effect $\boldsymbol{\alpha}' = 0$, the mediator completely mediates causal relationship *X* to *Y*. The subtraction $\boldsymbol{\alpha} - \boldsymbol{\alpha}'$ denotes a decrease from overall direct effect $\boldsymbol{\alpha}$ to the partial direct effect $\boldsymbol{\alpha}'$. The multiplication $\boldsymbol{\beta} \times \boldsymbol{\gamma}$ indicates the mediation effect of *X* on *Y*. Theoretically, $\boldsymbol{\alpha} - \boldsymbol{\alpha}'$ is identical to $\boldsymbol{\beta} \times \boldsymbol{\gamma}$ in the population with the ordinary least squares. Meanwhile, these identities hold only in linear regression and structural equation modeling (SEM) where *Me* and *Y* are continuous (MacKinnon *et al.*, 1995). In the case where the dependent variable both *Y* and *Me* are discrete variables, the above identity does not hold. This study deals with a binary outcome - mode choice (U_{mi}), a binary mediator – residential location (U_{ri}), and an independent variable - income factor ($X_{inc,i}$), and thus, the above mentioned conventional approach, where only continuous variables are handled, cannot be directly used. Figure 5.3b shows the diagram for the mediation model.

For the discrete outcome and mediator, either the logit or probit framework could be used. In this study, the logit framework is employed, since the total effects of income can be analytically calculated as shown below.

The utility and the probability for each choice model are defined as follows:

Residential location choice

$$U_{ri} = \boldsymbol{\beta}_r \boldsymbol{X}_{ri} + \varepsilon_{ri} \tag{5-7}$$

$$P_{ri} = \frac{e^{\boldsymbol{\beta}_r \boldsymbol{X}_{ri} + \varepsilon_{ri}}}{1 + e^{\boldsymbol{\beta}_r \boldsymbol{X}_{ri} + \varepsilon_{ri}}} \tag{5-8}$$

Travel mode choice

$$U_{mi} = \boldsymbol{\alpha}'_m \boldsymbol{X}_{mi} + \gamma_m P_{ri} + \varepsilon_{mi} \tag{5-9}$$

$$P_{mi} = \frac{e^{\boldsymbol{\alpha}'_m \boldsymbol{X}_{mi} + \gamma_m P_{ri} + \varepsilon_{mi}}}{1 + e^{\boldsymbol{\alpha}'_m \boldsymbol{X}_{mi} + \gamma_m P_{ri} + \varepsilon_{mi}}} \tag{5-10}$$

where γ_m is a parameter representing the impacts of residential location choice on mode choice; thus, assuming that $\boldsymbol{X}_{ri}$ and $\boldsymbol{X}_{mi}$ include income variable $\boldsymbol{X}_{inc,i}$ with the associated parameters $\boldsymbol{\beta}_r^{inc}$ and $\boldsymbol{\alpha}'^{inc}_m$ respectively (i.e., both direct and indirect effects of income are taken into account), the total effects of income can be defined below.

$$\frac{\partial U_{mi}}{\partial \boldsymbol{X}_{inc,i}} = \boldsymbol{\alpha}'^{inc}_m + \gamma_m \boldsymbol{\beta}_r^{inc} P_{ri}(1 - P_{ri}) \tag{5-11}$$

Here $\boldsymbol{\alpha}'^{inc}_m$ denotes the partial direct effect of income on the mode choice, while the multiplication $\gamma_m \boldsymbol{\beta}_r^{inc} P_{ri}(1 - P_{ri})$ indicates the mediation effect of $\boldsymbol{X}_{inc,i}$ on U_{im}. Thus, the indirect effects have non-linear effects, where the effects will be maximum when P_{ri} =0.5. This makes a substantial difference between the joint choice model and the proposed mediation model estimated with the impacts of income on mode choice. Note that this modeling framework is already introduced in other fields, known as a path analysis with multiple discrete outcomes (Frölich and Huber, 2014), though to the authors' knowledge, there is little application in the field of transportation. One may consider about a model with mediation effects and correlation of unobserved error terms simultaneously, but existing studies show that this model potentially leads to violated assumptions of no mediator-outcome confounding (Bengt, 2011; ImaiKeele and Tingley, 2010; ImaiKeele and Yamamoto, 2010).

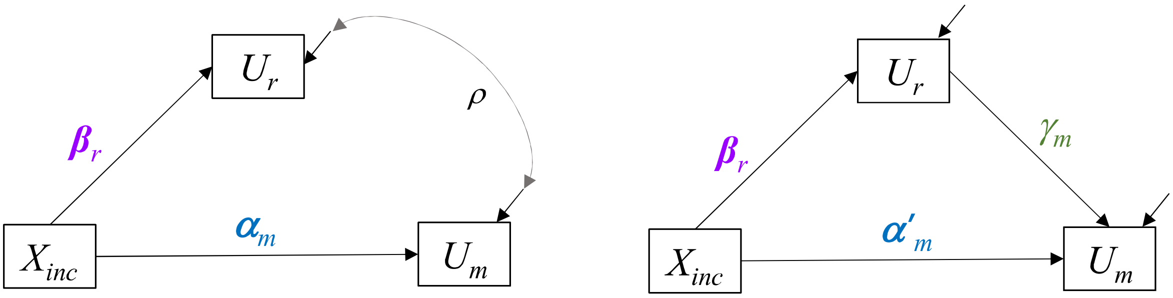


Figure 5.3: Path diagrams for *(a)* the joint choice model and *(b)* the mediation model

5.4 Model estimation and simulation results

5.4.1 Model estimation results

Table 5.2 shows explanatory variables introduced in this study. The estimation results for the joint model between residential location choice and travel mode choice is summarized in Table 5.3, and results of the mediation model are shown in Table 5.4.

Regarding the joint model, the correlation between error terms (ρ) is statistically significant at 0.1% level. This confirms the residential self-selection effects related to mode choice decisions. The negative correlation value indicates that unobserved factors contributing to decisions about living in Ecopark co-vary with unobserved factors affecting people's use of walking/cycling. As expected, income is statistically significant at 1% level and has a positive sign in the residential location choice model. This indicates that high-income people tend to live in Ecopark. In the case of travel mode choice, results show that people with higher income are more likely to use walking/cycling for their trips within their neighborhoods. Concerning other variables in the residential choice model, the age variables (age itself and its squared value) in the residential location choice model are significant at 0.1% level. The negative sign of the squared age indicates that effects of age on residential locations choices follow a quadratic function (downward convex) with a minimum of utility at around 55 years of age. The age variables are also influential in travel mode choice; however, the signs are opposite to those in the residential choice model. Concretely speaking, the influence of age on travel mode choice surely shows a quadratic-type relationship, but its form is upward-convex with a maximum of utility at around 35 years of age. Regarding the travel mode choice, the coefficient of trip distance has an expected positive sign, meaning that people tend to use motorcycle for a longer trip, rather than walking/cycling. In contrast, the educational level is not significant to both types of choices, and gender and motorcycle ownership are not influential to travel mode choice, either.

Concerning the results of the mediation model, where travel mode choice is an outcome and residential location choice is a mediator, we see that as expected, there are significant differences between the joint model and the mediation model with respect to the effects of income. Concretely, in the mediation model, income first has a direct effect, being positive and significant, on travel mode, whereas this direct effect is negative in the joint model. On the other hand, income also positively affects residential location choice; however, the probability of residential location choice has a negative influence on travel mode choice. In other words, the direct effect and mediation effect of income on mode choice are contradictory. To clarify the overall effects of income, it is necessary to make a simulation analysis, which will be shown later. As for other variables, distance, age, gender, education, and motorcycle ownership in the mediation model show similar influences as observed in the joint model, in terms of both signs and statistical significance.

Table 5.2 Explanatory variables

Explanatory variables	Description	Mean	SD
Trip distance	Trip distance, *km*	0.45	0.41
Age	Individual age	43.95	14.56
Age*Age/100	Multiple individual age by 100	21.43	14.31
Male	1: Male; 0: Otherwise	0.41	0.49
High Education	High Education (1: From Bachelor; 0: Otherwise)	0.79	0.41
Income	Individual income per month, (1E+8 *VND*)	0.10	0.09
Motorcycle Ownership	Number of motorcycle per household	1.60	0.85
Residential location	Residential location (1: Ecopark; 0: non-Ecopark)	0.36	0.48
Travel mode	Travel mode (1: Motorcycle; 0: non-motorized mode)	0.16	0.37

Table 5.3 Estimation results of the joint model

Explanatory variables	Residential location		Travel mode	
	Estimated parameter	z value	Estimated parameter	z value
(Intercept)	2.73	6.10	-3.58	-5.52
Trip distance	na	na	1.44	17.58
Age	-0.16	-8.23	0.11	3.70
Age*Age/100	0.15	8.01	-0.16	-4.79
Male	-0.33	-4.76	0.02	0.18
High Education	-0.07	-0.78	0.12	0.99
Income	5.74	14.26	-0.88	-1.81
Motorcycle Ownership	na	na	0.07	1.12

Correlation ρ = -0.681 (t= -20.641)

Sample size n = 2,094

Initial Loglikelihood = -1,451.45

Final Loglikelihood = -1,241.25

Note: na = not applicable;

Table 5.4 Estimation results of the mediation model

Explanatory variables	**Residential location**		**Travel mode**	
	Estimated parameter	z value	Estimated parameter	z value
(Intercept)	4.11	6.49	-4.33	-3.48
Trip distance	na	na	2.56	13.60
Age	-0.25	-9.10	0.14	2.48
Age*Age/100	0.25	8.99	-0.24	-3.70
Male	-0.39	-3.54	-0.24	-1.51
High Education	-0.12	-0.85	0.22	0.96
Income	10.36	13.12	2.60	2.66
Motorcycle Ownership	na	na	0.03	0.23
The probability of residential location choice	na	na	-3.06	-11.15

Sample size n = 2,094

Initial Loglikelihood = -1,451.45

Final Loglikelihood = -590.91

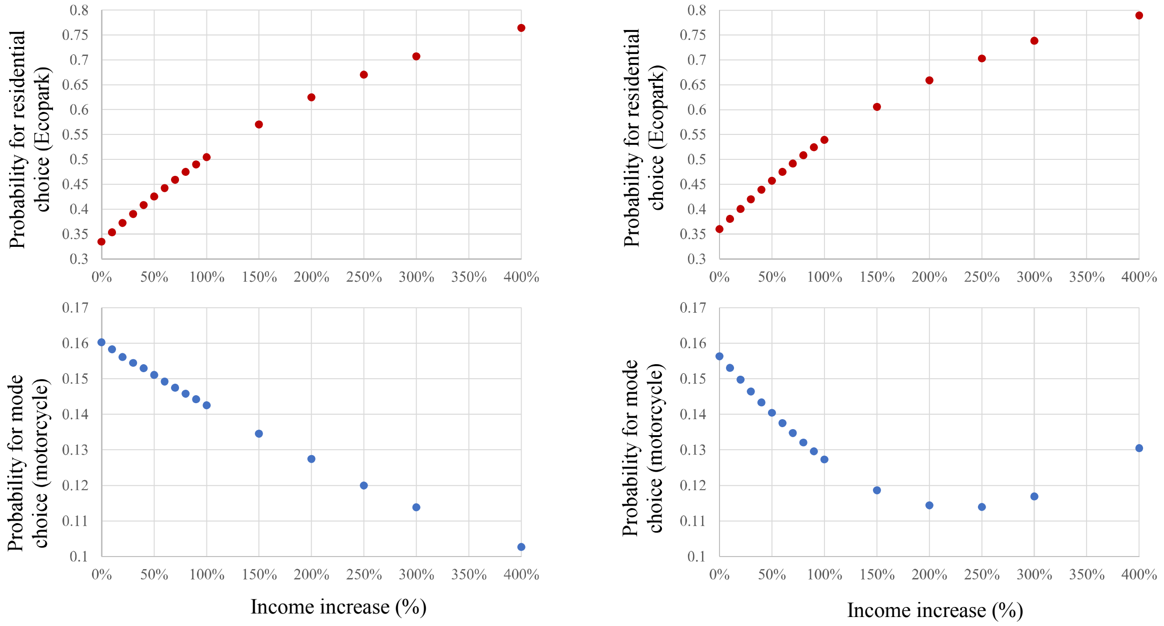
Note: na = not applicable;

5.4.2 Simulation results

A simulation analysis is conducted to examine the overall effects of income on mode choice in a future context based on GDP per capita in Vietnam predicted by the Hongkong and Shanghai Bank Corporation (HSBC) report (the GDP per capita in 2050 is more than six times of that in 2010) (Ward, 2012), where all parameters estimated are assumed to applicable in the future. The simulated probabilities of residential location (the probability of choosing Ecopark) and mode choice (the probability of choosing a motorcycle) are shown in Figure 5.4, based on the estimation results of the mediation model. As a comparison, the results from the joint model are also shown.

First, it is confirmed that in the joint model, as income increases, the choice probability of motorcycles decreases gradually and that of choosing to live in Ecopark increases. The mediation model shows a similar trend with regard to the residential location choice; however, it confirms a different influencing pattern of income on mode choice. Concretely speaking, motorcycle users first decline sharply with increase in income up to a point when income increases to 250% per month, but the share of motorcycle users rises again after that point.

While only a direct income effect on travel mode choice exists in the joint model, both direct and indirect income effects exist in the mediation model. When income increases less than 250%, the indirect income effect exceeds the direct one in the mediation model. However, when income increases more than 250%, the direct income effect becomes larger than the indirect one, and thus the income effect becomes positive. This is because most residents already moved to a good built environment, and thus little residential relocation would happen even when income further rise.



(a) *(b)*

Figure 5.4: Simulation results for *(a)* the joint model and (*b)* the mediation model

5.4.3 The model selection

As mentioned above, the joint model and mediation model could provide substantially different implications. Thus, the selection of the appropriate model is crucial, particularly in practical use. Our results demonstrate that the conventional assumption about income effects (direct effects) may not hold in all cases, implying that wrong policy decisions could be made if the conventional assumption is automatically applied. Though the statistical performance, such as goodness-of-fit, may be helpful in selecting an appropriate model to some extent, the consistency with well-established theories is crucial. This is because assumptions on cause-effect relationships are distinct in concept rather than in the statistical performance in general (Wu and Zumbo, 2008). Clearly, estimation result of the joint choice model in the current study is inconsistent with the findings in existing literature: income has a negative effect on motorized private mode use. Meanwhile the result of the mediation model is consistent with existing studies: there is a positive effect of income on using private vehicles. From this viewpoint, it could be concluded that the mediation model is a better model than the joint model in this particular case study.

5.5 Conclusion

Effects of income on travel behavior have been studied extensively in literature. However, relevant studies in the context of developing countries are limited, and especially, mediation effects of income have remained unknown. Income is a base for various life choices. Direct effects of income on travel behavior are understandable, which have also been examined in existing studies. Recently, it has been argued that travel may result from life choices (Zhang, 2014; 2015; Zhang, 2016). If this is the case, income may not only affect travel behavior directly, but also affect it indirectly via influences on other life choices (i.e., mediation effects). Ignoring mediation effects of income may wrongly predict future travel demand and even lead to wrong transport policy decisions, resulting in a waste of investments and/or inefficient use of limited land resources used for transportation infrastructure construction.

Targeting a developing city, Hanoi of Vietnam, this study has examined both direct effects and mediation effects of income on travel mode choices in the context of short-distance trips. To confirm the existence and influencing degree of mediation effects, a joint model of residential location and travel mode choices and a path model for the above two choices were estimated based on data of 2,094 trips within 469 respondents' neighborhoods, collected in 2015. The joint model incorporates the influence of self-selection effects between travel mode and residential location choices. The path model represents both direct effects and indirect effects of income on travel mode choice behavior via a mediator: i.e., residential location choice behavior. One attractive feature of the path model is that income has a non-linear indirect effect. The most important finding is that income has both direct and indirect effects on modal choice, and the mediator introduced in this study (i.e., residential location choice) is effective in capturing the non-linear mediation effects. More concretely, it is found that the relationship between motorcycle usage and income, by considering both direct and indirect effects as a whole, is quadratic with a minimum of motorcycle share at a certain income level. This finding is unique, as a cause-effect relationship, by compared with existing literature.

Having summarized the findings from this case study, limitations should be recognized, which can be explored in future studies. First, residential environment has been proved to affect both residential and travel behavior, which is however ignored in this study due to data limitations. Second, the discussion focuses on the cause of the binary discrete outcomes to simply demonstrate the main points, but the model needs to be extended to the case of more than two alternatives. Third, mediation effects of income on travel mode choice have been examined via residential location choice; however, the effects may also be observed via other life choices. Considering that different life choices may not be independent of each other (Zhang, 2014; 2015; Zhang, 2016), mediation effects of income on travel mode or more general travel behavior may need to be examined by building an integrated choice model covering more life choice variables and accommodating multiple interdependencies. Next, the above modeling efforts should be re-evaluated from the perspective of policy making in countries with different income levels. Last but not least, similar mediation effects may also be observed with respect to other socio-demographic factors, which require future research.

6 EXPLORING SELF-CONTAINMENT OF DISCRETIONARY ACTIVITIES IN AN AGING NEW TOWN OF JAPAN BASED ON A DESTINATION CHOICE MODEL WITH SOCIAL NETWORK EFFECTS

Across Japan, the rapidly aging population is becoming more visible, especially in "aging new towns". Since mobility levels are usually decline with age, having a self-contained neighborhood could be more important than before. This chapter therefore explores the self-containment status of new towns for discretionary activities (shopping, volunteer, recreation and so on), by using a multi-period (two waves) and multi-day (two weeks) panel survey data collected in Koyo New Town located in Hiroshima, Japan. For this purpose, a panel mixed logit model of destination choice with a focus on the impacts of social networks will be developed. How self-containment contributes to the improvement of residents' SWB will also be examined.

6.1 Introduction

Japan experienced a rapid population growth from the 1950s to 1980s, leading to the development of new neighborhoods, so-called “new towns”, in suburban areas. A rapidly aging population has recently been observed in Japan, especially in “aging new towns”, since many of the residents living in the new towns belong to a specific age group (over 65 years). Mobility level usual decreases with age due to physical changes and reduction of level-of-services of local public transport. It can also be expected that activity space of the elderly tends to be smaller after retirement, since they may not need to make long distance trips to working places (mainly located in CBD). Instead, going to the park, taking walks around, visiting their friends and so forth may become dominant trip purposes, most of which are done within the neighborhood. As a result, having a self-contained neighborhood could be more important than before.

The concept of self-containment ("balance") has been embodied in the planning objectives of many new towns, especially in Europe but also in some cases in the United States. This concept was first promoted by Ebenezer Howard via the Garden City Movement which was planned as self-supporting communities (Howard, 1898, cited from Cervero, 1995a), in order to relieve London from overcrowding in the post-World War II period. Conventionally, self-containment has usually been interpreted as a balance between jobs and housing (job-housing balance) in a community. Thus, a number of studies have discussed self-containment in relation to working trips (Cervero, 1995a; Curtis and Olaru, 2010; Hui and Lam, 2005; Yigitcanlar *et al.*, 2008). Taking a broader perspective, self-containment was considered as a form that allows people to live, work, shop and create within a community (Burby & Weiss, 1976, cited from Cervero, 1995a; Cervero, 1995b; Hui and Lam, 2005; Lee and Ahn, 2005; Pakzad *et al.*, 2007; Yigitcanlar *et al.*, 2008) Non-working trips are said to account for a majority of total commuting trips in metropolitan areas, for example approximately three-quarters of all trips in American metropolitan areas and Europe (Richardson and Gordon, 1989, cited from Cervero, 1995b; Salomon *et al.*, 1993), and hence, some studies have recently focused on the issue of self-containment from the perspective of non-working trips. Lee and Ahn (2005) state that five new towns and nearby residential areas in the Seoul metropolitan area have a fairly favorable degree of self-containment in terms of non-working trips, whereas Pakzad *et al.* (2007) assess new town self-sufficiency based on working and non-working activities. Since working trips constitute a minor portion of all travels in aging new towns in Japan where a significant number of residents are retired, this study focuses on discretionary trips, namely shopping, volunteer, recreation and so on to examine the self-containment status of new towns, which can be understood as a collective nature of each individual's destination choice.

Social network of people are formed through family relations and friendships, as well as through various activities and places, which shows that social contact among people is crucial (Páez and Scott, 2007; Páez *et al.*, 2008). The impacts of social relations on travel decisions have been widely studied in the field of transportation (Harvey and Taylor, 2000). According to Dugundji and Walker (2005), decision makers are influenced by both social (e.g. interactions with other people) and spatial (e.g. locations where they live) networks. Social networks often create demand for traveling (Carrasco and Miller, 2009; Farber and Páez, 2009), and hence travel behavior and mobility are coupled with social bonds and locations (Ryley and Zanni, 2013). In particular, social networks may be important factors for destination choices of discretionary activities, since these activities are often done with family members, relatives and/or friends and thus he/she may not be able to decide the destination based solely on his/her preferences. This would be especially true in Asian society where social ties might be stronger than Western countries.

In this regard, this study explores the self-containment status of a new town for discretionary activities with a focus on the impacts of social networks. For this purpose, a panel mixed logit model of destination choice is developed, and the impacts of social networks and other relevant factors on destination choice are empirically examined by using a multi-period and multi-day panel survey data, collected in Koyo New Town located in Hiroshima, Japan. Then the impacts of their destination choice and social networks on SWBis addressed to understand whether or not having ore self-contained neighborhood contributes to having a better quality of life. Answering these questions would be crucial for anticipating the possible impacts of urban planning policies, such as the “compact city” policy. For example, when residents are encouraged to move from the current neighborhood to others, their social networks and activity locations could be mismatched, potentially causing negative impacts on their quality of life, especially for those who have higher mobility constraints.

6.2 Descriptive Analysis

Among 38 panel respondents, the valid samples which are available for both waves is 31 for GPS data and 26 for paper-based data. While paper-based data provide trip purpose and travel mode information that cannot be collected through GPS devices, GPS data provide the precise activity location information. Thus, in this study, to utilize these advantages of two data sources, GPS data and paper-based data were merged. For GPS data processing, first, trip ends were detected within GPS data stream by searching for time periods of non-movement. The GPS data (decomposed to trips) and paper-based data are then merged based on departure and arrival time information. There are a lot of literature reviews to identify thresholds in detecting trips and merging GPS data with paper-based data. These thresholds vary primarily depending on the characteristics of local activities. Wolf *et al.* (2001) state that two-minute threshold yielded the best prediction of the true trip ends. It is considered as a gap whenever the time interval or the distance between consecutive points is greater than two minutes or 250 meters (Chen *et al.*, 2010), while a trackpoint is removed when distance between two consecutive trackpoints less than 10 meters (Bohte and Maat, 2009). Schüssler and Axhausen (2008) also use two-minute threshold to assume as stopped activities. Based on the findings of existing studies, in the current paper, we consider a movement is regarded as a trip when it is more than 100 meters within two minutes, and use a time-interval condition with 30-minute threshold to merge two kinds of data.

Based on the available samples which existed in both waves, destinations of mandatory trips (working, school, medical treatment and pick-off/drop-off) and discretionary trips (shopping, volunteer, meeting with friends/acquaintance, club activities, eating out, taking around, leisure activities, and so on) are shown in Table 6.1. First, it is confirmed that discretionary activities are dominant activities in the current samples. This would be because most respondents are already retired, and thus, in this study the discretionary activities are examined. Second, discretionary activities tend to be done inside the new town compared to mandatory activities, implying that their activity locations tend to be inside new town after retirement. Since self-containment status has been measured based on residents’ actual behavior (i.e., how many residents do activities inside/outside the neighborhood) in most existing studies, these results indicate that progress in aging could result in more self-contained neighborhood. Meanwhile, self-containment is treated as an aggregation of destination choice analysis.

Table 6.1 Destinations of mandatory and discretionary activities

	Destination		
	Inside new town	Outside new town	Total
Mandatory activities	93	87	180
	51.7%	*48.3%*	*100%*
Discretionary activities	477	228	705
	67.7%	*32.3%*	*100%*

In the case of discretionary activities, the status of social network may influence destination choice. Table 6.2 shows destinations of discretionary activities by the status of social network. The results indicate that the respondents who belong to inside-network group did 71.1% of activities inside new town, while those who are in outside-network group tend to do activities outside new town. These results indicate that their activity spaces would be formed based on their social network distributions.

Table 6.2 Destinations of discretionary activities by the status of social network

	Destination	
	Inside new town	Outside new town
Inside-network group	315	128
	71.1%	28.9%
Outside-network group	162	100
	61.8%	38.2%

6.3 Modeling destination choice

In order to examine the impacts of social networks on destination choice under the control of other influential factors, a destination choice model is developed based on a panel binary mixed logit model (also called random-parameters or error components logit) to account for unobserved heterogeneity among respondents and the correlations in unobserved utility over repeated choices by each individual. In fact, a variety of studies developed mixed logit model for modeling location choice. Bhat and Gossen (2004) use a mixed logit model to analyze in-home, out-of-home, and pure recreational activities; while resident's trips-making propensity to urban parks is estimated by a mixed logit model

(Kemperman *et al.*, 2005). The model is also applied to location-related choice (Bhat and Guo, 2004), and migration to urban and rural areas (Détang-Dessendre *et al.*, 2008).

In this study, a destination choice model is developed based on a simple panel mixed logit model specification, since the sample size may not be large enough to develop the full random-coefficients model. Concretely, only the constant term as a random term is handled which varies over respondents but being constant over choice situations for each respondent. In this case, utility U_{njt} that an individual n ($n = 1, 2, \ldots, N$) associates with a destination j ($j = 1,2$) in day t may be written as

$$U_{njt} = \alpha_j + \beta \mathrm{x}_{\mathrm{njt}} + \eta_{nj} + \varepsilon_{njt} \qquad (6\text{-}1)$$

where α_j is a constant term for destination j, β is a vector of parameters, x_{njt} is a vector of explanatory variables (including the status of social networks), η_{nj} is a random term which is normally distributed with mean 0 and variance σ^2_η capturing unobserved heterogeneity among respondents, and ε_{njt} is an error term which is Gumbel distributed.

Conditional on η_{nj}, the probability that individual n chooses destination i in day t follows the standard logit formulation:

$$L_{nit}\left(\beta \mid \eta_{nj}\right) = \prod_{t=1}^{T} \left[\mathrm{e}^{\beta \mathrm{x}_{\mathrm{nit}}} \Big/ \sum_{j} \mathrm{e}^{\beta \mathrm{x}_{\mathrm{njt}}} \right] \qquad (6\text{-}2)$$

The unconditional probability is the integral of the conditional probability over all possible value of η_{nj}:

$$P_{nit} = \int L_{nit}\left(\beta \mid \eta_{nj}\right) f\left(\eta_{nj}\right) d\eta_{nj} \qquad (6\text{-}3)$$

The model estimation is done by using Software R with package lme4 (Bates, 2010). It is hypothesized that a greater number of friends within the new town leads to increasing discretionary activities in the new town, and vice versa. It should be noted that in this study facilities variables are not used for the modeling. Accessibility to the facilities do not really vary across residents, since almost all facilities are located in the neighborhood center, including community hall, shopping center, bank, post office, hospital, sport club, and so on. To explore the impacts of facilities, two or more new towns should be simultaneously examined.

6.4 Estimation Results

The estimation results are shown in Table 6.3. The impacts of status of social network are captured by the number of friend variables. It is confirmed that the more number of friends inside [outside] increases the number of activities inside [outside], indicating that the status of social network statistically influences the self-containment status of the new town. It is also found that the non-motorized variable is indeed significant at the 1% level with the a positive sign, indicating that owning non-motorized vehicles would result in the increase of inside activities. This finding is basically consistent with Fujiwara's (2012) finding that the introduction of personal mobility vehicles increases activities inside new towns. The motorized vehicle ownership variable is not statistically significant, but it shows the negative sign as expected: those who have a car tend to do activities outside the new town. The age variables are significant at the 1% level. The negative sign of age squared variable indicate that age impacts follow the quadratic function (upward convex) with a maximum at around 70 years old. Job and gender variables are not significant, but the signs are as expected: males those and who are working tend to do activities outside new town. In addition, as can be seen in the result of chi-squared test, the differences between with and without random terms σ^2_η are statistically significant at 0.1% level, illustrating that there is a heterogeneity among respondents.

Table 6.3 Binary mixed logit model for destination choice

Variable	Estimate	z value
Constant	-64.343	-2.931**
Year (1: 2011, 0: 2010)	-0.247	-0.878
Log(the number of friends inside + 1)	0.327	1.902+
Log(the number of friends outside + 1)	-0.420	-1.992*
Motorized vehicle ownership (1: own; 0: otherwise)	-0.444	-0.976
Non-Motorized vehicle ownership (1: own; 0: otherwise)	1.395	3.090**
Age	1.857	3.051**
Age*Age (divided by 100)	-1.309	-3.130**
Job (1: having job; 0: otherwise)	-0.690	-1.273
Gender (1: male; 0: female)	-0.174	-0.329
Random term σ^2_η	0.694	[26.28] **
Initial log-likelihood	*-488.7*	
Final log-likelihood	*-370.3*	
Sample size	*705*	

Notes: ** $p < 0.01$; * $p < 0.05$; + $p < 0.10$. The value in [ ] means the results of chi-squared test with/without random term σ^2_η.

6.5 Discussions

In the previous sections, it has been confirmed that social network has a significant impact on destination choice decisions. The results shown that, when residents have more friends inside, they tend to conduct activities inside, and vice versa. According to Gagliardi *et al.* (2007) and Spinney *et al.* (2009a), the elderly people's ability to travel and participate in mobility and social interaction is positively associated with their cognitive subjective well-being. But what will happen when they have more friends outside the neighborhood, but actually cannot engage activities outside due to mobility constraints? Answering this question would be crucial for implementing compact city policies, where the residential relocation from suburban areas to the central areas would be involved: after relocation, social network distribution and activity space could be mismatched, implying that social contacts would become more difficult. This could cause negative impacts on their quality of life, especially for those who have higher mobility constraint. In addition, it should be noted that main purpose of using SWB is to represent an evaluation part for the proposed framework in this study. In other words, there are several indicators that can represent for the evaluation part for the framework, and SWB would be one of them.

As mentioned in the subsection 3.2.1 Chapter 3, in 2011 respondents were asked to report on their happiness. Thus, this section attempts to provide some additional insights on the impacts of the mismatching on quality of life by comparing the SWB among different groups: (1) those who belong to inside-network group with more activities inside, (2) those who belong to outside-network group with more activities inside, (3) those who belong to inside-network group with more activities outside, and (4) those who belong to outside-network group with more activities outside. Our particular interest is in the group (2): if their SWB is significantly lower than the other groups, then the mismatching between social network distribution and activity space would be an important aspect of compact city policy debates.

Table 6.4 presents the level of SWB across four groups. It is confirmed that the respondents belonging to the inside-network group (groups (1) and (3)) get higher SWB than those in the outside-network group. Although activity locations seem not to be really influential on subjective well-being, it is found that the group (2) shows the smallest subjective well-being, indicating that residential relocation policies should be designed with due considerations of maintaining social relationships.

Table 6.4 Level of subjective well-being across four groups

	Those who did more activities inside	Those who did more activities outside
Inside-network group	7.98 [group (1)]	8.08 [group (3)]
Outside-network group	7.20 [group (2)]	7.37 [group (4)]

As can be seen from Table 6.5, there is statistically significance for friend networks, with the representatives of inside-network category ($M = 8.00$) ranking higher in happiness than the members of outside-network one ($M = 7.29$) $t = -3.629$, $p < 0.001$. This proves the level of well-being is significantly influenced by social network existing in residents' location. It is also worth pointing out significant differences in the group (1) and (2), demonstrating members of the group (1) get higher SWB than those of the group (2). In this context, for the elderly, the existence of friend network far away from daily activity location leads to a decrease in subjective well-being. No statistically significant difference, in contrast, is found in the destination choices between the inside and the outside, indicating that there is not a significant impact of self-containment on subjective well-being. This could be because of the limited sample size, and it may have to be reconfirmed with a larger scale dataset.

Table 6.5 The results of t tests for two groups of social networks based on level of subjective well-being

Variable	n	Mean	*t*-value
Those who did more activities inside	179	7.87	
Those who did more activities outside	64	7.78	
			-0.459
Inside-network group	191	8.00	
Outside-network group	52	7.29	
			-3.629**
inside-network group with more activities inside [group (1)]	154	7.98	
outside-network group with more activities inside [group (2)]	25	7.20	
			-3.537**

Notes: ** $p < 0.01$; * $p < 0.05$; + $p < 0.10$.

The findings are consistent with the literature reviewed and the hypothesis presented earlier in this study. Friend networks affect self-containment of discretionary trips (choosing destinations inside or outside the new town) as well as residents' happiness. In other words, it is thanks to friends in the new town that the respondents have a higher number of trips within the new town and a higher level of happiness is obtained. Policy-makers in urban and transportation planning, therefore, should carefully consider policies promoting residents to move out from the aging new towns.

6.6 Conclusion

In Japan, due to population decline and aging, it becomes an urgent task to reorganize the neighborhoods particularly new towns, which had been built around 40 years ago in the period of a rapid population growth. Since aging would increase the demand for activities inside new towns, having more self-contained neighborhoods would be more preferable for the elderly people. This study has examined the self-containment status, which were associated with original concepts of new towns, of discretionary activities in an aging new town. Many researchers have assessed self-contained neighborhoods based on working trips, while a recent study has examined the self-containment respecting to non-working or discretionary trips. By following the latter stream, in this study the self-containment status has been explored by developing a destination choice model.

Since social bonds are considered as important factors of life particularly in Asian countries, effects of social relationships on destination choices also have been examined in this study. A series of empirical analysis by using a multi-period (two waves) and multi-day (two weeks) panel survey data were collected in Koyo New town (Hiroshima, Japan) in 2010 and 2011. The primarily aggregate analysis shows that a greater number of friends within the new town leads to increasing discretionary activities in the new town. The model estimation results of destination choice behavior also support this finding. These imply that the status of social network significantly influences on destination choice sets, and hence, it is an influential factor of the self-containment status of the new town. It was also confirmed that owning non-motorized vehicles would further enhance the self-containment of the neighbourhood was also confirmed. Finally, the relationships among destination choice, social network and SWB have been examined particularly to examine the possible consequences of residential relocation policies, which often appear on the agenda of compact city policy debates. The results show that, the more friends the respondents have in the neighborhood, the more SWB they would obtain. This indicates that residential relocation policies should be designed with due considerations of the mismatching between social network distribution and activity space.

A number of remaining issues need to be addressed in future studies. First, although the current study has provided some useful insights for future urban and neighborhood planning, more empirical evidences is certainly needed, since the sample used in the empirical analysis is quite limited. Empirical analysis with large scale data and/or in different neighborhoods would be necessary before giving a general conclusion. Second, mainly due to the limited sample size, the analysis had to be simplified as much as possible: only two destinations and two social network groups are considered. The model could be more generalized with larger scale data.

7 EXPLORING THE INFLUENCE OF SOCIAL CAPITAL ON TRIP GENERATION AND DESTINATION CHOICE IN NEW URBAN AREAS IN VIETNAM

Travel engages in making new connections and extending one's network or sustaining one's existing networks; such a social engagement would be essential to enhance one's social capital. As a result of growing urban development, a strong local social capital could be more important, especially in Asian societies where social ties are believed stronger than Western ones. This chapter will explore impacts of social capital measured in two dimensions (i.e. social network and participating in local community activities) on travel choice for discretionary activities. For this purpose, by using data collected in Hanoi (Vietnam), a logit model for destination choice and an ordered probit model for trip generation will be developed with controlling for socio-demographic attributes, mobility and accessibility, and built environment factors.

7.1 Introduction

In order to understand the factors that influence travel choice decisions, transport planners focus particularly on analyzing transport demand, then proposing new transport policies and investments. For instance, changes in trip generation and destination choice could be attributed to factors related to the socio-demographics (e.g. age, gender, income and education), mobility and accessibility (e.g. vehicle ownership and distance to nearest transit stop), context (i.e. trip purpose), and built environment. In transport modeling literature there has been rising recognition that the aforementioned factors are not sufficient to capture travel behavior of a decision maker. As a result, there is increasing interest in examining new variables (e.g. attitudes, habit, awareness and social capital) that can be incorporated in transport models (Anable, 2005; Ben-Akiva *et al.*, 2002; Cantillo *et al.*, 2007; Deutsch and Goulias, 2010; Di Ciommo *et al.*, 2014; Domarchi *et al.*, 2008; Hwang *et al.*, 2006; Páez, 2013)

Recent studies have also recognized that social engagements influence travel behavior (Ben-Akiva *et al.*, 2012; Carrasco and Miller, 2006) by extending choice models including some specific elements of social influences (e.g. family and friends) that impact the process of making a choice. In addition, some studies have stated that travel engages in making new connections and extending one's network or sustaining one's existing networks, and such a social engagement would be essential to enhance one's social capital (Di Ciommo *et al.*, 2014; Gray *et al.*, 2006; Kamruzzaman *et al.*, 2014; Stanley *et al.*, 2011; Urry, 2012). It is possibly because of the difficulty in measuring the social capital of people with respect to their social relationships, variables representing key components of social capital are quite different across these studies.

Social capital is an original term used in the discipline of sociology, and it is complicated because it has various and sometimes ambiguous definitions. Social capital refers to the advantages an individual can gain from social participation/networks, reciprocity and mutual trust (Putnam, 1993). Like financial capital, it is also like a capital captured though social relations, or "investment in social relations with expected returns in the marketplace" (Lin, 2002). The matter of social capital has become a prominent subject for many debates; one of these is from the theoretical perspective of whether social capital refers only to an individual matter or whether it relates to a broader context – community level (Currie and Stanley, 2008). For social capital at the individual level, one of the earliest writers, Bourdieu (1985), views narrowly social capital as a means to gain access through social bonds, to economic and cultural capital. In his view, the volume of the social capital depends on the size of the network of connections and on the volume of the other possessed capitals. Some followers have extended Bourdieu's definition by associating it with other capitals such as financial, cultural and human capitals (Fine, 2001; Lin, 2002). This approach would be applicable because (1) according to Gray *et al.* (2006), a range of acquaintance groups (including families, schools, colleagues and virtual bonds via internet) spatially scatter across regions, and thus social capital would vary and (2) an advantages of this approach - focusing only on structure, such as groups and network, would reduce the complexity of handling social capital in empirical studies. On the other hand, such definition would not be able to encompass participation in community and to capture networks automatically gaining more benefits (Johnson *et al.*, 2003). With regards to social capital at community level, Putnam tends to deal with the concept of social capital which is associated with civic engagements in communities/towns (Putnam, 1993; Putnam, 1995a; 1995b; 2000). Particularly, as a measurement through membership in community groups, parents associations and sport clubs, there has been a decline in America's level of civic and political engagements, resulting in negative economic and political consequences (Putnam, 1995b). Putnam believes that social capital refers to community context rather than individual.

In the context of social capital and transport, it has been argued that there are negative relations between car dependence and the development of social capital, resulting in an increase in commuting time and a decrease in community engagements (Adams, 1999). There is a recommendation for enhancing more casual socializing in the community

(Putnam, 2000). Additionally, in the case that people move in towns but maintain previous activities (e.g. working, shopping and social engagement patterns) without integrating them into the new locations, the social capital in the towns would be immediately weakened (Urry, 2002). By focusing on environmentally friendly travel modes (e.g. public transport, walking and cycling), Vuchic (2000) argues the notion of transport planning to create "livable cities" with three major characteristics (environmentally efficient, economically viable, and socially sound). Despite no direct reference, to some extent the aspect of socially sound is implied in social capital. Finally, growing private vehicles dependence and increasing new urban areas nearby downtowns have been witnessed in many countries as a result of rapid economic development, leading to overloading of the urban transport system (e.g. traffic jam) and to undermine social capital in a locality (Adams, 1999). Therefore, having a strong local social capital could be more important, especially in Asian societies where social ties are believed to be stronger than Western ones.

Social capital can be fostered through social engagements that are geographically stretched out, making travel often desirable and necessary (Páez *et al.*, 2008; Urry, 2012). According to Dugundji and Walker (2005), decision makers are influenced by both social (e.g. interactions with other people) and spatial (e.g. locations where they live) networks. Social networks often create demand for traveling (Carrasco and Miller, 2009; Farber and Páez, 2009), and hence travel behavior and mobility are coupled with social bonds and locations (Ryley and Zanni, 2013). In particular, social networks may be an important factor for destination choice and trip generation of discretionary activities, since these activities are often done with family members, relatives and/or friends and thus he/she may not be able to decide solely based on his/her preferences.

Motivated by the above discussions in existing studies on the link between social capital and travel choice behavior, the current study tries to further examine the causal relationship between social capital and travel choice. Social capital would be affected by travel behavior in the long term, while the opposite causal relation may exist in the short term. Following the latter, this study attempts to capture the impacts of social capitals, as measured in two dimensions (i.e. individual - social network, community - participating in local community activities) on trip generation and destination choice of non-mandatory activities.

A logit model of destination choice and an ordered probit model of trip generation were developed to identify different impacts of social capitals, controlling for socio-demographics, mobility and accessibility, and built environment factors. The results show that for both models the individual's social network variables are statistically significantly, while insignificant effects are found for participating in community activities. In other words, the individual's social network has significantly higher impact on destination choice and trip generation for non-mandatory activities compared to participation in local community activities.

Then the relationship among destination choice and social capital related to SWB is discussed to examine whether having more activities and social capitals inside new urban areas contributes to having a better quality of life or not. Through answering these questions, it would be essential for urban planning policies can be developed to improve self-contained neighborhoods. For example, due to housing shortages in urban areas, after moving to new urban areas, residents' social engagements and activities inside should be promoted, potentially leading to positive impacts on their quality of life. Data used in this study were collected in 2015 from a travel diary survey with respect for 469 respondents in three new urban areas in Hanoi Metropolitan Area of Vietnam.

7.2 Descriptive analysis

A total of 469 respondents from 243 households, participated in the survey. Some respondents had to be excluded due to missing data (incomplete daily travel diaries, unwillingness to provide some individual characteristics and household attributes), and then some trips with purposes of going home and others also were excluded. As a result, destinations of mandatory trips (working, school, medical treatment and pick-off/drop-off) and discretionary trips (shopping, personal business, meeting with friends/acquaintance, doing exercise, eating out, taking around, leisure activities, and so on) are shown in Table 7.1. The majority of mandatory activities are done outside the new urban area. It is because most respondents travel outside of the areas for commuting – typical characteristics of new urban areas located in HMA. In contrast, discretionary activities tend to be done inside the area. Since new urban areas were not planned for providing jobs or quality hospitals/universities at the beginning, it would not be easy to reduce traveling out for mandatory purposes. In this case, focusing on discretionary activities looks appropriate to examine ways of reducing vehicle miles traveled. For the analysis, 1718 discretionary trips were therefore selected for the binary destination choice model.

Table 7.1 Destinations of mandatory and discretionary activities

	Destination		
	Inside area	Outside area	Total
Mandatory activities	260	718	978
	26.6%	*73.4%*	*100%*
Discretionary activities	965	753	1718
	56.2%	*43.8%*	*100%*

Table 7.2 shows basic statistics on share of discretionary trip generation per day. Two and one trips per day make up the two biggest shares with 35.9% and 30.7%, respectively, followed by three trips per day with 19.2%. In contrast, having no trip and more than three trips per day just accounts for approximately 7%. Thus five categories are selected in the ordered probit model for trip generation with 889 individual-days.

Table 7.2 The share of trip generation for discretionary activities

Number of trip generation per day	Number	Share (%)
Zero trip	61	6.9%
One trip	273	30.7%
Two trips	319	35.9%
Three trips	171	19.2%
More than three trips	65	7.3%
Total	*889*	*100.0%*

Built environment has been examined as a key factor affecting trip generation and destination in many studies. Due to limitations in collecting built environment information in the three areas, perceived built-environment measures are used to handle the impact of neighborhood built environment (Michael *et al.*, 2006; Sallis *et al.*, 1997; Wood *et al.*, 2010; Zhang, 2013), instead of objective built-environment measures. As one part of the survey, subjective residential environment measurement focuses on the household's perceptions of the quality of their residential environment. These variables were collected using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to gauge satisfaction regarding sixteen aspects related to residential environments (e.g. shops/markets for non-daily shopping and daily shopping, kinder garden, school, restaurants, open/green space, and so on). Then, three new synthetic variables created based on the result of factor analysis, which include leisure satisfaction, education satisfaction and shopping satisfaction, are incorporated into the models.

For social capital factors considered in this study for both models, social capital at the individual level is represented by social network composition (i.e. number of acquaintance in and out the areas) and "close" social network composition (i.e. number of "close" social network in the areas), while social capital at the community level is represented by participation in community activities. With regards to social network composition, the respondents reported the number of children/parents, relatives, and acquaintances who they do not live with, and still keep in touch with (i.e. face-to-face communicate at least once within six-months). As a typical feature of residents living in the areas is that they moved in recently, and have children/parents and relatives living outside their areas, they are commencing to establish new social capitals in the locality and to maintain old ones. Hence, the number of acquaintances in and out of the areas were added in the models. Regarding the "close" social network is defined by activities consisting of meeting face-to-face often for non-working purposes, discussing important matters with, and needing help. From information of six people related to being so-called "small worlds" (Watts, 2003) (including basic individual's characteristics, relationship, location, and conversation frequency), to capture the local social capital, the number of "close" social network in the areas was added in the models. As for participation in community activities (comprising civic community, parents' associations and sports clubs, women associations and so forth), despite the existence of these community groups in the area, some residents do not engage in these community activities. For this reason, participating in the community was treated as a variable in the models.

7.3 Model Estimation

7.3.1 Modeling Travel Choice

A logit model for destination choice and an ordered probit model for trip generation were developed to identify different impacts of the social capital at different levels with controlling for socio-demographic attributes, mobility and accessibility, and built environment factors (Washington *et al.*, 2010). The utility function was assumed to be a linear function of explanatory variables. The model estimation is done by using Software R. It is hypothesized that a greater social capital at individual level leads to increasing discretionary activities in the area, and vice versa. The basic models are presented below

7.3.1.1 Destination Choice Model

The utility U_{njt} that an individual n ($n = 1, 2, \ldots, N$) who travel on a t-th trip ($t = 1, 2, \ldots, T$) chooses destination choice alternative j ($j = 1, 2$) may be written as

$$U_{njt} = \beta x_{njt} + \varepsilon_{njt} \tag{7-1}$$

where β is a vector of parameters, x_{njt} is a vector of explanatory variables, and ε_{njt} is an error term which is Gumbel-distributed.

The probability that individual n chooses destination choice i can be written as the following standard logit formulation.

$$P_{njt}(\beta) = \prod_t \left[\frac{e^{\beta x_{nit}}}{\sum_j e^{\beta x_{njt}}} \right] \tag{7-2}$$

7.3.1.2 Trip Generation Model

The model platform is an underlying random utility model or latent regression model y^* that an individual n ($n = 1, 2, \ldots, N$) chosen trip generation alternative y ($y = 1, 2, \ldots, J$) may be written as

$$y_n^* = \beta x_n + \varepsilon_n \tag{7-3}$$

where β is a vector of parameters, x_n is a vector of explanatory variables, and ε_n is an error term.

The probabilities of making j trips can be written as

$$P_n(y = j) = P(\mu_{j-1} < y_n^* < \mu_j) = P(\mu_{j-1} - \beta x_n < \varepsilon_n < \mu_j - \beta x_n) \tag{7-4}$$

where μ_j are the unknown threshold parameters, defined as $\mu_{-1} = -\infty$, $\mu_j = +\infty$, and $\mu_{-1} < \mu_j$ for all j. More concretely, the choice probabilities of the ordered probit model is written as

$$\begin{aligned}
&P_n(y=0) = \Phi(-\beta x_n)\\
&P_n(y=1) = \Phi(\mu_1 - \beta x_n) - \Phi(-\beta x_n)\\
&\ldots\\
&P_n(y=j) = \Phi(\mu_j - \beta x_n) - \Phi(\mu_{j\text{-}1} - \beta x_n)\\
&\ldots\\
&P_n(y=J) = 1 - \Phi(\mu_{J-1} - \beta x_n)
\end{aligned} \tag{7-5}$$

where Φ represent the cumulative normal distribution function.

7.3.2 Estimation results and discussion

Table 7.3 and Table 7.4 show explanatory variables introduced in the destination choice model and the trip generation model. In general, there are four main groups of explanatory variables (1) socio-demographic and trip context, (2) mobility and accessibility, (3) built environment and (4) social capital. There are some specific reasons for looking at age and social capital at the individual level. In particular, the age variable in this study is divided into five age groups to understand differences among these groups on the choice models, while incorporating logarithm of some acquaintances inside/outside into the choice models increases the model fit significantly.

Estimation results for the destination choice and the trip generation are shown in Table 7.5 and Table 7.6, respectively. A set of four model results is presented in each table with the first model is a base model, the second model considers social capital at individual level, the third model considers social capital at the community level, and the final one considers social capital at both levels.

Estimation results for the destination choice and the trip generation are shown in Table 5.5 and Table 5.6, respectively. A set of four model results is presented in each table of estimation result where the first model as a base model, the second model regarding social capital at individual level, the third model respecting to social capital at the community level, and the final one considering social capital at both levels.

First, as for the destination choice, as expected, the three variables characterizing for social capital at the individual level are statistically significant across models. Especially, the number of acquaintance inside [outside] increases the number of activities inside [outside], being consistent with Nguyen *et al.* (2016) finding that a greater number of friends within the new town leads to increasing discretionary activities in the new town. In contrast, social capital at the community level does not affect the destination choice for non-mandatory activities. Although only age variable from 51 to 60 years old is indeed significant at 5% level, other socio-demographic factors other show signs as predicted: (1) working-age residents tend to travel outside of the areas, and female or low/middle individual income or high education people favor in traveling inside the area maybe because of covering house works usually located nearby their houses, vehicle ownership constraints and so on. Almost all trip context variables are significant at 0.1% level, suggesting that discretionary activities related to doing exercise/daily shopping/recreation tends to be done inside the areas. There is a statistically significance for mobility and accessibility with a negative sign (excepted for car ownership), implying that close accessibility to transit stops foster to travel outside by public transport and those who have a vehicle tend to do activities outside the residential areas. The built-environment variable associated with leisure has a significant effect on destination choice, indicating that residents tend to do activates inside because of satisfaction on recreation in the current residential areas. Based on the goodness-of-fitness among the four models, it is confirmed that social capital at the individual level has a significant impact on deciding travel in/out for the residents.

For the estimation results on trip generation, social capital at individual level is statically significant (excepted for acquaintance outside), while it is interesting that those participating in community' activities leads to an increase in the trip generation. However, when adding both social capital related variables into the model 4b, social capital at the community becomes statically insignificant. It is also found that all age-group variables negatively influence the generation of discretionary trips and most of them are statistically significant (excluding the group 51-60 years), indicating that the young lessen in discretionary activities as a burden of commuting and schooling. While female/high education people tend to generate more discretionary trips, low/middle individual income tend to reduce the number of these trips. The weekend variable is significant at 1 % level. This would be because of stress in working days; residents tend to cut off discretionary trips at the weekend. Motorcycle ownership has a significant impact at 5% level in all four models, meaning that owning a motorcycle spurs more short-distance non-mandatory activities. Besides, the results show that satisfaction on education/ leisure in residential built-environment result in rising non-mandatory activities.

In summary, based on the estimation results, it is obvious that social capital at individual level significantly affects destination choice and trip generation for discretionary activities. Also, social capital at the community level has insignificant impacts on destination, while it could have modest impacts on generating trips though it becomes insignificant when adding both social capital related variables. Thus, social capital at the individual level generally has more impact on travel choice (i.e. destination, trip generation) compared with one at the community level. From statistical aspect based on Akaike information criterion (AIC), the second models (model 2a, model 2b) including only social capital at the individual level is the best model for the both destination choice and trip generation.

Table 7.3 Explanatory variables for the destination choice

Explanatory variables	Definition	Mean	SD
Socio-demographic and trip context			
Age22	1: < 22years old; 0: Otherwise	0.011	0.102
Age30	1: 23-30 years old; 0: Otherwise	0.147	0.354
Age40	1: 31-40 years old; 0: Otherwise	0.437	0.496
Age50	1: 41-50 years old; 0: Otherwise	0.121	0.326
Age60	1: 51- 60 years old; 0: Otherwise	0.121	0.327
Male	1:Male; 0: Otherwise	0.433	0.496
High education	1: From Bachelor; 0: Otherwise	0.809	0.393
Low individual income	1: Lower than 3 *mil. VND*; 0: Otherwise	0.121	0.327
Middle individual income	1: 3-9 *mil. VND*; 0: Otherwise	0.379	0.485
Weekend	1: Weekend day; 0: Otherwise	0.536	0.499
Doing exercise	1: Exercise purpose; 0: Otherwise	0.208	0.406
Doing daily shopping	1: Daily shopping purpose; 0: Otherwise	0.190	0.392
Doing recreation	1: Recreation purpose; 0: Otherwise	0.229	0.420
Mobility and accessibility			
Car own	1: Household having a car, 0: Otherwise	0.421	0.494
Motorcycle own	1: Household having a motorcycle, 0: Otherwise	0.920	0.272
Distance to nearest bus stop	Distance to nearest bus stop, *meter*	290.472	213.906
Built environment			
Leisure satisfaction	Satisfaction on leisure environment in the area	3.849	0.239
Education satisfaction	Satisfaction on education environment in the area	3.867	0.197
Shopping satisfaction	Satisfaction on shopping environment in the area	3.761	0.224
Social capital			
Acquaintance inside	Log(Number of acquaintance in the area + 1)	1.809	1.255
Acquaintance outside	Log(Number of acquaintance out the area + 1)	2.833	0.979
Close social network inside	Number of close social network in the area	1.131	1.547
Participating	1: Participating community's activities; 0: Otherwise	0.496	0.500

Table 7.4 Explanatory variables for the trip generation model

Explanatory variables	Definition	Mean	SD
Socio-demographic and trip context			
Age22	1: < 22years old; 0: Otherwise	0.018	0.133
Age30	1: 23-30 years old; 0: Otherwise	0.142	0.349
Age40	1: 31-40 years old; 0: Otherwise	0.474	0.500
Age50	1: 41-50 years old; 0: Otherwise	0.124	0.329
Age60	1: 51- 60 years old; 0: Otherwise	0.108	0.311
Male	1: Male; 0: Otherwise	0.436	0.496
High education	1: From Bachelor; 0: Otherwise	0.819	0.385
Low individual income	1: Lower than 3 *mil. VND*; 0: Otherwise	0.117	0.322
Middle individual income	1: 3-9 *mil. VND*; 0: Otherwise	0.372	0.484
Weekend	1: Weekend day; 0: Otherwise	0.398	0.490
Mobility and accessibility			
Car own	1: Household having a car, 0: Otherwise	0.435	0.496
Motorcycle own	1: Household having a motorcycle, 0: Otherwise	0.937	0.243
Distance to nearest bus stop	Distance to nearest bus stop, *meter*	296.249	209.701
Built environment			
Leisure satisfaction	Satisfaction on leisure environment in the area	3.835	0.234
Education satisfaction	Satisfaction on education environment in the area	3.853	0.193
Shopping satisfaction	Satisfaction on shopping environment in the area	3.754	0.212
Social capital			
Acquaintance inside	Log(Number of acquaintance in the area + 1)	1.702	1.254
Acquaintance outside	Log(Number of acquaintance out the area + 1)	2.836	0.970
Close social network inside	Number of close social network in the area	1.002	1.470
Participating	1: Participating community's activities; 0: Otherwise	0.469	0.499

Table 7.5 Model estimation results for the destination choice

Independent Variables	Model 1a		Model 2a		Model 3a		Model 4a	
	Estimate	z value	Estimate	z value	Estimate	z value	Estimate	z value
(Intercept)	-1.169	-0.80	-0.304	-0.20	-1.160	-0.79	-0.312	-0.21
Socio-demographic and trip context								
Age22	-0.900	-1.68^{+}	-0.671	-1.25	-0.879	-1.63	-0.690	-1.27
Age30	-0.237	-1.06	-0.061	-0.27	-0.221	-0.96	-0.076	-0.33
Age40	-0.278	-1.35	-0.200	-0.96	-0.273	-1.32	-0.206	-0.98
Age50	-0.424	-1.79^{+}	-0.360	-1.50	-0.417	-1.76^{+}	-0.369	-1.53
Age60	-0.459	-2.02*	-0.459	-2.01*	-0.454	-1.99*	-0.465	-2.03*
Male	-0.096	-0.81	-0.077	-0.65	-0.093	-0.78	-0.080	-0.67
High education	0.088	0.53	0.106	0.64	0.086	0.52	0.107	0.64
Low individual income	0.306	1.40	0.193	0.87	0.299	1.36	0.200	0.90
Middle individual income	0.088	0.65	0.021	0.15	0.088	0.65	0.020	0.15
Weekend	-0.011	-0.10	-0.022	-0.20	-0.011	-0.10	-0.022	-0.20
Doing exercise	2.722	13.75***	2.739	13.71***	2.720	13.73***	2.743	13.71***
Doing daily shopping	0.721	4.80***	0.745	4.92***	0.720	4.80***	0.747	4.93***
Doing recreation	1.060	7.64***	1.047	7.49***	1.060	7.64***	1.047	7.49***
Mobility and accessibility								
Car own	-0.026	-0.23	0.041	0.35	-0.026	-0.23	0.040	0.34
Motorcycle own	-0.874	-3.81***	-0.889	-3.82***	-0.872	-3.80***	-0.891	-3.83***
Distance to nearest bus stop	-0.001	-2.04*	-0.001	-1.88^{+}	-0.001	-2.05*	-0.001	-1.85^{+}
Built environment								
Leisure satisfaction	0.447	1.85^{+}	0.436	1.79^{+}	0.445	1.84^{+}	0.438	1.80^{+}
Education satisfaction	0.165	0.57	0.119	0.41	0.160	0.55	0.124	0.42
Shopping satisfaction	-0.163	-0.64	-0.320	-1.23	-0.166	-0.65	-0.319	-1.23
Social capital								
Acquaintance inside	-	-	0.087	1.78^{+}	-	-	0.090	1.82^{+}
Acquaintance outside	-	-	-0.151	-2.43*	-	-	-0.151	-2.41*
Close social network inside	-	-	0.123	3.09**	-	-	0.125	3.11**
Participating	-	-	-	-	0.038	0.33	-0.042	-0.36
Observations n = 1706								
Initial log-likelihood	*-1182.51*		*-1182.51*		*-1182.51*		*-1182.51*	
Final log-likelihood	*-997.88*		*-987.28*		*-997.83*		*-987.21*	
McFadden's Rho-square $\bar{\rho}^2$	*0.139*		*0.146*		*0.138*		*0.145*	
Akaike information criterion (AIC)	*1.193*		***1.184***		*1.194*		*1.185*	

*** Significant at 0.1% level; ** Significant at 1% level; * Significant at 5% level; + Significant at 10% level

Table 7.6 Model estimation results for the trip generation

Independent variables	Model 1b		Model 2b		Model 3b		Model 4b	
	Estimate	z value	Estimate	z value	Estimate	z value	Estimate	z value
(Intercept)	-0.506	-0.50	-0.500	-0.49	-0.523	-0.54	-0.503	-0.46
Socio-demographic and trip context								
Age22	-1.169	-4.02***	-0.996	-3.32***	-1.072	-3.60***	-0.943	-3.15**
Age30	-0.417	-2.84**	-0.264	-1.72^{+}	-0.350	-2.27*	-0.230	-1.49
Age40	-0.604	-4.52***	-0.536	-3.89***	-0.577	-4.18***	-0.521	-3.81***
Age50	-0.515	-3.34***	-0.462	-2.92**	-0.478	-3.00**	-0.440	-2.78**
Age60	-0.104	-0.71	-0.048	-0.32	-0.078	-0.52	-0.035	-0.23
Male	-0.052	-0.70	-0.047	-0.63	-0.045	-0.61	-0.043	-0.57
High education	0.091	0.86	0.095	0.89	0.088	0.83	0.093	0.87
Low individual income	-0.111	-0.78	-0.134	-0.93	-0.136	-0.94	-0.149	-1.03
Middle individual income	-0.122	-1.40	-0.162	-1.83^{+}	-0.122	-1.39	-0.161	-1.82^{+}
Weekend	-0.211	-2.88**	-0.244	-3.28**	-0.220	-2.99**	-0.248	-3.33***
Mobility and accessibility								
Car own	-0.098	-1.32	-0.108	-1.43	-0.098	-1.33	-0.106	-1.41
Motorcycle own	-0.316	-2.05*	-0.342	-2.20*	-0.316	-2.05*	-0.342	-2.19*
Distance to nearest bus stop	-0.000	-0.38	-0.000	0.17	-0.000	-0.45	0.000	0.09
Built environment								
Leisure satisfaction	0.317	1.93^{+}	0.307	1.88^{+}	0.315	1.95^{+}	0.306	1.86^{+}
Education satisfaction	0.404	2.16*	0.415	2.17*	0.390	2.08*	0.406	2.08*
Shopping satisfaction	0.050	0.29	-0.034	-0.20	0.046	0.27	-0.032	-0.18
Social capital								
Acquaintance inside	-	-	0.070	2.19*	-	-	0.064	2.01*
Acquaintance outside	-	-	0.025	0.64	-	-	0.022	0.55
Close social network inside	-	-	0.090	3.34***	-	-	0.087	3.22**
Participating	-	-	-	-	0.161	2.18*	0.099	1.31
Threshold 2	1.111	36.94***	1.118	36.94***	1.112	36.96***	1.119	36.95***
Threshold 3	0.996	41.49***	1.001	41.48***	0.997	41.48***	1.002	41.48***
Threshold 4	0.925	28.64***	0.935	28.62***	0.927	28.63***	0.935	28.61***

No. of observations n = 889

Initial log-likelihood	*-2308.06*	*-2308.06*	*-2308.06*	*-2308.06*
Final log-likelihood	*-1226.15*	*-1214.56*	*-1223.78*	*-1213.70*
McFadden's Rho-squared $\bar{\rho}^2$	*0.447*	*0.4566*	*0.448*	*0.4569*
Akaike information criterion (AIC)	*2.803*	***2.7842***	*2.800*	*2.7845*

Note: *** Significant at 0.1% level; ** Significant at 1% level; * Significant at 5% level; + Significant at 10% level

7.4 The relations among destination choice, social capitals, and subjective well-being

In the previous sections, it has been confirmed that the social capitals at different levels have a significant impact on destination choice decisions. The result shows that, when residents have more social fabric (acquaintance, close social network, participating to community activities) inside, they tend to conduct activities inside, and vice versa. The social and psychological aspects associated with transport mobility have focused on SWB aspects. For example, participating in a range of activities outside homes is important for well-being (Spinney *et al.*, 2009b). According to Stanley *et al.* (2011), boosting mobility and a sense of community have been shown to be associated with improved personal well-being. However, would having more activities inside new urban areas contributes to having a better quality of life or not? Through answering these questions, urban planners could find new ways of improving self-contained neighborhoods. For example, due to housing shortage in urban areas, after moving to new urban areas, residents' social capitals and activities inside should be promoted, potentially leading to positive impacts on their quality of life. In addition, it should be noted that main purpose of using SWB is to represent an evaluation part for the proposed framework in this study. In other words, there are several indicators that can represent for the evaluation part for the framework, and SWB would be one of them.

As mentioned in the subsection 2.1, this section attempts to provide some additional insights on the impacts of doing activities and social networks inside the areas on quality of life by comparing the SWB among different groups. Our particular interest is in the group relating to inside the areas: if their SWB is significantly higher than the other groups, then maintaining the self-contained area would be an important aspect of neighborhood planning. Another important classification in this study is that, to represent respondents' social capital status in a simple manner, respondents are divided into two groups: those who have more acquaintances inside the new town compared to the outside is grouped into "inside-network" group, and those who have more acquaintances outside is classed as "outside-network" group.

Table 7.7 presents the level of SWB across four groups. It is confirmed that the respondents belonging to the inside-network group have higher SWB than those in the outside-network group, but activity locations do not seem really influential on subjective well-being.

As can be seen from Table 7.8, there is statistically significance for friend networks, with the representatives of inside-network category ranking higher in happiness than the members of outside-network one. This result proves the level of well-being is significantly influenced by social network existing in residents' location. A statistically significant difference is also found in the destination choices between the inside and the outside, indicating that there are significant impacts of activities inside the residential areas on subjective well-being.

Table 7.7 Level of subjective well-being across groups

	Those who did more activities inside	Those who did more activities outside
Inside-network group	8.98	8.90
Outside-network group	8.87	8.55

Table 7.8 The results of t tests for two groups of social networks based on level of subjective well-being

Variable	n	Mean	*t*-value
Those who did more activities inside	956	8.90	
Those who did more activities outside	750	8.62	
			5.519***
Inside-network group	442	8.95	
Outside-network group	1264	8.71	
			4.472***

The findings are consistent with the literature reviewed and the hypothesis earlier in this study. Social capitals affect destination choice of discretionary trips (choosing destinations inside or outside the new town) as well as residents' happiness. In other words, it is thanks to social fabrics in the new town that the respondents have a higher number of trips within the areas and a higher level of happiness is obtained. Policy-makers in urban and transportation planning, therefore, should carefully consider policies promoting mobility and fostering social life inside neighborhoods.

7.5 Summary

Effects of social capital on travel behavior have been studied recently in literature. However, relevant studies in the context of developing countries are limited, and especially, the impacts of social capital at different levels on travel choice have remained unknown. As a result of growing private vehicle dependence and increasing new urban areas located in the urban fringe, many countries have experienced congested urban transport systems (e.g. traffic jam) and lower social capital in the locality. Therefore, one having a strong local social capital could be more important, especially in Asian societies where social ties are believed to be stronger than Western ones. Ignoring the impact of social capital at different levels on travel choice may lead to a misunderstanding about the factors affecting travel demand and even can lead to wrong transport policies, resulting in lessening the sustainable development of new urban areas.

Targeting a developing city, Hanoi Metropolitan Area (HMA), Vietnam, this study has examined the impacts of both individual and community levels of social capital on destination choice and trip generation in the context of discretionary activities. A logit model of destination choice and an ordered probit model of trip generation were developed to identify different impacts of the social capitals with controlling for socio-demographics, mobility and accessibility, and built environment factors based on data collected in three new urban areas in HMA in 2015. For social capital factors considered in both models, social capital at the individual level is represented by social network composition (i.e. number of acquaintance in and out the areas) and "close" social network composition (i.e. number of "close" social network in the areas), while social capital at the community level is characterized by participation in community activities. It is found that social capital at the individual level significantly affects destination choice and trip generation for discretionary activities, and social capital at the community level has no significant impact on destination choice. More concretely, social capital at an individual level has more impact on travel choice (i.e. destination, trip generation) compared with one at the community level. In other words, social capital is one of important components of self-containment inherent in this study. We also examine whether or not increasing activities and social capital in residents' location contribute to the improvement of their subjective well-being. The result reveals that social networks have a positive impact not only on self-containment of discretionary activities but also on residents' subjective well-being.

There are some remaining issues that need to be addressed in future studies. First, the residential environment has been proved to affect travel behavior, which is however measured by perceived information in this study. Also, social capital at the community level is simplified through only one variable (participation) due to data limitations. Second, it would be worth examining how daily social capitals contributes to enhancing one's social capital, which requires longer time-period data such as biographical survey data (e.g. Zhang *et al.*, 2014).

8 ENDOGENOUS EFFECT OF SOCIAL NETWORK ON DESTINATION CHOICE IN THE NEIGHBORHOOD

Social networks play an important role in shaping the travel behaviour choice, especially destination choice. In the previous chapter, the social network or social engagements were examined as exogenous variables. As an example, examining the feedback effects, this chapter examines the endogenous effects of social network in neighborhood on destination choice in Hanoi Metropolitan Area of Vietnam. Specifically, a logit-based destination choice model is developed, where the impacts of social network is represented by the average destination choice probability of his or her acquaintances. Two methodological challenges are addressed in this chapter: (1) observing the whole social network in a neighborhood is not feasible, and thus we simulate it based on the partial information of social network, and (2) a structural estimation method under the control of unobserved neighborhood-level characteristics is adopted to reduce biases in the estimated social interaction effects. Using data collected at three new neighborhoods in Hanoi in 2015, the existence of significant social interaction effects on destination choice behavior is confirmed.

8.1 Introduction

Although there are many definitions of neighborhood (Kallus and Law-Yone, 2000; Minnery *et al.*, 2009), a common idea underlying these definitions is that the neighborhood is physically located in suburban areas of cities. Typically, the objectives of neighborhood planning are to achieve good physical and social environments. For this goal, a majority of neighborhood planners have focused on physical design, and attempted to build a sense of community via specific design elements, for example, by integrating residential and public spaces, careful designs and layouts of infrastructure in the neighborhood, and so forth (Boarnet and Compin, 1999; Cervero, 1994; Ewing and Cervero, 2001; 2010). In addition, Perry (1929) proposed the concept of neighborhood unit - a good neighborhood design embodied in neighborhood plans later - which could incite a sense of community and which should be nourished to bring civic benefits, moral and social values to residents.

Therefore, the contribution to the community development is essential in neighborhood planning.

Some physical urban planners advocate that neighborhood forms affect social behavior. In other words, in their view, the notion of community is tied to physical design which is seen as fixed after neighborhoods are constructed. Talen (2000) has stated that the idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process and that this process is primarily nurtured through a promotion social solidarity and resident bonding whereby existing problems are handled collectively. Madanipour (2001) also notes that neighborhood planning is under severe criticism because it emphasizes the physical rather than the social setting. As a result, such planning may create physical proximity among residents, but it may not create social bonds among them.

Social networks of people are formed through family relations and friendships, as well as through various activities and places, which shows that social contact among people is crucial (Páez and Scott, 2007; Páez *et al.*, 2008). The impacts of social relations on travel decisions have been widely studied in the field of transportation (Harvey and Taylor, 2000). According to Dugundji and Walker (2005), decision makers are influenced by both social (e.g. interactions with other people) and spatial (e.g. locations where they live) networks. Social networks often create demand for traveling (Carrasco and Miller, 2009; Farber and Páez, 2009), and hence travel behavior and mobility are coupled with social bonds and locations (Ryley and Zanni, 2013). In particular, social networks may be important factors for destination choices of discretionary activities, since these activities are often done with family members, relatives and/or friends, and thus he/she may not be able to decide the destination based solely on his/her preferences. This would be especially true in Asian society where social ties might be stronger than Western countries.

An individual's destination choice is often made as the result of joint choice with those whom the individual wants to travel or to meet. Even when activities are not jointly done, their behavior can be similar since they share information which would affect their travel decisions. The existence of such social interactions may require neighborhood planners to see their travel behavior as an endogenous outcome of a set of decisions' makers in the social network.

Social capital may be fostered through social engagements that are geographically stretched out, making travel often desirable and necessary (Páez *et al.*, 2008; Urry, 2012). The destination choice of an individual is often as the result of joint choices with those whom the individual wants to travel or to meet. Clearly, the social network geography of the associated individual(s) will be a key factor for the destination choice of the individual. Instead of relying on the generalized cost, socio-demographic characteristics, mobility and accessibility, built environment factors, and attitudes and preferences, adding social network geography of an individual and network-based decision-making would be crucial in shaping the destination choice set of the decision maker in the field of transport modeling and travel behavior. In this case, although the decision maker is the individual, his/her decision follows a group of individuals (Arentze and Timmermans, 2008;

Axhausen, 2008; Doi *et al.*, 2008). In other words, the decision maker interacts with other members in the same group especially with ones in his/her social network. Therefore, the individual form rational decision choice regarding acquaintances' choice probabilities from his/her acquaintances' network is examined in this chapter. Meanwhile, social interaction of the decision maker for destination choice is captured as an endogenous effect by his/her actual acquaintances' network as a reference group - a small group interaction rather than using a broad group.

There are a variety of terms implying endogenous social effects, depending on the context, referred to as "social interactions", "neighborhood effects", "peer effects", "conformity effects" and so on (Manski, 1993). To explore the factors making an individual behave similarly with other members in his/her reference group, Manski (1993) classified social interaction effects into three components: endogenous effect, exogenous effect (contextual effect), and correlated effect. Manski shows the difficulties of distinguishing those three components empirically, when we use the standard linear-in-mean social interaction model (called the as "reflection problem"). On the other hand, recent works such as Lee *et al.* (2014) show that such a reflection problem does not really happen when we use a real social network instead of a reference group, since endogenous effects are heterogeneous across individuals. They also show that correlated effects can also be controlled by introducing random-effect or fixed-effect terms to take into account group-level unobserved factors. A remaining difficulty is how to observe a real social network, although a reference group may be primarily defined by presence of connections between individuals that based on explicitly social or shared socio-economic status or geographic nearness (Pike, 2015). Pike (2015) state that the connections are self-defined by network members as neighbors or friends, and deeply focuses on the social network (i.e., ego-network). We will solve this issue by simulating the whole social network in the neighborhood based on the partial observed information.

As we discussed above, linking neighborhood planning with social interactions would be crucial for a better neighborhood planning, yet few studies have been conducted with only a few exceptions. Schelling (1978) showed that residents would live in the neighborhood unless the percentage of residents of the opposite race exceed some threshold by using a theoretical social interaction model, while planners should keep the trade-off in design problem between suboptimal and social conflict through playing a game with a consideration of spillover effects (Haag and Lagunoff, 2006). Also, there are some recent studies which incorporate the spatially autoregressive structure of social network effects into choice models in transportation literature (Dugundji and Walker, 2005; Goetzke, 2008; Goetzke and Rave, 2011; Páez and Scott, 2007; Páez *et al.*, 2008), while these are not linked with neighborhood planning.

Motivated by the above shortcomings of existing studies on having a good community in neighborhood and the lack of studies in the context of developing country, this study attempts to capture the endogenous effects of social network on destination choice in the context of Hanoi, Vietnam. Concretely, a model destination choice behavior regarding discretionary activities is developed, where the average choice probability of acquaintances is incorporated in the model as an endogenous variable. Two methodological challenges are addressed in this chapter: (1) observing the whole social network in a neighborhood is not feasible, and thus the network is simulated based on the partial information of social network, and (2) a structural estimation method under the control of unobserved neighborhood-level characteristics (which is achieved by introducing a fixed-effect term) is adopted to reduce biases in the estimated social interaction effects.

8.2 Descriptive analysis

A total of 469 respondents, from 243 households, participated in the survey. Some respondents had to be excluded due to missing data (incomplete daily travel diaries, unwillingness to provide some individual characteristics and household attributes). In this study, we only focus on trips for discretionary activities, since the destination is usually fixed for mandatory activities such as work and school. After excluding the missing data (approximately 4% respondents) and trips for mandatory activities, there are 450 respondents with 1,706 discretionary trips (the trips with purposes are shopping, personal business, meeting with friends/acquaintance, doing exercise, eating out, taking walks around, leisure activities, and so on). Survey results show that around 56% of discretionary activities tend to be done inside the neighborhood. Since new neighborhoods in Hanoi were not planned for providing jobs or quality hospitals/universities at the beginning, it would not be easy to reduce traveling out for mandatory purposes (see Figure 8.1).

Figure 8.2 shows the distribution of respondents’ number of acquaintances inside the three new neighborhoods. In general, the respondents were likely to have rounded off their answer for convenience when reporting. The average number of acquaintance is highest in Ecopark (16.96), followed by Van Quan (8.77) and Viet Hung (7.95). The differences could be explained by the differences in the built environment: Ecopark has a lot of facilities, parks and clubs, encouraging residents to communicate with each other. Some of the respondents had no acquaintance in the areas (27% in Van Quan, 35% in Viet Hung, and 18% in Ecopark). This result is understandable and can be interpreted as the areas are “young” neighborhoods with less than a decade of development. Meanwhile, the residents in three neighborhood areas are on the way to developing their acquaintance network inside the area. About a half of respondents having 1-10 acquaintances within the areas, and the number of respondents answering more than ten acquaintances, is quite large.

The number of individual’s acquaintances in the neighborhood were collected in the survey. Based on this, a whole social network in each neighborhood area was generated by applying the configuration model mentioned above. Next, individual characteristics, household attributes, mobility and accessibility were generated into each node in the network. Each attribute follows the empirical distributions of the data. In this case study, the independent distribution is applied for each attribute. Although this may not be realistic, to use multivariate empirical distribution, sample size should be large enough to obtain stable distribution. Then, an adjacency matrix was obtained from the generated social network in each neighborhood area. Specific steps are as follows:

(a) The number of nodes in a network is assumed to be the number of residents whose ages over 16 years old in each neighborhood area. In this study, we use a rough number of population in three neighborhood area to decide the number of node (a network in Van Quan with 9800 nodes, a network in Viet Hung with 16800 nodes, and a network in Ecopark with 4000 nodes). It should be noted that these nodes include observed from collected and generated nodes. In other words, the number of generated nodes is the population minus the number of respondents.

(b) The number of acquaintances for each node (i.e., degree of node) is randomly generated based on the empirical distribution of acquaintances in the data. In addition, individual's characteristics, household attributes, mobility and accessibility are randomly generated for each node based on the empirical distribution of attributes in the data. Note that, for trip purpose dummy variables, instead of using random generation, we adopted the proportions of trip purposes for all generated nodes (i.e., exercise 20.8%, daily shopping 22.9%, and recreation 19.0%), since these can vary within an individual.

(c) Generate the social network by using the configuration model without self-links based on the degree of node created in step (b). The social network were generated for each neighborhood (i.e., three random graphs were generated).

(d) The generated adjacency matrix $\widetilde{W}_g$ was obtained from the generated social network for each neighborhood area.

In the model estimation, for p^0, we first use the neighborhood's average choice probability of choosing the destination inside the neighborhood (Van Quan: 56.45%, Viet Hung: 47.03%, and Ecopark: 65.88%), meaning that we ignore the heterogeneity of social interaction effects caused by the differences in the number of acquaintances. Second, we calculate the average probability of generated acquaintances by using the generated adjacency matrix $\widetilde{W}_g$, and then use the calculated average probability for θ^K in equation (3) to update structural parameters θ. Note that the model estimation is done only with observed data, i.e., generated nodes were not used for the model estimation.

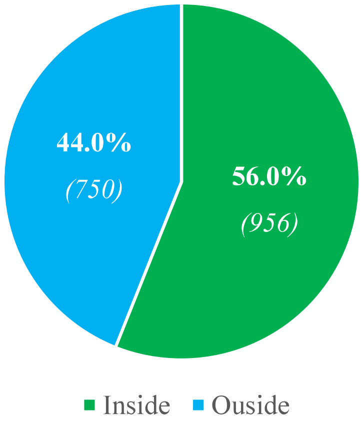


Figure 8.1: The share of destination choice

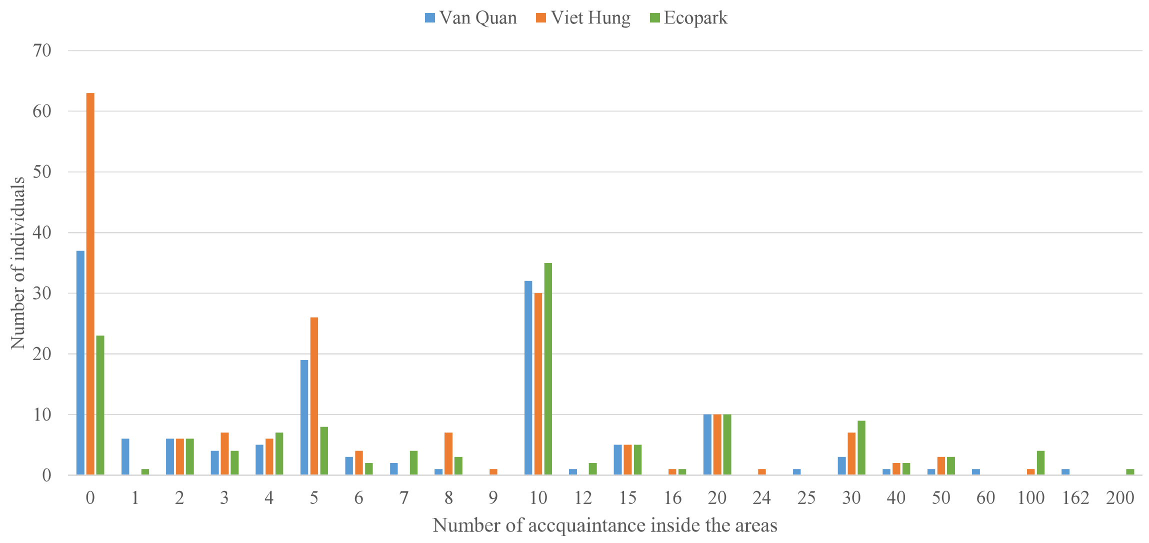


Figure 8.2: Distribution of number of acquaintance inside the areas

8.3 Model

8.3.1 Model specification

The model structure we employ is basically analogous with Lee *et al* (2014) (Lee *et al.*, 2014). Consider the destination choice of residents in a neighborhood g. We denote that the population of neighborhood g is N_g and the sample size collected through the survey is n_g. We define the utility U_{git} that an individual i (i = 1, 2, …, N_g) who travel on a t-th trip (t = 1, 2, …, T) chooses destination choice y_{git} = 1 (1: inside the neighborhood area, 0: outside the neighborhood area) in a sample of G neighborhood networks and N_g individuals (i.e., the number of connected nodes of the network g) in a neighborhood network g represented by an $N_g \times N_g$ adjacency matrix $W_g = \left(w_{g1},\ldots,w_{gi},\ldots,w_{gn_g}\right)$, where w_{gi} is the i-th row of W_g (i.e., $w_{gi} = (w_{gi1},\ldots, w_{gij},\ldots, w_{giNg})$). Here, w_{gi} represents the connection of nodes (i.e., individual i's number of acquaintances inside the neighborhood g), where the matrix with zero diagonal elements as self-influence is excluded (i.e., w_{gii} is assumed to be zero). Since in general no specific information is available about the importance of acquaintances, w_{gij} is assumed to be equal one if j is an acquaintance and zero otherwise, meaning that individual i's acquaintances receive equal weight. In this study, we row-normalize the values of the row of the weights matrix so that the row sum is 1. The utility U_{git} is follows:

$$U_{git} = \beta x_{git} + \lambda w_{gi} p_{git} + u_g + \varepsilon_{git} \tag{8-1}$$

where β, and λ are parameters, x_{git} is a vector of explanatory variables (including socio-demographic, trip purposes, mobility and accessibility), p_{git} is a vector of acquaintances' average probability of choosing the destination inside the neighborhood (i.e. destination choice decision will be influenced by his/her connected acquaintances in the neighborhood's network), u_g denotes neighborhood fixed effects which are unobserved effects of the common factors faced by the same neighborhood members, and ε_{git} is an error term which is Gumbel-distributed.

As mentioned in the introduction, social interaction effects need to be separate from other confounding effects. By using the conditional variance restrictions, a group random-effect would help to deal with group unobservable characteristics that tend to confound the interaction effects. The solution using the group random-effect will not be plausible unless three assumptions (i.e. independent random assignment, stochastic reparability, and peer quality variation) are satisfied (Graham, 2008; Lee *et al.*, 2014). Another solution to handle the correlated effect is to introduce a group fixed-effect to isolate possible unobservables in a group and effectively separate peer effects from other confounding effects (Lee, 2007; Lin, 2010), especially when the reference group is small as it will introduce not too many parameters to the model (Lee *et al.*, 2014). Therefore, controling the correlated effects by the group fixed-effects u_g may be appropriate in this study, since the number of groups are only three (Viet Hung, Van Quan and Ecopark).

The probability that individual i chooses destination choice inside a neighborhood within a given neighborhood's network g, can be written as the following standard logit formulation.

$$p_{git}\left(\beta,\lambda,\sigma\right)=\frac{\exp\left(\beta x_{git}+\lambda w_{gi}p_{git}+u_g\right)}{1+\exp\left(\beta x_{git}+\lambda w_{gi}p_{git}+u_g\right)} \tag{8-2}$$

For model estimation, several structural estimation methods have been proposed (Aguirregabiria, 2004; Aguirregabiria and Mira, 2002; 2007; Ellickson and Misra, 2011; Hotz and Miller, 1993; Rust, 1987). We use two estimation methods. First, Hoz and Miller (1993) proposed the conditional choice probability (CCP) estimator (Hotz and Miller, 1993). The CCP estimator is obtained in two stages. First, nonparametric estimators of probabilities are formulated, i.e., calculating P^0 based on the observed data. Second, the likelihood $\sum_{g=1}^{G}\sum_{i=1}^{n_g}\sum_{t=1}^{T}L_{git}\left(\beta,\lambda,y_{git}\mid x_{git},p_{git}^{0}\right)$ is maximized to get parameters θ, where $L_{git}()$ is loglikehood The second method we used is the pseudo maximum likelihood estimation proposed by Aguirregabiria and Mira (2004) (Aguirregabiria, 2004). This estimation procedure is similar with Hoz and Miller (1993) but takes further an iterative process as follows. Let $\overset{0}{P_T}=\overset{0}{P_T}\left(x\right)$ be the nonparametric frequency estimator of P^0. For $K \geq 1$, the K-stage nested pseudo maximum likelihood (NPL) estimator as follows,

$$\overset{K}{\theta_T}=\arg\ \max\sum_{g=1}^{G}\sum_{i=1}^{n_g}\sum_{t=1}^{T}L_{git}\left(\beta,\lambda,y_{git}\mid x_{git},p_{git}^{K-1}\right) \tag{8-3}$$

where the sequence of probability distributions $\{\overset{K}{P_T}:K\geq 1\}$ are constructed recursively as

$$P_T^K = L_{git}\left(\beta,\lambda,y_{git} \mid x_{git},p_{git}^{K-1}\right) \tag{8-4}$$

The above iterative process will be continued till the parameters θ_T^K are converged.

8.3.2 Generating the social network in the neighborhood

One of the difficulties in empirical analysis of social interaction models is the observation of social network. It is typically impossible to observe the whole social network in a certain group, and thus in this study we use the simulated social network.

Although an individual's social network is complex and diverse in the real world, the network can be simplified and defined by some basic properties in the empirical analysis. According to Jackson (2010), these properties are scale-free property" represented as power law degree distributions, a "small-world property" represented as small average inter-nodal distance, and a "cluster property" represented as a large clustering coefficient. In addition, the random graph-based model is one of the most widely used for social network model. In particular, one node could be simply connected with other node completely at random, and nodes in each network have an equal probability. For instance, a network including *m* nodes as an individual in a network, and the potential number of links (i.e. the potential number of connections among individuals in a network) will be *m(m-1)/2*, then the expected links could be formed in the network is *pm(m-1)/2* with *p* is independent probability of each link formed in the network. In random graph, although the degree distribution is essentially a convex combination of a degenerate distribution, the degree distribution is not often observed from a real social network.

To generate random networks with a given degree distribution, a numerous of methods have been proposed. One of the most intensively used is "configuration model" as originally developed by Bender and Canfield (1978). In general, configuration model works with degree sequences rather than degree distributions. For example, a network has *m* nodes, a list of the degree of different nodes (d_1, d_2, …, d_m) which is the degree of sequence. Though self-links are possibly occurred in configuration model, self-links should be ignored since this study focuses on the influence of social effects with other people. Therefore, a random graph model based on configuration model is generated in each neighborhood area that degree of a node is number of individual's acquaintances.

8.3.3 Model estimation results

Table 8.1 shows explanatory variables introduced in the model and detailed estimation results of five models are presented in Table 8.2. The models include:

- A conventional model without controlling the correlated effects (i.e., without fixed-effects) (Table 3, model 1) [base model]
- A conventional model with controling the correlated effects (Table 3, model 2)
- A social interaction model without controling the correlated effects where the CCP estimator is adopted (Table 3, model 3 (CCP))

- A social interaction model without controling the correlated effects where the NPL estimator is adopted (Table 3, model 4 (NPL))
- A social interaction model with controling the correlated effects where the NPL estimator is adopted (Table 3, model 5 (NPL))

As for the base model without controlling the correlated effects (model 1), as expected, age is statistically significant at 5% level and has a positive sign in the destination choice model. This indicates that people aged over 60 years old tend to travel in the neighborhood. In the cases of other socio-demographic variables, the results show that gender, high education and high income are not influential to travel destination choice. Concerning mobility and accessibility variables, motorcycle ownership and distance to the nearest bus stop are significant at 1% and 5% respectively, while only car ownership is insignificant. The negative sign of the motorcycle ownership and the distance variable indicate that residents having a motor cycle or whose houses far from bus stop are more likely travel out the neighborhood. Regarding the trip purposes, there are no surprising signs with positive and these parameters are significant, implying that the activities as doing exercise, daily shopping and recreation are tended to do inside the neighborhood.

Concerning the model with controling the correlated effects (model 2), with three social networks corresponding with the three neighborhoods in the sample, the two dummy variables represented Viet Hung and Ecopark are added in the model to represent for possible unobservables or similar environments faced by the same neighborhood. The magnitude, sign and significance of most of the variables in the model change only marginally (compared to model 1), by adding the fixed-effects. An exception is the distance variable, which retains the similar negative sign however the variable becomes insignificant. The estimation results of fixed-effects indicate that neighborhood environment in Ecopark encourage the residents to do the activities inside the neighborhood. The final log-likehood of model 2 improves a lot after controling the correlated effect. Regarding the social interaction model without controling the correlated effects where the CCP estimator is adopted (model 3 (CCP)), the magnitude, sign and significance of most of the variables in the model slightly change compared to model 2. The acquaintances' choice probability (i.e., social interaction effect), which has a positive sign and the parameter is significant at 0.1% level. This indicates that residents' choice decisions are influenced significantly by decisions of their acquaintances in the same neighborhood. The final log-likehood of Model 3 (CCP) also improves a lot compared to the model 1. The contribution of adding fixed-effects is quite analogous to that of acquaintances' choice probability in term of final log-likelihood, while the degree of freedom in Model 3 (CCP) is lower than that in Model 2. These results show that the distinction between the correlated effects and endogenous social interaction effects would be difficult, which is consistent with the "reflection problem" mentioned by Manski (1993). Note that the fixed-effect term is not able to add into the model 3 due to the identification problem since the CCP estimator here uses the group mean for p_{git}^{0}, meaning that endogenous effects are homogeneous across individuals. This problem is solved by introducing simulated social network, which generates heterogeneity in endogenous effects.

For the models employing NPL estimators (models 4 and 5) use the simulated social network in each neighborhood to calculate the acquaintances' choice probability instead of using the average of acquaintances' choice probability in the neighborhood as the CCP method did. Endogenous effects in these models vary across individuals in a neighborhood, and hence, we can the fixed-effects and (endogenous) social interaction effects are able to be simultaneously estimated. It is noted that the results shown in Model 4 (NPL) and Model 5 (NPL) are corresponding to the adjacency matrix of the generated network selected based on the best model (i.e., the model with the best final log-likelihood) after randomly generating 100 neighborhood's network. In general, although there is a similar sign for the parameter of the acquaintances' choice probability, magnitude and significance of this variable is descendant in model 4 (NPL) and model 5 (NPL), respectively. This indicates that both the assumption of model 2 (i.e., all social effects are assumed to be correlated effects) and the assumption of model 3 (i.e., all social effects are assumed to be endogenous effects) may not be correct. Comparing model 4 (NPL) with model 5 (NPL), we found that the distance to the nearest bus is significant in model 4 (NPL), but is not model 5 (NPL). The comparison also indicates that ignoring fixed-effects can overestimate the endogenous social interaction effects.

Table 8.1 Explanatory variables for the destination choice model

Explanatory variables	Definition	Mean	SD
Socio-demographic			
Over 60	1: > 60 years old; 0: Otherwise	0.163	0.369
Male	1: Male; 0: Otherwise	0.433	0.496
High education	1: From Bachelor; 0: Otherwise	0.809	0.393
High individual income	1: Higher than 9 *mils. VND*; 0: Otherwise	0.499	0.500
Mobility and accessibility			
Car own	1: Household having a car, 0: Otherwise	0.421	0.494
Motorcycle own	1: Household having a motorcycle, 0: Otherwise	0.920	0.272
Distance to nearest bus stop	Distance to nearest bus stop, *meter*	290.472	213.906
Trip purposes			
Doing exercise	1: Exercise purpose; 0: Otherwise	0.208	0.406
Doing daily shopping	1: Daily shopping purpose; 0: Otherwise	0.190	0.392
Doing recreation	1: Recreation purpose; 0: Otherwise	0.229	0.420
Representative for fixed effects			
Dummy for Viet Hung	1: Trips belongs to Viet Hung neighborhood; 0: Otherwise	0.365	0.482
Dummy for Ecopark	1: Trips belongs to Ecopark neighborhood; 0: Otherwise	0.321	0.467

Table 8.2 Explanatory variables for the destination choice model

Explanatory variables	Model 1		Model 2		Model 3 (CCP)		Model 4 (NPL)		Model 5 (NPL)	
	Estimate	t value	Estimate	t value	Estimate	t value	Estimate	t value	Estimate	t value
Constant	0.434	1.653+	-0.014	-0.039	-3.180	-5.554***	0.380	1.442	-0.024	-0.066
Socio-demographic										
Over 60	0.407	2.261*	0.385	2.108*	0.384	2.111*	0.396	2.191*	0.367	2.012*
Male	-0.127	-1.084	-0.061	-0.511	-0.062	-0.517	-0.150	-1.274	-0.084	-0.696
High education	0.102	0.660	0.021	0.134	0.021	0.137	0.139	0.898	0.052	0.329
High individual income	-0.072	-0.579	-0.152	-1.198	-0.152	-1.196	-0.094	-0.752	-0.166	-1.303
Mobility and accessibility										
Car own	-0.017	-0.149	-0.163	-1.411	-0.162	-1.405	-0.011	-0.095	-0.156	-1.348
Motorcycle own	-0.901	-4.004***	-0.545	-2.354*	-0.547	-2.369*	-0.930	-4.103***	-0.571	-2.455*
Distance to nearest bus stop	-0.74E-3	-2.812**	-0.52E-4	-0.113	-0.11E-3	-0.407	-0.69E-3	-2.628**	-0.82E-4	-0.178
Trip purposes										
Doing exercise	2.678	13.844***	2.794	14.107***	2.794	14.200***	2.694	13.836***	2.807	14.229***
Doing daily shopping	0.683	4.597***	0.817	5.327***	0.816	5.370***	0.696	4.657***	0.826	5.390***
Doing recreation	1.024	7.548***	1.108	7.931***	1.108	7.985***	1.037	7.602***	1.119	8.015***
Representative for fixed effects										
Dummy for Viet Hung neighborhood	na	na	-0.509	-2.955**	na	na	na	na	-0.520	-3.000**
Dummy for Ecopark neighborhood	na	na	0.577	2.284*	na	na	na	na	0.535	2.101*
Choice probability of acquaintances	na	na	na	na	5.683	7.045***	1.074	3.355***	0.977	3.021**
Observations n = 1706										
Initial log-likelihood	*-1182.509*		*-1182.509*		*-1182.509*		*-1182.509*		*-1182.509*	
Final log-likelihood	*-1001.640*		*-976.4649*		*-976.4795*		*-995.7258*		*-971.753*	
McFadden's Rho-square	*0.153*		*0.1742433*		*0.1742309*		*0.1579551*		*0.1782*	
Adjusted McFadden's Rho-square	*0.144*		*0.163*		*0.164*		*0.1478071*		*0.166*	

Note: na = not applicable; *** Significant at 0.1% level;** Significant at 1% level; * Significant at 5% level; + Significant at 10% level

8.4 Summary

Effects of social network on travel behavior have been studied extensively in the literature. However, relevant studies in neighborhood planning are limited, and especially, the impact of endogenous social interaction effects on destination choice have remained largely unexplored in the context of developing countries. Taking into account social interaction effects in the destination choice model would be particularly important to derive useful policy insights for neighborhood planning since the neighborhood characteristics (such as self-containment) would be collectively determined by the destination choice decisions of residents.

Targeting a developing city, Hanoi Metropolitan Area (HMA), Vietnam, this study has examined the endogenous effects of social network on destination choice for discretionary activities. The logit-based destination choice model was developed to identify the endogenous effect of the social network with controlling for socio-demographics, travel purpose, mobility, accessibility, and unobserved group effects (i.e., fixed-effects). The empirical analysis was conducted based on data collected in three new urban areas in HMA in 2015. Two methodological challenges were addressed in this paper: (1) observing the whole social network in a neighborhood is not feasible, and thus we simulated it based on the partial information of social network, and (2) a structural estimation method under the control of unobserved neighborhood-level characteristics (through fixed-effects) is adopted in order to reduce biases in the estimated social interaction effects. Using data collected at three new neighborhoods in Hanoi in 2015, we confirm that the ignorance of unobserved group effects would cause biases in the parameter of endogenous social interaction effects, while the modest social interaction effects on destination choice behavior would exist.

There are some remaining issues that need to be addressed in future studies. First, the acquaintances' network was generated randomly based on the degree of each node, however the links in the actual networks are formed based on not only degree of each note but also attributes among given nodes. Second, to capture the endogenous of social interaction effect, this study has used only CCP and NPL methods for model estimation. It would be worth comparing with other methods. Furthermore, although social networks play an important role in doing discretionary activities and making travel choices in a short term, it is needed to capture the social network in a long term since it can supposedly changes (Sharmeen *et al.*, 2014) and feedback among decision makers can be potentially be strengthened over the time (Walker *et al.*, 2011). In fact, neighborhood planning is done for the long term. A number of factors related to the built environment and social fabric are considered as exogenous factors in most travel behavior models, but these can become endogenous factors in the long term: for example, the service quality of the shopping center in a neighborhood will ultimately depend on how many residents will use it. Such long-term phenomena may need to be explored to fully link travel behavior analysis with neighborhood planning.

9 CONCLUSIONS AND FUTURE WORKS

There has been rapid urbanization in the Asian region, with some sources predicting that about 60% of Asia's population – 4.9 billion people - will live in urban areas in 2030. On the one hand, this urbanization may contribute to economic growth. On the other hand, rapid urbanization has had a variety of negative effects, such as traffic congestion, housing shortages, high population density, environmental pollution and high energy consumption.

To tackle these dilemmas, governments have relied upon several policies such as rural development, development of medium-size cities, and new urban areas near city centers, including new towns, new neighborhood, and newly developed areas. These areas have been developed in many nations as one strategy to relieve urban population density, and over the years their sizes and number have expanded considerably. While new towns were built mainly in developed countries since World War II, similar new areas have begun appearing in developing countries over the past decade.

In recent years, many developed countries have run into problems regarding the management of their aging populations, while it is expected that some developing ones will also face similar challenges in coming decades. Meanwhile, the aging rate in Asian countries is expected to be significantly faster, with the proportion of elder people growing at a faster rate than the rates seen in developed countries. In addition, many new towns in developed countries have run into new challenges after 50 years, which are now raising questions about the wisdom of neighborhood planning as well as earlier urban development policies relating to neighborhood development.

The findings of this thesis are first summarized below, and then implications of these findings, limitations, and directions for future research are discussed

9.1 Findings

9.1.1 The concept of self-containment in neighborhood planning

In the past, a majority of neighborhood planners have focused on physical design and attempt to build a sense of community via specific design elements. The idea of creating a sense of community is difficult to support if it is placed as an end state rather than as a fluid process, and this process is primarily nurtured by promoting social solidarity and resident bonding whereby existing problems are handled collectively. The conventional concept of self-containment has been associated with job-housing balance embodied in neighborhood planning. However, with rapid motorization and complex social networks and modern lifestyles, residents do not entirely conduct their activities inside the limited boundaries of neighborhoods and town. As a result, the concept of self-containment in the conventional sense would be not appropriate. Findings of this study are summarized as follows:

(i) The concept should be (i) adopted from the market-based approach, (ii) emphasize on non-working activities, instead of working activities, and (iii) examined with endogenous effects.
(ii) Multiple average choice level(s) in equilibrium is solved by equation proposed by Brock and Durlauf
(iii) The probability of choosing destination choice in/out of the neighborhood possibly falls into a low equilibrium (having low probability among two stable equilibrium points).

9.1.2 Elderly's heterogeneous responses to topographical factors in travel mode choice within a hilly neighborhood

Chapter 4 described a travel mode choice model developed based on a panel mixed logit model and focused on a hilly neighborhood called Koyo New Town in Hiroshima City, Japan, where a multi-period (two waves) and multi-day (two weeks) panel survey was conducted in 2010 and 2011. The survey consisted of a GPS-based survey and a paper-based travel diary survey. Heterogeneities were captured by introducing random effects of parameters of topographical factors, which are measured in terms of altitude difference, intensity of up/down movement, maximum slope, and changing slope. Furthermore, the effects of introducing personal mobility vehicles (PM) to mitigate negative impacts of topographical factors were also evaluated. Findings of this study are summarized as follows:

(1) Altitude difference and maximum slope factors, among four topographical factors under the study, have significant impacts on elderly's mode choice decisions.
(2) The usefulness of elderly-oriented personal mobility vehicles (PM) in mitigating the negative effects of topographical factors is also revealed. The study suggests that policies to introduce PM into hilly new towns can potentially contribute to the mobility of elderly residents

9.1.3 Mediation effects of income on travel mode choice

Chapter 5 develops a path model with multiple discrete choices to analyze travel mode choice in Hanoi Metropolitan Area of Vietnam. In the path model, mediation effects of income on travel mode choice are captured, with residential location choice being modelled as a discrete mediator which generates non-linear indirect effects of income on mode choice. For the purpose of this study, the proposed model is called the mediation model. As a comparison, a joint model of residential location and travel mode choices are built with only direct effects of income on both choices. Data collected from three new urban areas in Hanoi in 2015 were used to test the model. The findings of this study are summarized as follows:

(i) Income has both direct effects and indirect effects (a non-linear indirect effect) on travel mode choice behavior via a mediator (i.e., residential location choice behavior).

(ii) The relationship between motorcycle usage and income, by considering both direct and indirect effects as a whole, is quadratic with a minimum of motorcycle share at a certain income level.

There is a scenario for implementation for neighborhood planning process that can be achieved from the results of this chapter. Residents' income will increase in the future, potentially leading to an increase in traveling by motorcycle. The results in this chapter also shows that income has positive effects on residential location choice, then residential location negatively affect mode choice. This indicates that the mediation effect income on traveling by motorcycle lessen the direct effect of income on the motorcycle. In this case, a well-designed neighborhood with nice environment contributes to reduce motorcycle users, and hence, the neighborhood planning shed light upon residents' travel choices for sustainable development of new neighborhood.

9.1.4 Self-containment of discretionary activities in an aging new town of Japan based on a destination choice model with social network effects

Chapter 6 explored the self-containment status of new towns for discretionary activities (shopping, volunteer, recreation and so on), by using a multi-period (two waves) and multi-day (two weeks) panel survey data collected in Koyo New Town, located in Hiroshima, Japan. For this purpose, a panel mixed logit model of destination choice with a focus on the impacts of social networks was developed. The analysis also aimed to answer the question of whether self-containment contributes to the improvement of residents' subjective well-being. Findings of this study are summarized as follows:

(i) A greater number of friends within the new town leads to increasing discretionary activities in the new town. These imply that the status of social network significantly influences on destination choice sets, and hence, it is an influential factor of the self-containment status of the new town.

(ii) Owning non-motorized vehicles would further enhance the self-containment of the neighborhood.

(iii) The more friends the respondents have in the neighborhood, the more SWB they would obtain. This indicates that having more self-contained neighborhood enhances subjective well-being, and thus improve the quality of life for residents living in.

9.1.5 Influence of social capital on trip generation and destination choice

Chapter 7 looked at the impacts of social capital, as measured in two dimensions (i.e. social network and participating in local community activities), on travel choice for discretionary activities. For this purpose, data collected in Hanoi, Vietnam, was used and a logit model for destination choice and an ordered probit model for trip generation were developed, controlling for socio-demographic characteristics, mobility and accessibility, and built environment factors. Findings of this study are summarized as follows:

(i) Social capital at an individual level has more impact on travel choice (i.e. destination, trip generation) compared with one at the community level.

(ii) Social captial has a positive impact not only on self-containment of discretionary activities but also on residents' subjective well-being. This indicates that having more self-contained neighborhood enhances subjective well-being, and thus improve the quality of life for residents living in.

9.1.6 Influence of endogenous effect of social network on destination choice

Chapter 8 focuses on the impacts of social network as an endogenous variable, as measured by the average destination choice probability of his or her acquaintances. For this purpose, a logit model a logit model for destination choice was developed, controlling for socio-demographic characteristics, trip purposes, mobility, accessibility, group fixed-effect and probability of the individual's acquaintance choosing the destination inside the neighborhood area (i.e. endogenous effect of social network). As an initial example, the model is estimated using data collected in three new neighborhood areas in Hanoi Metropolitan Area of Vietnam in 2015. Findings of this study are summarized as follows:

(i) The endogenous effect of social network is statistically significant with positive sign, indicating that the decisions of residents' acquaintances positively affect their decisions on doing the discretionary activities in the neighborhood area.

(ii) Without controling the group fixed-effects represented by unobservables or similar environments faced by the same neighborhood, the social interaction effects on destination choice are over-estimated.

Another scenario may be concluded from the result of Chapter 8 that is the existence of endogenous of social effects among residents living the neighborhood. At the early stage of the neighborhood's development, some providing amenities and service inside the neighborhood is planned or designed by a neighborhood' planner and is considered as exogenous. However, residents living in the neighborhood will influence on the maintenance of these amenities and service in the next stage of neighborhood's development. In fact, neighborhood planning is done for the long term, and these amenities and services are captured as exogenous factors in the short term, but can become endogenous ones in the long term.

9.2 Contributions

This research represents the first attempt in the literature to expand the concept of self-containment in theory and examine it in empirical studies, taking into account different neighborhood societies based on travel choice behaviors in a consistently and comprehensively way.

Several important policy implications about the findings from this thesis in terms of theoretical and practical applications are discussed below.

9.2.1 Academic contributions:

The concept of self-containment in neighborhood planning is expanded in theory in developed and developing cities. In particular, this study could successfully

(i) Establish a theoretical approach to self-containment which can be used in quantitative analysis for neighborhood planning

(ii) Propose a framework to understand the mechanism of self-containment for neighborhood planning.

9.2.2 Practical Contributions:

(i) While neighborhood planning has been solved mainly based on neighborhood attributes, the previous studies did not handle income increase directly. Income factor is an important matter in developing cities, and also can be mediated by neighborhood attributes.

(ii) This study found a fact that, even in its poor conditions, the development of social capital a neighborhood helps to increase the level of self-containment and thereby improve the quality of life for residents.

(iii) Endogenous effect is a non-negligible factor to make neighborhood more sustainable with a long-term aspect, to dispel the planning fallacy in neighborhood that conventional overestimation of exogenous market and social effects in a short-term aspect may reach to unstable or low-level equilibrium. Therefore, the concept of self-containment with a consideration of social interaction (i.e. non-market interaction) could be a key concept to design and plan the neighborhood in both developed and developing countries.

9.2.3 Contributions to policy implications:

(i) Self-containment of neighborhoods contributes to improve the quality of life. Therefore, policy makers should give more attention to the mismatched between social networks and activity locations, especially for those who have higher mobility constraints.

(ii) Policy-makers can enhance social multiplier effects for residents living in neighborhoods by understanding for the level of self-containment existing in each neighborhood.

(iii) Local resources can be utilized to maintain or revitalize the neighborhood since residents tend to invest economically and socially in their neighborhood.

(iv) For the neighborhood in aging society, one of the important factors is topography, pointing to the need to pay attention to providing appropriate and friendly travel modes for the residents. For neighborhoods which are yet to have an aging population, more attention should be paid to the built environment and how to develop a self-contained neighborhood.

Several important policy implications about the findings from this thesis in terms of theoretical and practical applications are discussed below.

9.3 Limitations and Future research

Several research limitations need to be emphasized in this study.

(i) Analysis: First, there is a potential existence of self-selection when examining the influence of mode choice through residential location or built environment. Second, the study focused on the cause of the binary discrete outcomes to simply demonstrate the main points, but the model needs to be extended to the case of more than two alternatives. Third, as mediation effects of income on travel mode choice may be observed via other life choices, further work is needed for building an integrated choice model covering more life choice variables and accommodating multiple interdependencies. Fourth, to capture the endogenous of social interaction effect, this study uses only NPL method to estimate parameters, other methods should be examined in the future. Fifth, the acquaintances' network were generated randomly based on the degree of each nodes, however the links in actual network is formed based on not only degree of each note but also constrains among given notes.

(ii) Data: First, due to the limited sample size, the analysis of the panel data had to be simplified as much as possible: only two destinations and two social network groups are considered. Second, due to data limitations, social capital at the community level is simplified through only one variable – participation. Third, as a further study, it would be worth examining how daily social capital contributes to enhancing one's social capital, which would require a longer time-period data such as biographical survey data.

(iii) For further studies in term of theoretical development the concept of self-containment, there two assumptions can be considered to release: (1) residents in nearby neighborhood areas should be included as consumers of the neighborhood's facilities; (2) relationship between attractiveness and demand for neighborhood's facilities should be examined as non-linear.

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Zhang, J., Yu, B., Chikaraishi, M. (2014) Interdependences between Household Residential and Car Ownership Behavior: A Life History Analysis. *Journal of Transport Geography*, 34, 165-174.

11 PUBLICATIONS

Referred Journal Papers

① Hong T. A. NGUYEN, Makoto CHIKARAISHI, Hajime SEYA, Akimasa FUJIWARA, Junyi ZHANG, Exploring Self-Containment of Discretionary Activities in an Aging New Town of Japan Based on a Destination Choice Model with Social Network Effects, *Asian Transport Studies*, 4(1), pp 129-139, March, 2016

② Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG Mediation Effects Of Income On Travel Mode Choice: An Analysis Of Short-distance Trips Based On A Path Analysis With Multiple Discrete Outcomes, *Journal of the Transportation Research Board*, No. 2664, 2017 (doi: 10.3141/2664-03) *(SCI journal, IF=0.77)*

③ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Hajime SEYA, Akimasa FUJIWARA, Junyi ZHANG, Elderly's heterogeneous responses to topographical factors in travel mode choice within a hilly neighborhood: An analysis based on combined GPS and paper-based surveys, *The European Journal of Transport and Infrastructure Research*, 17(3), pp 411-424, May, 2017 *(SSCI journal, IF=0.57)*

④ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG, Exploring the Influence of Social Capital at Different Levels on Trip Generation and Destination Choice for Discretionary Activities, *Journal of the Eastern Asia Society for Transportation Studies*, 2017 *(Conditionally accepted)*

Referred Conference Papers

① Hong T. A. NGUYEN, Makoto CHIKARAISHI, Hajime SEYA, Akimasa FUJIWARA, Junyi ZHANG, Travel behavior in a hilly neighborhood in Japan: A case study on the impacts of slope on elders' mode choice decisions, *The 14th International Conference on Travel Behaviour Research*, London (England), July, 2015

② Hong T. A. NGUYEN, Makoto CHIKARAISHI, Hajime SEYA, Akimasa FUJIWARA, Junyi ZHANG, Exploring Self-Containment of Discretionary Activities in an Aging New Town of Japan Based on a Destination Choice Model with Social Network Effects, *The 12th International Conference of Eastern Asia Society for Transportation Studies*, Cebu (Philippines), September, 2015

③ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG Mediation Effects Of Income On Travel Mode Choice: An Analysis Of Short-distance Trips Based On A Path Analysis With Multiple Discrete Outcomes, *Transportation Research Board 96th Annual Meeting*, Washington (USA), January, 2017

④ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG, Exploring the Influence of Social Capital at Different Levels on Trip Generation and Destination Choice for Discretionary Activities. *The 12th International Conference of Eastern Asia Society for Transportation Studies*, Ho Chi Minh (Vietnam), September, 2017 *(Accepted)*

⑤ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG Mediation Endogenous Effects of Social Network on Destination Choice in the Neighborhoods in Hanoi, Vietnam, *Transportation Research Board 97th Annual Meeting*, Washington (USA), January, 2018 *(Under reviewing)*

Non-referred Papers/ Presentations

① Hong T. A. NGUYEN, Makoto CHIKARAISHI, Hajime SEYA, Akimasa FUJIWARA, Junyi ZHANG, Self-containment of Non-mandatory Activities in an Aging Newtown: Modelling Destination Choice with Social Network effects, *第51回土木計画学研究発表会 (春大会)*, Kyushu (Japan), June, 2015 (CD-ROM)

② Hong T. A. NGUYEN, Moderation and mediation effects of income on travel mode choice in three new urban areas in Hanoi, *Joint Seminar on Urban Transportation Research between the University of Tokyo and Hiroshima University*, Kagawa (Japan), June, 2016 *(Outstanding presentation award)*

③ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG, Moderation and mediation effects of income on travel mode choice in developing countries: A case study in Vietnam, International Seminar on Transportation in Developing Countries (Committee of Infrastructure Planning and Management - Japan Society of Civil Engineers) , Tokyo (Japan), June, 2016

④ Hong T. A. NGUYEN, Understanding the effects of income on travel mode choice based on moderation and mediation models, *Joint Seminar on Transport between Yokohama National University and Hiroshima University*, Hiroshima (Japan), July, 2016

⑤ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG, Understanding the Effects of Income on Travel Mode Choice Based on Mediation Model: An Analysis of Short-distance Trips, *The 3rd JASID Western Japan Research Meeting*, Kyushu (Japan), August, 2016

⑥ Hong T. A. NGUYEN, Makoto CHIKARAISHI, Akimasa FUJIWARA, Junyi ZHANG, Exploring the influence of social engagements on trip generation and destination choice, *第55回土木計画学研究発表会 (春大会)*, Ehime (Japan), June, 2017 (CD-ROM)

12 APPENDICES

移動に関するモニター調査

－ 個人票 －

個人番号

世帯票を確認し、あなたの個人番号をご記入ください

広島市
Hiroshima City

広島大学

移動に関するモニター調査にご協力下さる皆様へ

この度は、広島市と広島大学が協力して実施する「移動に関するモニター調査」にご参加いただき、誠にありがとうございます。

1970年代以降に郊外に集中的に建設されたニュータウンでは、住民の高齢化が急速に進展するとともに、核家族化に伴い人口が減少する傾向があります。

そのため、高齢者の日常的な移動（例：バス停や駅までのアクセス）や活動（例：買い物や通院）をサポートしていく仕組み作りが今後ますます重要となってきます。

以上のことから、この度、高齢者が利用しやすい新しい移動手段[※1]の開発促進や普及の可能性の検討や、地域の皆様が助け合って高齢者の移動・活動をサポートする仕組み作りを検討するための基礎資料を得ることを目的として、移動に関するモニターの調査を実施することとなりました。

この調査票に記入された内容は、統計データとしてのみ使用するもので、この目的以外に使うことはありません。

本調査の趣旨をご理解いただきまして、ご協力くださいますようお願い申し上げます。

※1 新しい地区内移動手段の例

電動アシスト自転車	電動アシスト四輪車	電動車いす	電動ミニカー
			

注意事項

個人票は、「あなた自身について」、「あなたの家族・親戚・友人について」、「日々の移動実態について」、「移動中に危険・不便と思った場所について」の4つから構成されています。

- 個人票は高校生以上の世帯員全員の方が記入して下さい。
- 「あなた自身について」および「あなたの家族・親戚・友人について」につきましては、10月31日までに、お時間のとれるときにまとめてご記入ください。
- 「日々の移動実態について」および「移動中に危険・不便と思った場所について」につきましては、**10月18日から10月31日まで毎日ご記入**ください。なお、移動の詳細を把握するため、**世帯内の65歳以上の高齢者の方お一人様には、本調査期間中GPS（全地球測位システム）機器を常時持ち歩いていただきます**。詳細は別紙「ＧＰＳの使い方」をご確認下さい。

本調査票（個人票）の構成

個人票①

あなた自身について

http://www.city.kyoto.lg.jp

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【 広島大学】 082-424-4342
※市外局番からおかけ下さい

コラム① 市民で作るまちづくり
～「いきいき活動隊」の取り組み～

地域の資産を大切に活かし、地域の問題に取り組み、住んでいる人達が元気になるような面白い取組みが各地で行われています。以下では、「わがまち元気※1」に紹介されている、三重県紀勢町の「いきいき活動隊」の取り組みについて紹介します。

少子高齢化と過疎が進む紀勢町では、平成９年６月、「働くことを通して社会の役に立ちたい」お年寄りの思いを叶える高齢者による有償ボランティア「いきいき活動隊」を組織されました。社会福祉協議会（社協）が、地域における日常生活に密着した臨時・短期的な仕事を、町などから有償で引受け、「いきいき活動隊」の隊員に提供し、隊員は、１日に１～２時間、１週１～２回を目途に就業する仕組みです。

主な仕事は、公園等の清掃、草刈り、植栽、フラワーガーデンの作業、公衆トイレの清掃や点検、水道メーター検針、町の広報誌の配布などがあります。その他、町は、高齢者に向けて、(1) お年寄りが家の中に引きこもることなく仲間どうしで楽しくコミュニケーションが図れるよう、高齢者サロンを集会所などで実施する「高齢者サロン事業」、(2) 元気なお年寄りの介護予防を目的にいきがい通所事業として老人福祉センターで週１回昼食会を開く「ランチクラブ事業」、(3) お年寄りが水中歩行を楽しむことができる温水プールを備えた「トロピカル・ガーデン」などの事業を行っており、隊員に交流の場を提供するとともに、市民のネットワークが自律的に広がる仕組みが提供されています。

「いきいき活動隊」には、“たとえ人口が少なくなっても、今を生き生きと暮らし、長生きを楽しんでもらいたい” という紀勢町の人々の願いがこめられています。

※1 わがまち元気：
http://www.wagamachigenki.jp/kyodo/index.html

あなた自身について

A あなたの移動・活動状況についてお尋ねします。

1. 主要な生活関連施設の利用頻度をお答えください。

また、施設までの**主な移動手段を表Aから1つ選択**してください。

※頻度の単位に注意ください

	頻度	移動手段(表Aより)
1. 市役所/役場や公民館	回/年	
2. 郵便局や銀行	回/年	
3. 病院	回/月	
4. JR駅	回/月	
5. バス停	回/月	
6. ｽｰﾊﾟｰﾏｰｹｯﾄ	回/月	

B あなたの健康状態に関してお尋ねします。

1. 歩行できる状況をお答えください。	□ 1. 休憩なしで200m以上歩行できる □ 2. 休憩なしで200m以上歩行できない
2. 現在、定期的に通院していますか。	□ 1. 通院していない □ 2. 通院している 回/月
3. あなたは日常生活において、介護または支援を必要としていますか。	□ 1. 必要でない □ 2. 必要としている

表A

イ.	徒歩	へ.	手動車いす	ヌ.	自動車（家族等が運転し同乗）
ロ.	自転車（一般的な人力のもの）	ト.	電動車いす	ル.	バス
ハ.	電動アシスト自転車（二輪）	チ.	タクシー・ハイヤー	ヲ.	電車
ニ.	電動アシスト自転車（三輪）	リ.	自動車（自分で運転）	ワ.	その他（＿＿＿＿＿）
ホ.	電動アシスト四輪車				

C お住まいの地区の交通環境についてお尋ねします。

	そう思う	ややそう思う	あまり思わない	思わない
1. 坂が多く、歩行・自転車等による移動が困難	□	□	□	□
2. 歩道にベンチがない	□	□	□	□
3. 歩道で自転車と歩行者が混在して危ない	□	□	□	□
4. 公共交通が不便（住区内での移動）	□	□	□	□
5. 公共交通が不便（住区外への移動）	□	□	□	□
6. バス停・駅までが遠い	□	□	□	□

D 日常生活への満足度についてお尋ねします。

	満足している	まあ満足している	どちらかといえば不満である	不満である
1. 家族関係	□	□	□	□
2. ご近所の人間関係	□	□	□	□
3. 友人関係	□	□	□	□
4. 職場の人間関係	□	□	□	□
5. 地域での活動	□	□	□	□
6. 医療制度全般	□	□	□	□
7. 介護制度全般	□	□	□	□
8. 年金制度全般	□	□	□	□
9. 日常生活への総合的な満足度	□	□	□	□

個人票②

あなたの家族・親戚・友人について

http://gigazine.net/

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※市外局番からおかけ下さい

コラム② コミュニティで助け合い ～京都市三条の「たすけあい」～

市民が安心して暮らせるまちをつくるためには、互いに助け合うことのできるコミュニティをつくり、地域の住民がお互いに助け合う「互助」の力を高めることが大切だと再認識されています。今回は、京都市三条でのコミュニティ再生の取り組みについて紹介します。

京都市三条では、「た・す・け・あ・い（楽しく、すみよく、健康で安心できる、明るく、いつでもどこでも人間が尊敬しあえるまちづくり)」がまちづくりのキーワードとして挙げられています。この「たすけあい」を具体化するために、見守りを中心とする「コミュニティ・ケア」をメインテーマに設定し、「人権・福祉・教育のまちづくり」を推進する試みがなされています。たとえば「まちのつぶやき拾い」や統廃合後の小学校の活用の検討など、地域資源の活用を通じた安心居住を実現することを目標とするとともに、東山区が中心になり立ち上げた地元団体等による「いきいきネットワーク」、地元のコミュニティセンター、行政等関係機関の三者が連携し、在宅高齢者に優しい、様々な視点からの地域見守り体制の構築が図られています。

特に、地域住民が主体である「いきいきネットワーク」では、地域が育ててきたコミュニティをより強固なものとし，まちの活性化につなげるためのさまざまな取組がなされています。たとえば高齢者の交通事故防止を説明するチラシや反射材を配布したり、介助や生活上の相談に乗ったりする活動が、地域住民が中心となって行われています。

※1 東山区役所：
http://www.city.kyoto.lg.jp/higasiyama/
※2 都市再生本部：
http://www.toshisaisei.go.jp/index.html

あなたの家族・親戚・友人について

問1　以下の項目に挙げた人の**おおよその人数を記入**して下さい。※当てはまらない項目は無記入で結構です。

別居しているお子さん	□人	別世帯の親戚	□人	高陽ニュータウン外での友人	□人	高陽ニュータウン内の友人	□人

問2　問1で挙げた人の中から、**特に親密な関係の人を最大6人**記入してください。

→困ったときにお互い助け合ったり、相談しあう間柄。

※7ページ**表Bから1つ**選択して下さい。

あだ名又はイニシャル	性別と職業	年齢	世帯形態	あなたとの関係	一ヶ月の交流頻度	
					直接会って会話	電話・メール等で会話
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					
□	□ 1. 男 □ 2. 女 職業 □	□ 20歳未満 □ 21～45歳 □ 46～64歳 □ 65～74歳 □ 75歳以上	□ 1. 一人暮らし □ 2. 夫婦のみ □ 3. 子や孫と同居 □ 4. その他（＿＿＿）	□ 1. 別居しているお子さん □ 2. 別世帯の親戚 □ 3. ニュータウン内の友人 □ 4. ニュータウン外の友人	□回	□回
	お住まい：□ 真亀・亀崎地区　□ 落合地区　□ 倉掛地区　□ 広島市内　□ 広島県内　□ 広島県外					

問3　下記のような問題が起こった時、**あなたは誰を頼りにしますか。**
同じ世帯の方であれば、世帯票の個人番号を、**問2**においてお答え頂いた方であれば，問２のあだ名又はイニシャルを，行政サービスや民間会社をご利用される場合は、行政機関名（例えば広島市）や会社名（例えば広島タクシー）をお答えください。また、頼める人が複数いる場合、最大３人までご記入下さい。

	世帯内の方の場合：世帯票の個人番号 家族/友人/親戚の場合：問２のあだ名又はイニシャル 行政ｻｰﾋﾞｽ/民間会社の場合：行政機関名/会社名		
1.　病院に行きたくても移動手段がなく、自分で移動できないとき誰に送ってもらいますか。			
2.　JR駅に行きたくても移動手段がなく、自分で移動できないとき誰に送ってもらいますか。			
3.　買物に行きたくても移動手段がなく、自分で移動できないとき誰に送ってもらいますか。			
4.　自分で買い物に行けないとき、代わりに買い物を頼む人は誰ですか。			
5.　家庭の用事（大掃除・庭の手入れ等）をするために人手がほしいとき、誰に頼みますか。			
6.　病気で自活困難になったとき、誰に介助・介護を頼みますか。			
7.　普段利用している交通手段が急に利用できなくなり、突然送迎を頼むとき、誰に送ってもらいますか。			
8.　数日間外出しなければならず、家の留守（家族の世話や郵便など）を任せることができる人は誰ですか。			

	職業をお持ちの方・退職されている方はこちらからお選びださい。（退職されている方は、最も長く従事した職種を選択ください）		職業をお持ちでない方
表B	1. 専門的・技術的職業	6. 保安職業	11. 学生
	2. 管理的職業	7. 農業・漁業	12. パートアルバイト
	3. 事務	8. 運輸・通信	13. 専業主婦
	4. 販売	9. 生産過程・労務作業	14. その他
	5. サービス通信社員	10. その他（＿＿＿＿＿＿）	（＿＿＿＿＿＿＿）

コラム③　ニュータウンの復興
～兵庫県明舞団地での取り組み～

昭和３０年代から昭和４０年代にされたニュータウンでは、居住者の方の高齢化や住宅・施設の老朽化等が急速かつ一斉に進展し、人口減によるコミュニティ機能の衰退等が課題となりつつあります。兵庫県にあるニュータウンの1つである明舞団地では、兵庫県のサポートものと、これらの問題へ対応するための様々な取り組みが行われてきました[※1]。

明舞団地での取り組み内容のひとつとして、多世代共生モデル事業があります。多世代共生モデル事業は、明舞まちづくり広場の機能を強化するとともに、地域住民なら誰でも参加できるボランティアチーム「明舞お助け隊」を組織し、地域の困りごとを地域住民で解決する仕組みを作ることで、地域活性化・地域活動の受け皿・住環境の改善などを目指す取り組みです。具体的には、まちづくりカフェ、まちづくり図書館、明舞まちづくり広場通信」情報誌の発行等が行われています。その他、たとえば老朽化した建物を再生したり、まちの生活サービス機能を充実させることにより、NPO や若者を誘致することが図られています。

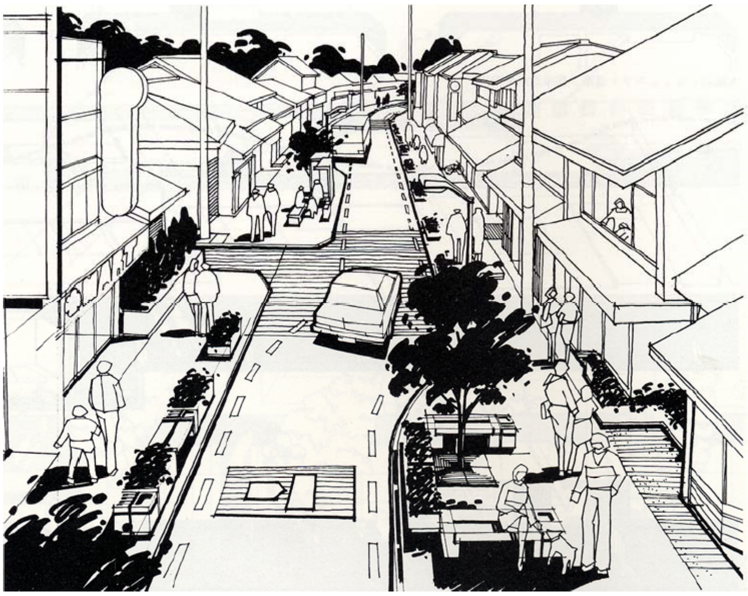
現在も活発に行われている、「子供と孫が帰ってこられる街にしたい[※2]」という住民の思いがこもったニュータウン再生のための取り組みです。

※1 明舞団地のまちづくり情報発信基地：http://support.hyogo-jkc.or.jp/m/

※2 2005 年 11 月 23 日産経新聞

個人票③

日々の移動実態について



www.shse.u-hyogo.ac.jp/inoue/Download/Comunitydouro.pdf

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※市外局番からおかけ下さい

日々の移動実態について

問 1　あなたが頻繁に訪れる場所をお答えください。
この表を、13 ページからの交通日記記入の際、目的地を記入する代わりに登録番号を利用して頂きます。例えば、お勤め先や頻繁に行くショッピングセンター、通院先の病院などをご記入ください。

目的地登録表

指定の到着地について記入して下さい。
※「勤務地」はお仕事をされている方、
「学校」は学生の方のみ記入お願いします。

登録番号	施設名	住　所
1	**自宅**	
2	**勤務地（＿＿＿＿＿＿＿＿＿＿＿）**	
3	**学校　（＿＿＿＿＿＿＿＿＿＿＿）**	
4	**フジグラン高陽**	**広島市安佐北区亀崎 1 丁目 1-6**
5	**高陽ニュータウン病院**	**広島市安佐北区亀崎 4 丁目 7-1**
6	**高陽中央病院**	**広島市 安佐北区落合 5 丁目 1-10**
7		
8		
9		
10		
11		
12		
13		
14		
15		

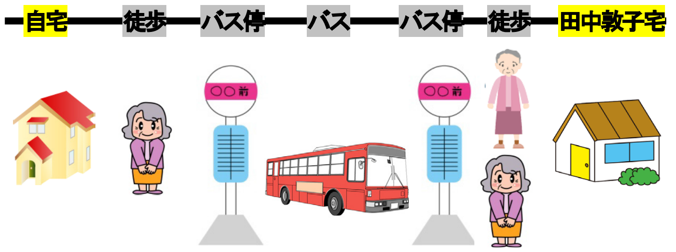
この欄に頻繁に訪れる到着地を
自由にご登録ください。

記入例

以下の鈴木さと子さんの記入例を参考に、あなたの移動実態をご報告下さい。
なお、実際に移動をご報告していただく欄は13ページからとなります。

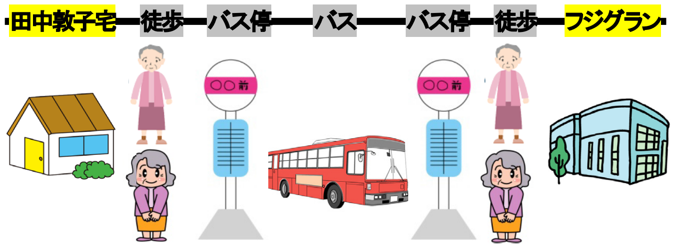
鈴木さんの１日の移動に関する概略図

１番目の移動



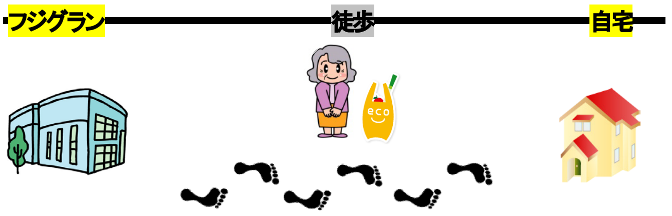
出発時刻 **8:00**	徒歩 6分 150m	待ち時間 4分	バス 乗車時間 10分	徒歩 5分 100m	**到着時刻** **8:25**

２番目の移動



出発時刻 **14:00**	徒歩 5分 100m	待ち時間 2分	バス 乗車時間 10分	徒歩 3分 50m	**到着時刻** **14:20**

３番目の移動



出発時刻 **15:30**	徒歩 15分	**到着時刻** **15:45**

記入上の注意

注１　まず記入する日の日付を記入してください。同じ日の移動について記入する際は、「**前と同じ**」にチェックしてください。

注２　「一緒に活動を行なった人」とは、**目的地において**一緒に活動を行った人のことを指します。「一緒に移動した人」とは、**目的地まで**一緒に移動した人を指します。例えば、同居する家族の人１人と一緒に車で買物に行く場合、「一緒に活動を行なった人」は１人、「一緒に移動した人」は１人となります。送迎のみしてもらった場合は、「一緒に活動を行なった人」は０人、「一緒に移動した人」は１人となります。
「だれと一緒でしたか」の欄には、家族と一緒であった場合は、世帯票の「個人番号」を、６ページに記入した友人と一緒であった場合は、その人の「あだ名又はイニシャル」を記入して下さい。

注３　公共交通に乗る場合は、「主な交通手段」には、利用された公共交通機関を選択してください。
乗る場所までの移動については「**駅/バス停まで(から)の移動」に記入**して下さい。上段へは出発地から駅/バス停までの距離、下段へは駅/バス停から目的地までの距離を記入して下さい。乗る場所まで「徒歩」で移動した場合には、「移動手段」に「徒歩」と記入して下さい。

注４　買い物を行なった際には、「**買物の量**」に記入をお願いします。
- ✓ ここで、日常用品とは食料品や日用品など頻繁に購入するものです。非日常品とは洋服・電化製品など頻繁には購入しない贅沢品などです。
- ✓ 買物袋の大きさは、レジ袋30号（タテ380㎜×ヨコ300㎜：一般的なレギュラーサイズ）を使用した場合を想定してください。大まかで構いません。

注５　よく行く場所は、P9の「目的地登録表」にあらかじめ記入してください。登録してある到着地への移動は、登録番号のみの記入で構いません。

注６　「散歩，ドライブ」といった、目的地のない動きについてもご記入ください。
　また、この際の記入は「日付」、「出発時刻」、「移動目的」、「一緒に活動を行なった人」のみで構いません。

p. 47 で使用します

移動番号	① 番目の移動 注意 1	② 番目の移動	③ 番目の移動
日付	10 月 18 日	月 日 ✓前と同じ	月 日 ✓前と同じ
出発時刻	8 時 00 分	14 時 00 分	15 時 30 分
移動目的	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ○ 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ● 知人・友人との交際/つきあい ○ 公園 ○ 散歩 ○ ドライブ ○ 余暇 内容： ○ その他 内容： ○ 帰宅	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ● 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ○ 知人・友人との交際/つきあい ○ 公園 ○ 散歩 ○ ドライブ ○ 余暇 内容： ○ その他 内容： ○ 帰宅	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ○ 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ○ 知人・友人との交際/つきあい ○ 公園 ○ 散歩 注意 6 ○ ドライブ ○ 余暇 内容： ○ その他 内容： ● 帰宅
買物の量	荷物の量：買物袋 　 袋相当	注意 4 荷物の量：買物袋 2 袋相当	荷物の量：買物袋 　 袋相当
一緒に活動を行った人	あなたを除いて 1 人 だれと一緒でしたか（複数可） 注意 2 T. A. さん	あなたを除いて 1 人 だれと一緒でしたか（複数可） T. A. さん	あなたを除いて 　 人 だれと一緒でしたか（複数可）
一緒に移動した人	あなたを除いて 　 人 だれと一緒でしたか（複数可）	あなたを除いて 　 人 だれと一緒でしたか（複数可） T. A. さん	あなたを除いて 　 人 だれと一緒でしたか（複数可）
主な移動手段	○ 徒歩 ○ 自転車（一般的な人力のもの） ○ 電動アシスト自転車（二輪） ○ 電動アシスト自転車（三輪） ○ 電動アシスト四輪車 ○ バイク（原付を含む） ○ 手動車いす ○ 電動車いす ○ 自動車（自分で運転） ○ 自動車（家族等が運転し同乗） ● バス 注意 3 ○ タクシー・ハイヤー ○ 電車（ＪＲ・市内電車・宮島線） ○ その他 移動手段名：	○ 徒歩 ○ 自転車（一般的な人力のもの） ○ 電動アシスト自転車（二輪） ○ 電動アシスト自転車（三輪） ○ 電動アシスト四輪車 ○ バイク（原付を含む） ○ 手動車いす ○ 電動車いす ○ 自動車（自分で運転） ○ 自動車（家族等が運転し同乗） ● バス ○ タクシー・ハイヤー ○ 電車（ＪＲ・市内電車・宮島線） ○ その他 移動手段名：	● 徒歩 ○ 自転車（一般的な人力のもの） ○ 電動アシスト自転車（二輪） ○ 電動アシスト自転車（三輪） ○ 電動アシスト四輪車 ○ バイク（原付を含む） ○ 手動車いす ○ 電動車いす ○ 自動車（自分で運転） ○ 自動車（家族等が運転し同乗） ○ バス ○ タクシー・ハイヤー ○ 電車（ＪＲ・市内電車・宮島線） ○ その他 移動手段名：
駅/バス停まで(から)の距離	出発地から：150 m 目的地まで：100 m 移動手段　：徒歩	出発地から：100 m 目的地まで：50 m 移動手段　：徒歩	出発地から：　 m 目的地まで：　 m 移動手段　：
目的地	登録番号：　 番 住所：広島市安佐北区＊＊ 施設名：友人宅	登録番号：4 番 注意 5 住所： 施設名：	登録番号：1 番 住所： 施設名：
到着時刻	8 時 25 分	14 時 20 分	15 時 45 分
	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。

問2　毎日の移動を記録して下さい。
10〜11 ページの記入例に従い、あなたが 10 月 18 日から 10 月 31 日の期間中に行った移動に関すること（移動目的・出発時刻・到着時刻・誰と一緒に移動したか・誰と一緒に活動したかなど）をお答えください。回答欄は 13 ページからとなります。

以下の「記入に関するお願い」にある「記入しない動き」を除き、ニュータウン内の移動・ニュータウン外の移動両方を含む、全ての移動実態についてお答えください。

記入に関するお願い

記入にあたっては、次のことに注意してください。

1 記入しない動き
次の動きは個人票に記入しないでください。

（イ）立ち寄り：到着地への途中で立ち寄った場合
例1：出勤途中、たばこや新聞などささいな買物をした場合
例2：ドライブ途中、ガソリンスタンドで給油をした場合

（ロ）近くの道路上での動き
例1：　路上での遊び
例2：清掃や荷物の積下ろしなどの作業
近くとは 50m〜60m 程度の距離を目安にしてください。

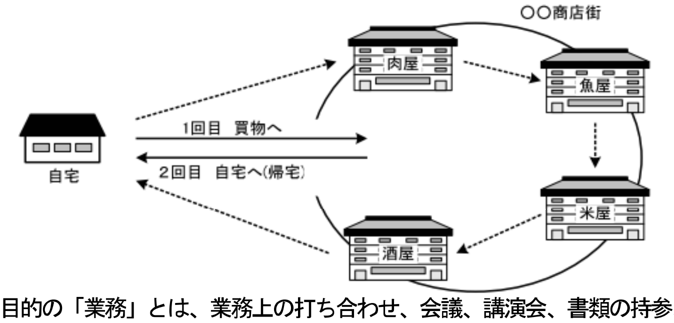
（ハ）同じ敷地内での動き
例1：　同じ敷地内でいくつもの建物の間を動いた場合
ただし、住宅団地のような場合で棟から棟へ一度路上に出た時の移動は動きとします。
例2：ビル・アパートなど同じ建物内での訪問・買物など。（路上へ出ない動き）

（二）隣近所での立ち話

（ホ）農家で、自分の畑から畑への移動

2. 記入において気をつけていただきたい動き

（イ）買物といった同一目的で商店街のように狭い範囲で何軒も回る場合は、**商店街へ行くまでを１回の動き**とし、**商店街から自宅へ帰るまでを１回の動き**とします。
・ このとき狭い範囲とは、一つの商店街程度の広がりを基準とし、商店街の町丁目、または主要な施設を到着地、出発地とします。



（ロ）移動目的の「業務」とは、業務上の打ち合わせ、会議、講演会、書類の持参、受領、集金、ガス・電気・水道の検針、商品のセールス、商品の配達・納品、製品の仕入・購入、業務上の送迎、接待、出張、修理、建物補修などの作業、業務上の視察、調査、医師の往診などの業務上の行動をいいます。また、以上の業務から勤務先に戻る場合も業務目的に分類されます。

移動番号	1　番目の移動	2　番目の移動	3　番目の移動
日付	月　日	月　日　前と同じ□	月　日　前と同じ□
出発時刻	時　分	時　分	時　分
移動目的	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ○ 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ○ 知人・友人との交際/つきあい ○ 公園 ○ 散歩 ○ ドライブ ○ 余暇　内容： ○ その他　内容： ○ 帰宅	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ○ 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ○ 知人・友人との交際/つきあい ○ 公園 ○ 散歩 ○ ドライブ ○ 余暇　内容： ○ その他　内容： ○ 帰宅	○ 家族や知人の送迎 ○ 通勤・通学 ○ 業務 ○ 日常的な買い物 ○ 非日常的な買い物 ○ 受診・診療 ○ 習い事 ○ クラブ ○ ﾎﾞﾗﾝﾃｨｱ活動・社会参加活動 ○ 知人・友人との交際/つきあい ○ 公園 ○ 散歩 ○ ドライブ ○ 余暇　内容： ○ その他　内容： ○ 帰宅
買物の量	荷物の量：買物袋　袋相当	荷物の量：買物袋　袋相当	荷物の量：買物袋　袋相当
一緒に活動を行った人	あなたを除いて　人 だれと一緒でしたか（複数可）	あなたを除いて　人 だれと一緒でしたか（複数可）	あなたを除いて　人 だれと一緒でしたか（複数可）
一緒に移動した人	あなたを除いて　人 だれと一緒でしたか（複数可）	あなたを除いて　人 だれと一緒でしたか（複数可）	あなたを除いて　人 だれと一緒でしたか（複数可）
主な移動手段	○徒歩 ○自転車（一般的な人力のもの） ○電動アシスト自転車（二輪） ○電動アシスト自転車（三輪） ○電動アシスト四輪車 ○バイク（原付を含む） ○手動車いす ○電動車いす ○自動車（自分で運転） ○自動車（家族等が運転し同乗） ○バス ○タクシー・ハイヤー ○電車（ＪＲ・市内電車・宮島線） ○その他　移動手段名：	○徒歩 ○自転車（一般的な人力のもの） ○電動アシスト自転車（二輪） ○電動アシスト自転車（三輪） ○電動アシスト四輪車 ○バイク（原付を含む） ○手動車いす ○電動車いす ○自動車（自分で運転） ○自動車（家族等が運転し同乗） ○バス ○タクシー・ハイヤー ○電車（ＪＲ・市内電車・宮島線） ○その他　移動手段名：	○徒歩 ○自転車（一般的な人力のもの） ○電動アシスト自転車（二輪） ○電動アシスト自転車（三輪） ○電動アシスト四輪車 ○バイク（原付を含む） ○手動車いす ○電動車いす ○自動車（自分で運転） ○自動車（家族等が運転し同乗） ○バス ○タクシー・ハイヤー ○電車（ＪＲ・市内電車・宮島線） ○その他　移動手段名：
駅/バス停まで(から)の距離	出発地から：　m 目的地まで：　m 移動手段　：	出発地から：　m 目的地まで：　m 移動手段　：	出発地から：　m 目的地まで：　m 移動手段　：
目的地	登録番号：　番 住所： 施設名：	登録番号：　番 住所： 施設名：	登録番号：　番 住所： 施設名：
到着時刻	時　分	時　分	時　分
	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。	高陽ﾆｭｰﾀｳﾝ内の移動中に**危険と感じたり，不便と思った箇所**がありましたら、47 ページにご記入下さい。

コラム④　歩行者・自転車利用者の事故

日本では、交通事故死者数全体に占める歩行者と自転車利用者の割合が約半数を占め、欧米と比べて高い割合となっています。また、歩行中の死亡事故の約 6 割が自宅から 500m 以内で発生しています※1。そのため、特に主に歩行者と自転車利用者が通行する団地内の安全の確保するための方法が、自動車が普及し始めた 1930 年ころから継続的に議論されてきました。

有名な方法の１つが、人と車を完全に分離することにより、人と車が接触する機会を０にし、事故が起こり得ない地区を実現するラドバーン方式と呼ばれる地区計画手法です。ただし、このような利点の反面、分離されているがゆえに、「自動車が優先」という考え方がもたれるようになり、自動車交通を優遇すべきでない地区においても車が高速で走行するようになるという負の影響も現れ始め、皮肉にも、そのような地域での歩行者や自転車の事故を急増させる原因となってしまうケースがありました。また、住民の立ち話や子供の遊びといった生活空間としての機能を奪ってしまった点も問題として指摘されています。

交通問題の解決を図ったつもりが、生活空間の機能に影響を与えてしまう場合もあり、各地域の特徴をしっかりと踏まえた上で、その地域に適した交通体系を考える必要があります。

※１ 国土交通省道の相談室：http://www.mlit.go.jp/road/110.htm

個人票④

移動中に危険・不便と思った場所について

Preliminary and Subject to Change
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お問い合わせ

広島大学

交通工学研究室

□ 調査専用ダイヤル】 080-6329-9808
【 広島大学】 082-424-4342
※市外局番からおかけ下さい

APPENDIX 2 QUESTIONNAIRE FORM OF HOUSEHOLD INTERVIEW SURVEY IN HIROSHIMA (JAPAN) IN 2011

It is noted that this questionnaire form was designed by Kenta Tanaka and Tatsuki Agatsuma

2011 年度 第二回
生活実態に関するモニター調査
-個人票-

個人番号

世帯票を確認し、個人番号をご記入ください

広島市
Hiroshima City

広島大学

http://econavi.owners.ne.jp

生活実態調査にご協力下さる皆様へ

広島市と広島大学が協力して実施する生活実態調査にご参加いただき、誠にありがとうございます。

1970年代前後に郊外に集中的に建設されたニュータウンでは、住民の高齢化が急速に進展しており、高齢者の日常的な移動（例：バス停や駅までのアクセス）や活動（例：買い物や通院）をサポートしていく仕組み作りが今後ますます重要となってきます。

以上のことから、高齢者が利用しやすい新しい移動手段「パーソナルモビリティ」※1の開発促進や普及の可能性の検討や、地域の皆様が助け合って高齢者の移動・活動をサポートする仕組み作りを検討するための基礎資料を得ることを目的とした生活実態の調査を実施することとなりました。

昨年度の調査では、郊外ニュータウンにお住いの皆様の移動実態を把握することを目的とした調査を実施いたしました。本年度は、希望された方に実際にパーソナルモビリティを２週間ご利用いただき、パーソナルモビリティの利用が生活にどのような影響を及ぼすのか、その利用効果と実用性を確認する調査を実施いたします。なお、パーソナルモビリティを利用されない方も、調査にご協力ください。

この調査票に記入された内容は、統計データとしてのみ使用するもので、この目的以外に使うことはありません。

本調査の趣旨をご理解いただきまして、ご協力くださいますようお願い申し上げます。

※1 パーソナルモビリティの例

電動アシスト二輪 自転車	電動アシスト三輪 自転車	電動アシスト四輪 自転車	電動カート（四輪）
			

注意事項

個人票は、「あなた自身について」、「日々の生活について」の２つから構成されています。

➢ 個人票は15歳以上の世帯員全員の方が記入して下さい。

➢ 「あなた自身について」につきましては、10月30日までに、お時間のとれるときにまとめてご記入ください。

➢ 「日々の生活について」につきましては、10月17日から10月30日まで毎日ご記入ください。なお、移動の詳細を把握するため、世帯内の65歳以上の高齢者の方お一人様には、本調査期間中GPS（全地球測位システム）機器を常時持ち歩いていただきます。また、パーソナルモビリティをお使いの方がおられる場合、その方がGPSを携帯して下さい。詳細は別紙「ＧＰＳの使い方」をご確認下さい。

➢ 調査期間終了後、調査票回収の際にパーソナルモビリティがニュータウン内を走行していたことに関して、皆様のご意見を伺います。ご協力くださいますようお願い申し上げます。

本調査票（個人票）の構成

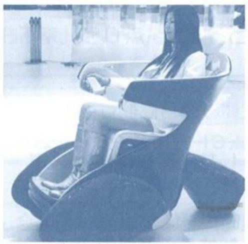
あなた自身について

個人票①

コラム①　未来のエコカー「パーソナルモビリティ」

乗り物の利用が環境問題にどのような影響を与えるかについて考えるとき、移動に要するエネルギー消費量をもとに、それぞれの乗り物の「エコ度」を計算します。公共交通がエコなのは大勢が乗るからであり、1 人あたりの消費エネルギーはクルマの約３分の１になります。８人乗りのミニバンにドライバーが１人だけ乗っているのを見かけて、「もったいない」と感じたことはありませんか。

また、クルマを出すほどの距離ではなくとも、徒歩ではなく、ラクに移動したいというニーズもあります。超高齢化国家へ突入した日本。地方都市の郊外で、日常の足に困っている高齢者の方が大勢います。そうしたおばあちゃん、おじいちゃんに家族から「危ないから免許は返上しちゃいなさい」と悲しい通告。こうなると、体は健康なのに，朝起きて、ボーとして、お菓子を食べて、昼寝して・・・、1 日ずっと家の中にいる生活になりかねません。そうした高齢者の足として期待されているのが、小型電動車（電動カート）です。さらに、この超小型のモビリティは都心や観光地での新たな移動手段としても活躍が期待されています。



トヨタ　i-REAL

こうした移動手段は、1 人乗り用の新たな移動体“パーソナルモビリティ”として、現在、多くの自動車会社が開発に尽力しています。

2007 年に開催された東京モーターショーではトヨタから「i-REAL」(アイリアル)、スズキから「ＰＩＸＹ」(ピクシー)というコンセプトモデルが出展されました。どちらも操作ノブやマウスによって簡単に操作できます。また、「ＰＩＸＹ」は衝突防止センサーを搭載し、障害物を検知すると進行方向や速度を自動で制御する仕組みになっており、安全に乗るための工夫がされています。

このように、将来はクルマとロボットが融合した新しい「家電」がまち中を走り回っているかもしれませんね。

スズキ　ＰＩＸＹ

引用)　ECO JAPAN：http://eco.nikkeibp.co.jp/

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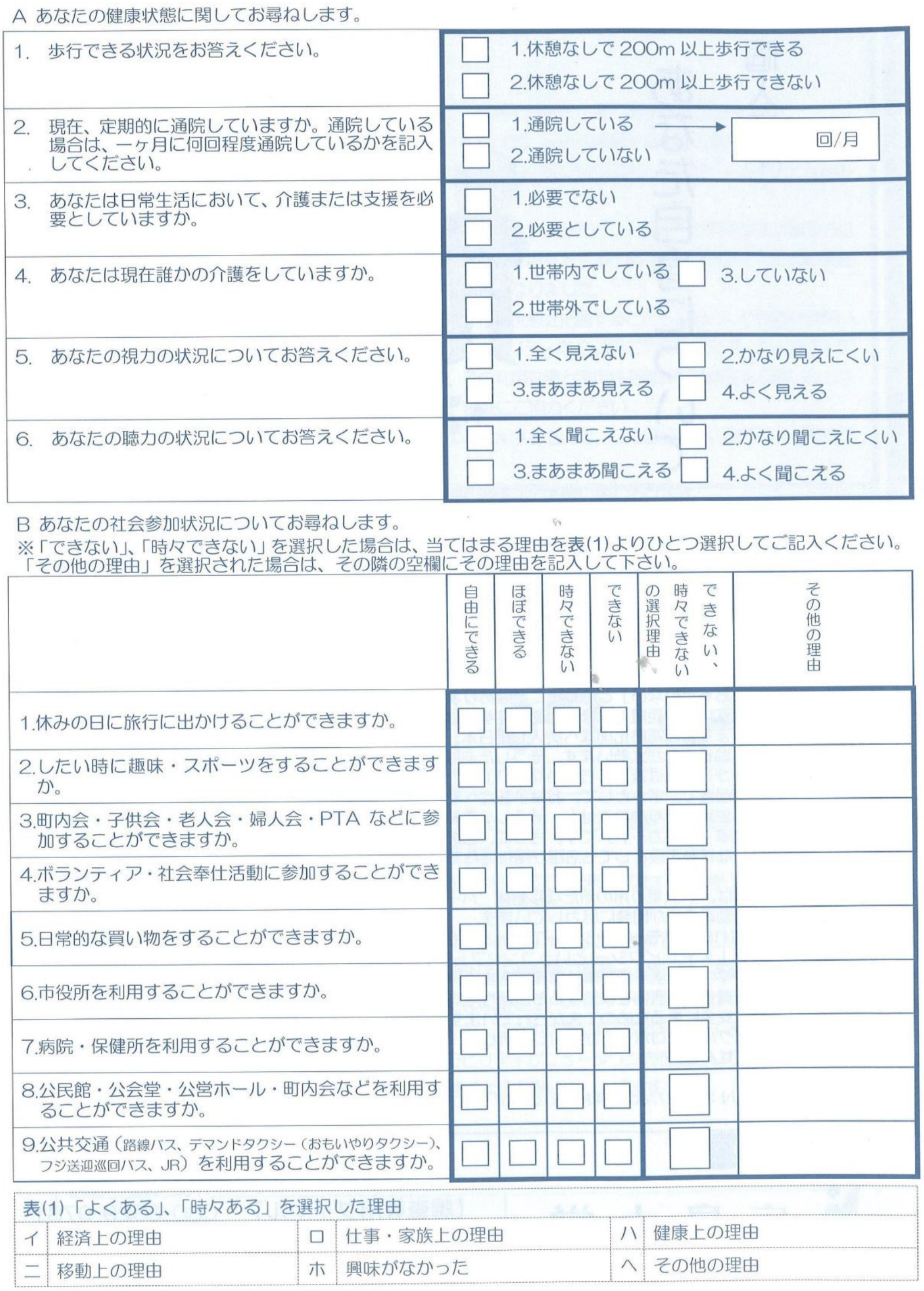

A あなたの健康状態に関してお尋ねします。

1. 歩行できる状況をお答えください。	□ 1.休憩なしで 200m 以上歩行できる □ 2.休憩なしで 200m 以上歩行できない
2. 現在、定期的に通院していますか。通院している場合は、一ヶ月に何回程度通院しているかを記入してください。	□ 1.通院している ──→ 回/月 □ 2.通院していない
3. あなたは日常生活において、介護または支援を必要としていますか。	□ 1.必要でない □ 2.必要としている
4. あなたは現在誰かの介護をしていますか。	□ 1.世帯内でしている □ 3.していない □ 2.世帯外でしている
5. あなたの視力の状況についてお答えください。	□ 1.全く見えない □ 2.かなり見えにくい □ 3.まあまあ見える □ 4.よく見える
6. あなたの聴力の状況についてお答えください。	□ 1.全く聞こえない □ 2.かなり聞こえにくい □ 3.まあまあ聞こえる □ 4.よく聞こえる

B あなたの社会参加状況についてお尋ねします。

※「できない」、「時々できない」を選択した場合は、当てはまる理由を表(1)よりひとつ選択してご記入ください。「その他の理由」を選択された場合は、その隣の空欄にその理由を記入して下さい。

	自由にできる	ほぼできる	時々できない	できない	できない、時々できないの選択理由	その他の理由
1.休みの日に旅行に出かけることができますか。	□	□	□	□		
2.したい時に趣味・スポーツをすることができますか。	□	□	□	□		
3.町内会・子供会・老人会・婦人会・PTA などに参加することができますか。	□	□	□	□		
4.ボランティア・社会奉仕活動に参加することができますか。	□	□	□	□		
5.日常的な買い物をすることができますか。	□	□	□	□		
6.市役所を利用することができますか。	□	□	□	□		
7.病院・保健所を利用することができますか。	□	□	□	□		
8.公民館・公会堂・公営ホール・町内会などを利用することができますか。	□	□	□	□		
9.公共交通（路線バス、デマンドタクシー（おもいやりタクシー）、フジ送迎巡回バス、JR）を利用することができますか。	□	□	□	□		

表(1)「よくある」、「時々ある」を選択した理由

イ	経済上の理由	ロ	仕事・家族上の理由	ハ	健康上の理由
ニ	移動上の理由	ホ	興味がなかった	ヘ	その他の理由

C あなたの生活の満足度についてお尋ねします。

	非常に満足	満足	どちらとも言えない	少し不満	非常に不満
1. あなたの居住環境に満足していますか。	□	□	□	□	□
2. あなたの世帯の経済状況に満足していますか。	□	□	□	□	□
3. あなたの健康の状態に満足していますか。	□	□	□	□	□
4. あなたの近隣住民との関係に満足していますか。	□	□	□	□	□
5. あなたの教育環境に満足していますか。	□	□	□	□	□
6. あなたの就業環境に満足していますか。	□	□	□	□	□
7. あなたの家庭生活に満足していますか。	□	□	□	□	□
8. あなたの余暇や娯楽の状況に満足していますか。	□	□	□	□	□
9. 以上の項目を踏まえ、あなたの生活に対して総合的に満足していますか。	□	□	□	□	□

D あなたは現在どの程度幸せだと感じていますか。「とても幸せ」を１０点、「とても不幸」を０点だとすると、何点くらいになると思いますか。いずれかの数字を選択してください。

とても不幸 ← → とても幸せ

０点	１点	２点	３点	４点	５点	６点	７点	８点	９点	１０点
□	□	□	□	□	□	□	□	□	□	□

E 以下の項目において頼れる人がいますか。家庭内および家庭外両方にいる場合、両方を選択してください。

	家庭内にいる	家庭外にいる	いない
1. 病気の時の世話	□	□	□
2. 一人ではできない家の周りの仕事の手伝い	□	□	□
3. 転職・転居・結婚などの相談	□	□	□
4. 配偶者・家庭内でのトラブルの相談	□	□	□
5. 子供や老親の世話	□	□	□

F 以下に挙げた人のおおよその総数を記入してください。※当てはまらない項目は無記入で結構です。

別居しているお子さん	人	別世帯の親戚	人	高陽ニュータウン外での友人	人	高陽ニュータウン内の友人	人

日々の生活について

個人票②

コラム②　ロボットのまちつくば

茨城県つくば市では、パーソナルモビリティの実用化に向けた取り組みをまち全体で行っています。

つくば市は、平成２３年３月２５日、日本で初めて「モビリティロボット実験特区」として、内閣総理大臣より認定されました。モビリティロボットは、現行法上、日本の公道を走行することができないため、実用化のための実証実験を行うことができません。しかし、モビリティロボットには、これからの低炭素社会、安全安心なまちづくり、少子高齢化社会の課題解決に役立つ可能性が高く、大きな期待が寄せられています。また、ロボットは産業としても将来大きな産業として育っていくことが期待されています。そうしたことから、つくば市では、一定エリアの公道において、モビリティロボットの社会的な有効性や歩行者等との親和性、社会受容性等についての検証実験に取り組み、パーソナルモビリティの実際社会への適用可能性が検討されています。

つくば市では、モビリティロボット以外にも、無人田植えロボット・調理支援ロボット・介護支援ロボットなど次世代の生活支援ロボット産業の拠点づくりに励んでおり、人とロボットが共生する新しい社会像を提案しています。

※パーソナルモビリティとモビリティロボットは呼び名だけで特に違いはありません。つくば市では特に次世代の乗り物ということに特化しているため「ロボット」という言葉を使って表現しているようです。

引用　ロボット特区実証実験推進協議会：

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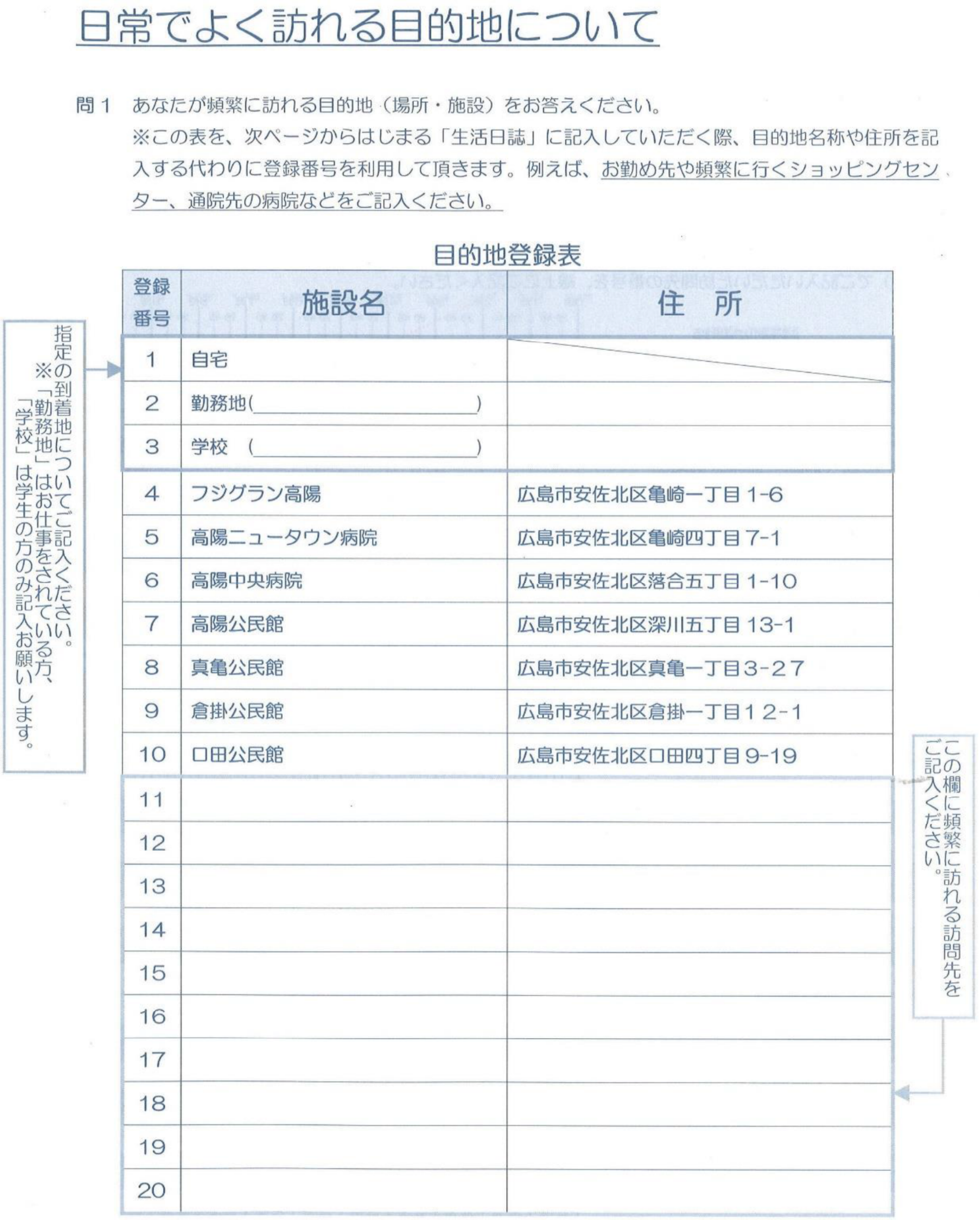


日常でよく訪れる目的地について

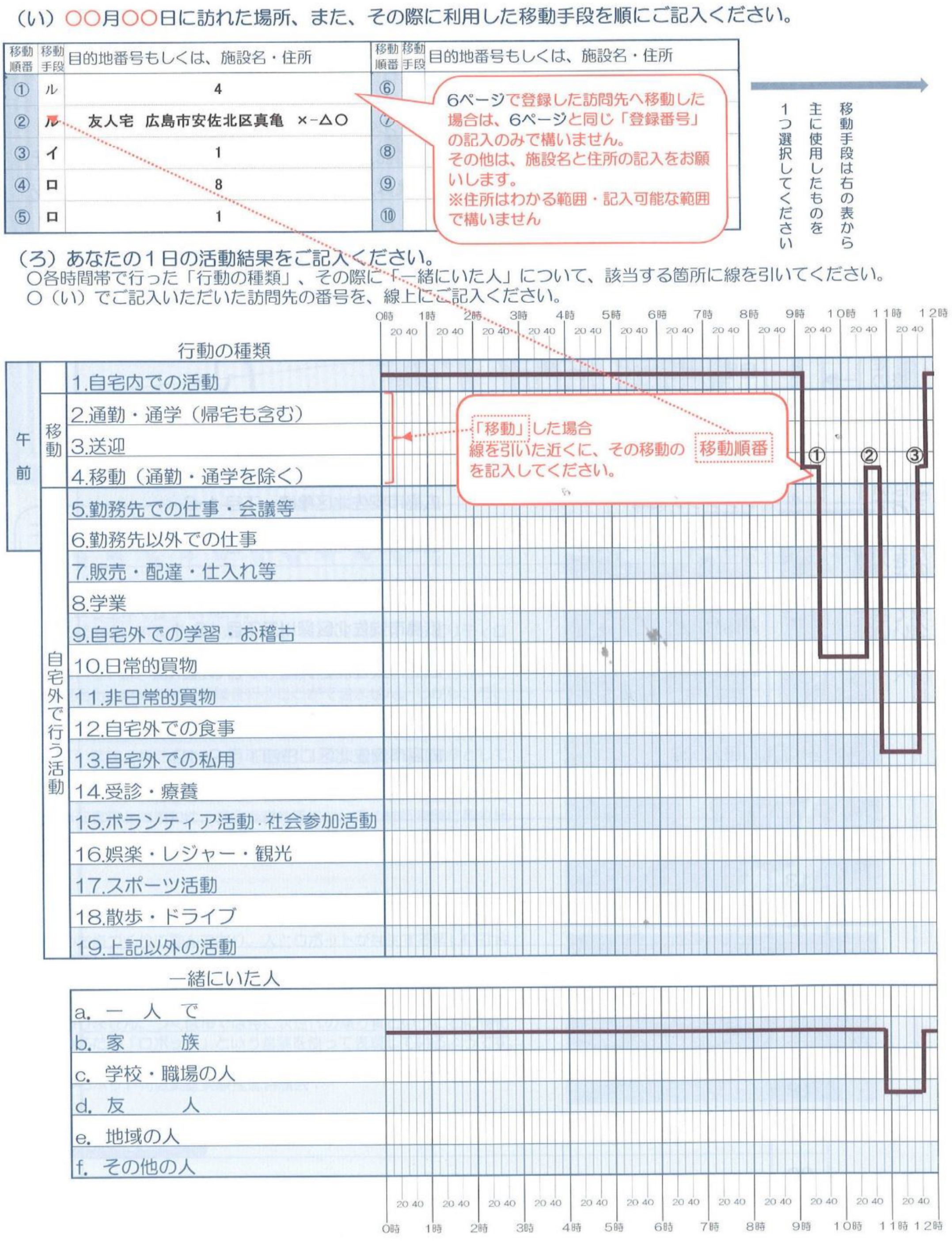
問１　あなたが頻繁に訪れる目的地（場所・施設）をお答えください。
※この表を、次ページからはじまる「生活日誌」に記入していただく際、目的地名称や住所を記入する代わりに登録番号を利用して頂きます。例えば、お勤め先や頻繁に行くショッピングセンター、通院先の病院などをご記入ください。

目的地登録表

指定の到着地についてご記入ください。
※「勤務地」はお仕事をされている方、
「学校」は学生の方のみ記入お願いします。

登録番号	施設名	住　所
1	自宅	
2	勤務地(　　　　　　　)	
3	学校　(　　　　　　　)	
4	フジグラン高陽	広島市安佐北区亀崎一丁目 1-6
5	高陽ニュータウン病院	広島市安佐北区亀崎四丁目 7-1
6	高陽中央病院	広島市安佐北区落合五丁目 1-10
7	高陽公民館	広島市安佐北区深川五丁目 13-1
8	真亀公民館	広島市安佐北区真亀一丁目３-２７
9	倉掛公民館	広島市安佐北区倉掛一丁目１２-１
10	口田公民館	広島市安佐北区口田四丁目 9-19
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

この欄に頻繁に訪れる訪問先を
ご記入ください。



（い）○○月○○日に訪れた場所、また、その際に利用した移動手段を順にご記入ください。

移動順番	移動手段	目的地番号もしくは、施設名・住所	移動順番	移動手段	目的地番号もしくは、施設名・住所
①	ル	4	⑥		
②	ル	友人宅 広島市安佐北区真亀 ×−△○	⑦		
③	イ	1	⑧		
④	ロ	8	⑨		
⑤	ロ	1	⑩		

6ページで登録した訪問先へ移動した場合は、6ページと同じ「登録番号」の記入のみで構いません。
その他は、施設名と住所の記入をお願いします。
※住所はわかる範囲・記入可能な範囲で構いません

移動手段は右の表から主に使用したものを1つ選択してください

（ろ）あなたの1日の活動結果をご記入ください。

○各時間帯で行った「行動の種類」、その際に「一緒にいた人」について、該当する箇所に線を引いてください。

○（い）でご記入いただいた訪問先の番号を、線上にご記入ください。

0時 20 40 1時 20 40 2時 20 40 3時 20 40 4時 20 40 5時 20 40 6時 20 40 7時 20 40 8時 20 40 9時 20 40 10時 20 40 11時 20 40 12時

行動の種類

午前

1.自宅内での活動

移動
2.通勤・通学（帰宅も含む）
3.送迎
4.移動（通勤・通学を除く）

「移動」した場合
線を引いた近くに、その移動の 移動順番 を記入してください。

① ② ③

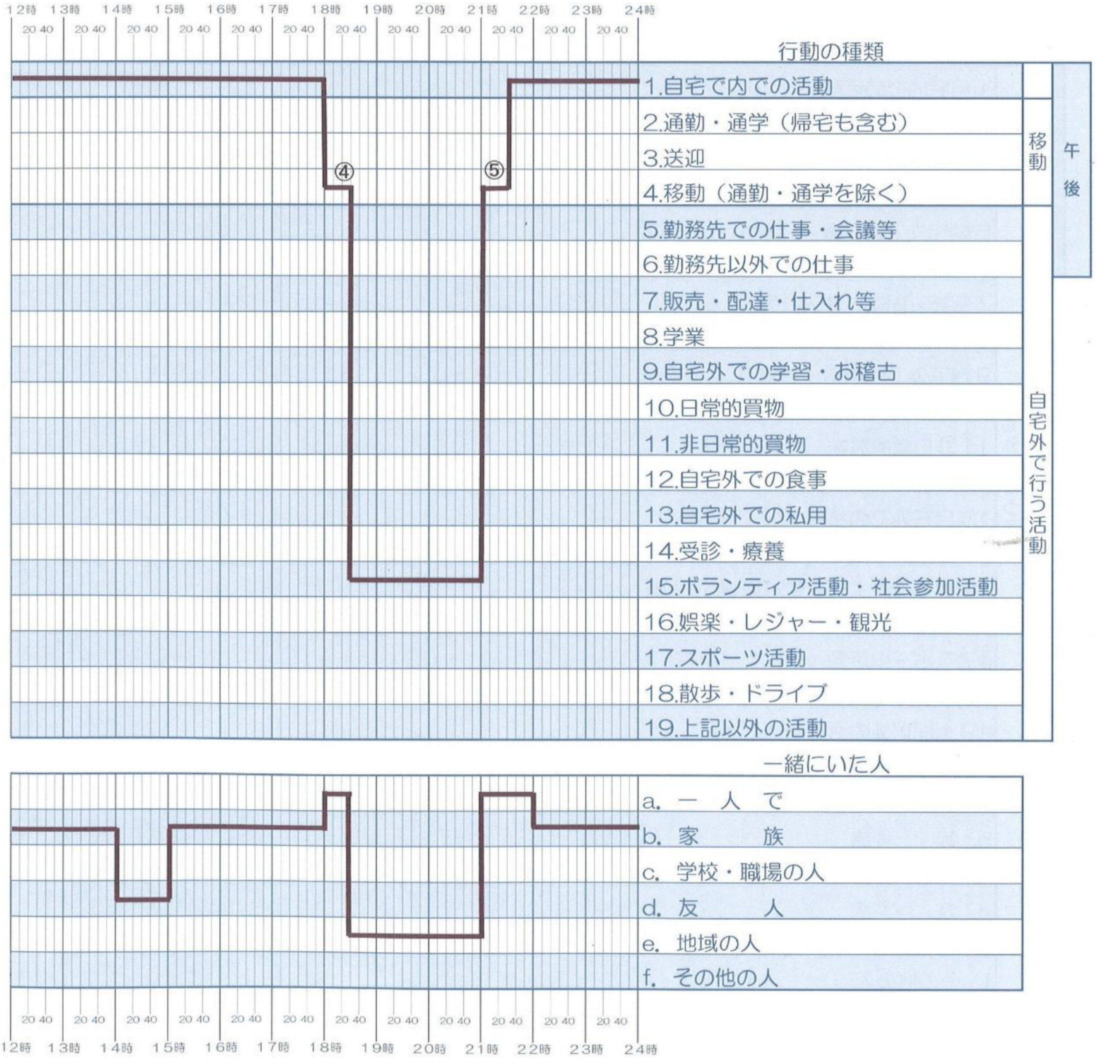
自宅外で行う活動
5.勤務先での仕事・会議等
6.勤務先以外での仕事
7.販売・配達・仕入れ等
8.学業
9.自宅外での学習・お稽古
10.日常的買物
11.非日常的買物
12.自宅外での食事
13.自宅外での私用
14.受診・療養
15.ボランティア活動・社会参加活動
16.娯楽・レジャー・観光
17.スポーツ活動
18.散歩・ドライブ
19.上記以外の活動

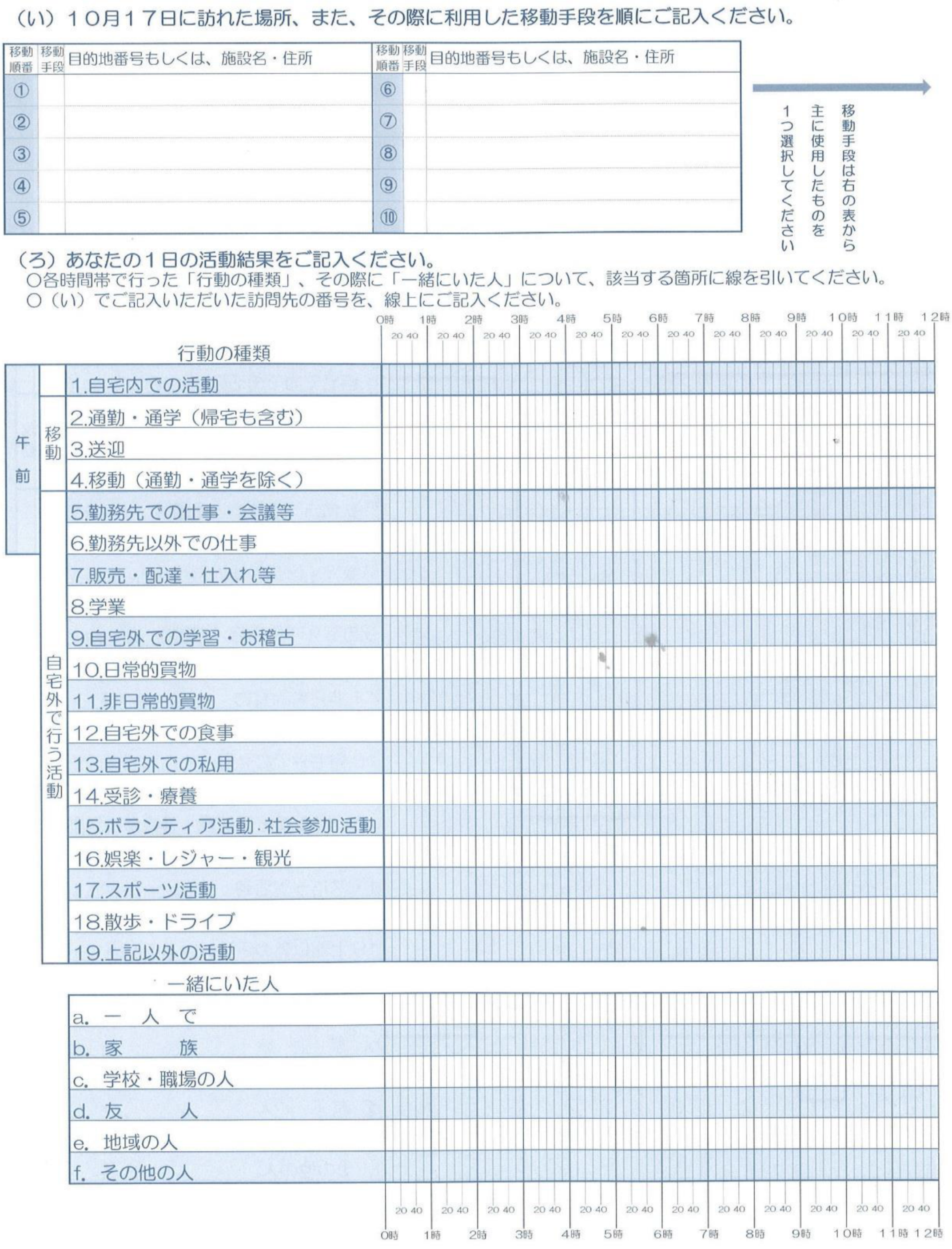
一緒にいた人
a. 一人で
b. 家族
c. 学校・職場の人
d. 友人
e. 地域の人
f. その他の人

20 40 20 40 20 40 20 40 20 40 20 40 20 40 20 40 20 40 20 40 20 40 20 40
0時 1時 2時 3時 4時 5時 6時 7時 8時 9時 10時 11時 12時

第　　日		
10　月	○○　日	○　曜日

イ	徒歩	ト	手動車いす	ワ	自動車（自分で運転）
ロ	自転車	チ	電動車いす	カ	自動車（家族・友人が運転し同乗）
ハ	電動アシスト二輪自転車	リ	バス	ヨ	バイク（原付も含む）
ニ	電動アシスト三輪自転車	ヌ	タクシー・ハイヤー	タ	電車（JR・市内電車・宮島線）
ホ	電動アシスト四輪自転車	ル	フジ送迎巡回バス	レ	その他（自由記述）
ヘ	電動カート（四輪）	ヲ	デマンド型乗り合いタクシー（おもいやりタクシー）		





（い）１０月１７日に訪れた場所、また、その際に利用した移動手段を順にご記入ください。

移動順番	移動手段	目的地番号もしくは、施設名・住所	移動順番	移動手段	目的地番号もしくは、施設名・住所
①			⑥		
②			⑦		
③			⑧		
④			⑨		
⑤			⑩		

移動手段は右の表から主に使用したものを１つ選択してください

（ろ）あなたの１日の活動結果をご記入ください。
○各時間帯で行った「行動の種類」、その際に「一緒にいた人」について、該当する箇所に線を引いてください。
○（い）でご記入いただいた訪問先の番号を、線上にご記入ください。

		行動の種類	0時	1時	2時	3時	4時	5時	6時	7時	8時	9時	10時	11時
			20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40
午前		1.自宅内での活動												
	移動	2.通勤・通学（帰宅も含む）												
		3.送迎												
		4.移動（通勤・通学を除く）												
	自宅外で行う活動	5.勤務先での仕事・会議等												
		6.勤務先以外での仕事												
		7.販売・配達・仕入れ等												
		8.学業												
		9.自宅外での学習・お稽古												
		10.日常的買物												
		11.非日常的買物												
		12.自宅外での食事												
		13.自宅外での私用												
		14.受診・療養												
		15.ボランティア活動.社会参加活動												
		16.娯楽・レジャー・観光												
		17.スポーツ活動												
		18.散歩・ドライブ												
		19.上記以外の活動												

一緒にいた人	0時	1時	2時	3時	4時	5時	6時	7時	8時	9時	10時	11時
a. 一　人　で												
b. 家　　族												
c. 学校・職場の人												
d. 友　　人												
e. 地域の人												
f. その他の人												
	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40	20 40

0時 1時 2時 3時 4時 5時 6時 7時 8時 9時 10時 11時 12時

第　　日		
10　月	17　日	月曜日

イ	徒歩	ト	手動車いす	ワ	自動車（自分で運転）
ロ	自転車	チ	電動車いす	カ	自動車（家族・友人が運転し同乗）
ハ	電動アシスト二輪自転車	リ	バス	ヨ	バイク（原付も含む）
ニ	電動アシスト三輪自転車	ヌ	タクシー・ハイヤー	タ	電車（JR・市内電車・宮島線）
ホ	電動アシスト四輪自転車	ル	フジ送迎巡回バス	レ	その他（自由記述）
ヘ	電動カート（四輪）	ヲ	デマンド型乗り合いタクシー（おもいやりタクシー）		

12時　13時　14時　15時　16時　17時　18時　19時　20時　21時　22時　23時　24時

20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40

行動の種類		
1.自宅内での活動		午後
2.通勤・通学（帰宅も含む）	移動	
3.送迎		
4.移動（通勤・通学を除く）		
5.勤務先での仕事・会議等	自宅外で行う活動	
6.勤務先以外での仕事		
7.販売・配達・仕入れ等		
8.学業		
9.自宅外での学習・お稽古		
10.日常的買物		
11.非日常的買物		
12.自宅外での食事		
13.自宅外での私用		
14.受診・療養		
15.ボランティア活動・社会参加活動		
16.娯楽・レジャー・観光		
17.スポーツ活動		
18.散歩・ドライブ		
19.上記以外の活動		

一緒にいた人
a. 一　人　で
b. 家　　族
c. 学校・職場の人
d. 友　　人
e. 地域の人
f. その他の人

20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40　20 40

12時　13時　14時　15時　16時　17時　18時　19時　20時　21時　22時　23時　24時

APPENDIX 3 QUESTIONNAIRE FORM OF HOUSEHOLD INTERVIEW SURVEY IN HANOI (VIETNAM) IN 2015

HIROSHIMA UNIVERSITY
Graduate School for International Development and Cooperation

Household No. ☐☐☐

QUESTIONNAIRE SURVEY ON UNDERSTANDING TRAVEL BEHAVIOR IN NEW URBAN AREAS IN HANOI

This survey is conducted to understand travel behavior of residents in new urban areas in Hanoi. All information obtained in this survey is used for ***research purpose only****, and* ***anonymity of respondents*** *is made absolutely sure.*

This survey is conducted by Nguyen Thi Anh Hong of Graduate School for International Development and Cooperation, ***Hiroshima University, Japan****, with the cooperation of the Consulting Center for Transport Development (TRANCONCEN),* ***University of Transport and Communication*** *(UTC), Vietnam, and the statistics obtained in this study goes to her dissertation and other related researches. Your kind cooperation is a critical contribution to the success of our research.*

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Lang Thuong Ward, Dong Da Dist., Hanoi

Household Interview Survey

INSTRUCTION FOR ANSWERING QUESTIONNAIRE FORMS
Please answer all the questions one by one sequentially. Print the information in the space provided or put a check mark in the appropriate box.

Form 1: Household information

*Only the **head of the household** has to complete Form 1.*

Form 2: Environment of Residential Area, and Relationship Information

*It should be completed by at least 2 household members **who are over 15 years old***
(Please specify their member code)

Form 3: Daily Activity Information

*It should be completed by at least 2 household members **who are over 15 years old** (same the person filling in Form 2)*
(Please specify their member code)

Interviewer	…………………………………………………………
Date / Month	…../10/ 2015
NUA Zone No.	…………
Household No.	…………

Form1: HOUSEHOLD INFORMATION

INSTRUCTION: To be completed by HEAD of HOUSEHOLD

Q1 Name

____

Q2 Address of household

No/ Room No.	Floor No.	Building/ House No.	Street	Commune	District	City
						Hanoi

Q3 Tel. Number (optional) ________________

Q4 Number of household member (all members live together in your household) _______(persons)

Q5 Total monthly household income (000 VND/month)

- **1.** Less than 1,000
- **2.** 1,001 – 3,000
- **3.** 3,001 – 6,000
- **4.** 6,001 – 9,000
- **5.** 9,001 – 13,000
- **6.** 13,001 – 17,000
- **7.** 17,001 – 21,000
- **8.** 21,001 – 25,000
- **9.** 25,001 – 30,000
- **10.** 30,001 – 40,000
- **11.** 40,001 – 50,000
- **12.** More than 50,000

Q6 Number of vehicles owned by household

Please see note List A

Type of vehicles	Number of units	Parking place	Distance from home to parking place (m)	Monthly fee (,000 VND/month)
(1) Bicycle				
(2) Electric bike				
(3) Motorcycle				
(4) Car				
(5) Other (………...)				

List A
- **1.** In house
- **2.** Below building (High-rise apartment)
- **3.** Temporary parking on pavement
- **4.** Parking elsewhere

Q7 How long has your family been staying in the present address?

________years

Q8 Where was your previous address?

Commune	District	City

Q9 Housing information

1) Type of house	**1.** High-rise apartment **2.** Detached house **3.** Villa **4.** Others (…….)
(2) If high-rise apartment, how many stories in your building?	……... stories

(3) Housing ownership	**1.** Own **2.** Rent
(4) If rented, how much do you pay per month?	VND …..,…..,000
(5) Floor area	…….. m2
(6) Number of rooms	…….. rooms
(7) Age of house	…….. years

Q10 Household member information

It should be completed for all households' members

			List B	List C	List D	List E	List E	List F	List F	List G	
Code	Gender	Age (*up to 10/ 2015*)	Relationship with head of household	Registration	Education	Occupation	Previous Job (5 years before)	Distance to workplace/ school	Monthly Income (*000, VND/month)*	Driving License	Having Mobile Phone
1	1. Male 2. Female	….. years	1					…….. Km			**1.** Yes **2.** No
2	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
3	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
4	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
5	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
6	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
7	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No
8	1. Male 2. Female	….. years						…….. Km			**1.** Yes **2.** No

List B

1. Head of household
2. Spouse
3. Children
4. Children's spouse
5. Grandchildren
6. Parents
7. Parents-in-law
8. Grandparents
9. Brother/Sister
10. House maid
11. Other relatives
12. Others

List C

1. Permanent (KT1)
2. Temporary (KT2)
3. Temporary (KT3)
4. Temporary (KT4)
5. Non-Registered

List D

1. Master / Doctor
2. Bachelor
3. Two-year college
4. High school or below

List E

1. Manage
2. Professional
3. Office worker
4. Service workers and shop and market sales worker
5. Factory worker
6. Site worker
7. Farmer
8. Part time job
9. Student
10. Pupil
11. Self-employed/small business
12. Housewife
13. Police/ Military
14. Jobless/Retired
15. Others

List F

1. Less than 1,000
2. 1,001 – 3,000
3. 3,001 – 6,000
4. 6,001 – 9,000
5. 9,001 – 13,000
6. 13,001 – 17,000
7. 17,001 – 21,000
8. 21,001 – 25,000
9. 25,001 – 30,000
10. 30,001 – 40,000
11. 40,001 – 50,000
12. More than 50,000

List G

1. Motorcycle
2. Car
3. Both
4. None

Household No. ☐☐☐ *Individual No.* ☐

Form2: <u>ENVIRONMENT OF NEW URBAN AREA (NUA), AND RELATIONSHIP INFORMATION</u>

INSTRUCTION: *To be completed by at least **<u>two</u>** household members who are **<u>over 15</u>** years old*

Q11 How often do you access to the following facilities per month? *(Please see the map of new urban area). If frequency of using facilities **<u>inside</u>** NUA is **<u>larger than zero</u>** (0), please report total satisfaction in the last column*

Facilities	Using facilities	Mode	Frequency (times/month)						
			Outside NUA	***Inside NUA***					
				<100m	100m - 500m	500m - 1000m	1km - 2km	>2km	Total satisfaction
(1) Your work office	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(2) Supermarket (for daily shopping)	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(3) Department store (for non-daily shopping)	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(4) Kinder garden	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(5) School	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(6) Bank (public/private)	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(7) Post office	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(8) Cinema/ Karaoke bar	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(9) Sports facility (sports ground, gym)	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(10) Hospital/ Clinic (public/private)	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(11) Pharmacy/ drug store	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(12) Cafeteria	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(13) Restaurant	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(14) Beauty salon/ barber shop	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(15) Park/ open space/ green space	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							
(16) Bus stop	**1.** Yes	**1.** Non-motorize							
	2. No	**2.** Motorize							

Note: Total Satisfaction are measured as the following

1	**2**	**3**	**4**	**5**
Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied

Household No. ☐☐☐ *Individual No.* ☐

Q12 Are you satisfied with the following transport environment *INSIDE* respondents' NUA?

Transport environment	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
(1) Width of pedestrian paths on most of streets	1	2	3	4	5
(2) Width of road network	1	2	3	4	5
(3) Pavement quality of road network	1	2	3	4	5
(4) Number of trees along streets	1	2	3	4	5
(5) Number of parking space	1	2	3	4	5
(6) Street lights at night	1	2	3	4	5

Q13 Please answer the following statements related to traffic safety and security INSIDE respondents' NUA?

Traffic safety and security	Very unsafe	Unsafe	Neutral	Safe	Very Safe
(1) Traveling	1	2	3	4	5
(2) Walking or cycling environment	1	2	3	4	5
(3) Crossing streets (pedestrians)	1	2	3	4	5
(4) Security	1	2	3	4	5

Q14 Please answer the following statements related to the relationship with neighborhood/ resident living INSIDE respondents' NUA?

Living environment	Very bad	Bad	Neutral	Good	Very Good
(1) Relationship with your neighborhoods	1	2	3	4	5
(2) Relationship with residents	1	2	3	4	5

Q15 Level of happiness. *Please rate your level of happiness on a scale of 1 to 10*

	Unhappy ←									→ Very happy
	1	2	3	4	5	6	7	8	9	10
Before moving to NUA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
After moving to NUA	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Household No. ☐☐☐ *Individual No.* ☐

Q16 Social network composition. *Please note that children/ parents/ relatives/ acquaintances (including friends, neighbors, colleagues,...) who live OUTSIDE your house and STILL KEEP IN TOUCH with you (meet you at least once every six-month).*

Number of children/ parents/ relatives/ friends					
Children/parents		Relatives		Acquaintances	
Inside NUA	Outside NUA	Inside NUA	Outside NUA	Inside NUA	Outside NUA
……..	……..	……..	……..	……..	……..

Q17 Close social network information

From question **Q17** choose a maximum of 6 people *whom they meet face-to-face most often* for *non-working purposes* (according to order). *Very close consisted of "people with whom you discuss important matters with, or regularly keep in touch with, or they are there for you if you need help". Somewhat close consisted of "more than just casual acquaintances, but not very close people"*

No.	**Gender**	**Age** (*Years*)	**Having Job**	**Relationship** *(If relationships are friends, please additional information that is how long have you known your friends)*	**Inside /Outside** NUA	**Distance** *from your house to relationship's house*	**Conversation frequency** *(Time(s) / month)*	
							Face-to-face	By mobile / email
R1 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)
R2 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)
R3 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)
R4 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)
R5 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)
R6 ……..	**1.** Male **2.** Female	☐ below 24 ☐ 24-45 ☐ 45-60 ☐ 61-74 ☐ above 75	**1.** Yes **2.** No	**1.** Children/parents live separately **2.** Relatives live separately **3.** Friends live separately *(…… Years)*	**1.** Inside **2.** Outside	…….. Km	…….. Time(s)	…….. Time(s)

Household No. ☐☐☐ *Individual No.* ☐

Q18 Why did you move to the NUA, instead of living in the previous address? *Please choose 2 options for the following reasons (which is compared with previous address)*

1. Have owned private space in NUA (share/rent a house/ apartment in previous address)	**6.** More social networks (friends, relatives, neighborhood) in NUA
2. Easily access/ close to workplace	**7.** Better transport environment in NUA
3. Better housing quality in NUA	**8.** Better traffic safety in NUA
4. More open/green space in NUA	**9.** Safer in NUA
5. More needed facilities near home in NUA	**10.** Others (…………………………..)

Q19 Is there any community in your new urban area?

1. Yes **2.** No

Q20 If yes, how often do you attend activities in that community per month?

________ (times/month)

Household No. ☐☐☐ *Individual No.* ☐

Form3: DAILY ACTIVITY INFORMATION

INSTRUCTION: *To be completed by all household members who are over 15 years old*

Q21 Daily Activity Information

Explanation for reporting travel diary

For Trip purpose

Trip purpose	Detail
Pick up / drop off	To pick up or drop off people from/ at: - Bus stop, railway station, airport - Kindergarten, child care, school - Hospital - Sports field, shop, etc.
Business trip	The trip related to your work: - Conference - Getting data, document - Field trip - Business trip, etc.
Recreation/ Religious	For example, - Cinema, theater, concert, museum - Trade fairs, exhibition, fairs - Church/ Temple/ Pagoda

Trip purpose	Detail
Joy riding/ driving	Just riding/ driving around without purpose
Personal business trip	- Authority, administrations - Hairdresser, cosmetics - Doctor, massage, optician - Post office, letter box - Petrol station, repair services - Shoemaker, tailor, laundry or similar

For Travel mode

In case of travelling by the mode in the list *(except for bus)*

For example:

→ Travelling by motorcycle (as driver)

Travel mode	**1.** Walk	
	2. Bicycle	
	3. Electric bicycle	
	[✓ **4.** Motorcycle (as driver)]	
	5. Motorcycle (as passenger)	
	6. Car (as driver)	
	7. Car (as passenger)	
	8. Taxi	
	9. Motorcycle taxi	
	10. Bus	
	11. Others (……)	
If you travel by bus, please report additional information	(1) Access mode	…..
	(2) Access time	….. minutes
	(3) Waiting time	….. minutes
	(4) Egress mode	…..
	(5) Egress time	….. minutes

In case of travelling by bus

For example:

→ Walking from origin to bus stop: 7 minutes

→ Waiting at bus stop: 3 minutes

→ Travelling by bus to bus stop near destination

→ Walking to destination: 5 minutes

Travel mode	**1.** Walk	
	2. Bicycle	
	3. Electric bicycle	
	4. Motorcycle (as driver)	
	5. Motorcycle (as passenger)	
	6. Car (as driver)	
	7. Car (as passenger)	
	8. Taxi	
	9. Motorcycle taxi	
	[✓ **10.** Bus]	
	11. Others (……)	
If you travel by bus, please report additional information	(1) Access mode	…1……
	(2) Access time	…7…… minutes
	(3) Waiting time	…3…… minutes
	(4) Egress mode	…1……
	(5) Egress time	…5…… minutes

Household No. ☐☐☐ *Individual No.* ☐

Date	…….	…….
Trip No.	**1**	**2**
Departure time	..……:………	..……:………
Arrival time	..……:………	..……:………
Trip purpose	**1.** Pick up / drop off **2.** Commuting **3.** Schooling (to study) **4.** Daily shopping **5.** Non-daily shopping **6.** Business trip **7.** Meeting friends **8.** Doing exercise **9.** Eating (not at home) **10.** Joy riding/driving **11.** Recreation/ Religious **12.** Personal business trip **13.** Others (…………………….) **14.** Go home	**1.** Pick up / drop off **2.** Commuting **3.** Schooling (to study) **4.** Daily shopping **5.** Non-daily shopping **6.** Business trip **7.** Meeting friends **8.** Doing exercises **9.** Eating (not at home) **10.** Joy riding/driving **11.** Recreation/ Religious **12.** Personal business trip **13.** Others (…………………….) **14.** Go home
Accompany	**1.** Alone **2.** With family member : ……....person(s) **3.** With other member : …..…..person(s)	**1.** Alone **2.** With family member : ……....person(s) **3.** With other member : …..…..person(s)
Address of Origin	**1.** Inside **2.** Outside ☐ Home ☐ Others ………………………………………… …………………………………………	☑ Previous Destination
Travel mode	**1.** Walk **2.** Bicycle **3.** Electric bicycle **4.** Motorcycle (as driver) **5.** Motorcycle (as passenger) **6.** Car (as driver) **7.** Car (as passenger) **8.** Taxi **9.** Motorcycle taxi **10.** Bus **11.** Others (……)	**1.** Walk **2.** Bicycle **3.** Electric bicycle **4.** Motorcycle (as driver) **5.** Motorcycle (as passenger) **6.** Car (as driver) **7.** Car (as passenger) **8.** Taxi **9.** Motorcycle taxi **10.** Bus **11.** Others (……)
If you travel by bus, please report additional information	(1) Access mode ……… (2) Access time ……… minutes (3) Waiting time ……… minutes (4) Egress mode ……… (5) Egress time ……… minutes	(1) Access mode ……… (2) Access time ……… minutes (3) Waiting time ……… minutes (4) Egress mode ……… (5) Egress time ……… minutes
Address of Destination	**1.** Inside **2.** Outside ☐ Home ☐ Others ………………………………………… …………………………………………	**1.** Inside **2.** Outside ☐ Home ☐ Others …………………………………………. …………………………………………..
Estimate Distance	…………. Km	………….Km

Household No. ☐☐☐ *Individual No.* ☐

Date	…….	…….
Trip No.	…..	……
Departure time	..……:………	..……:………
Arrival time	..……:………	..……:………
Trip purpose	**1.** Pick up / drop off **2.** Commuting **3.** Schooling (to study) **4.** Daily shopping **5.** Non-daily shopping **6.** Business trip **7.** Meeting friends **8.** Doing exercise **9.** Eating (not at home) **10.** Joy riding/driving **11.** Recreation/ Religious **12.** Personal business trip **13.** Others (…………………….) **14.** Go home	**1.** Pick up / drop off **2.** Commuting **3.** Schooling (to study) **4.** Daily shopping **5.** Non-daily shopping **6.** Business trip **7.** Meeting friends **8.** Doing exercises **9.** Eating (not at home) **10.** Joy riding/driving **11.** Recreation/ Religious **12.** Personal business trip **13.** Others (…………………….) **14.** Go home
Accompany	**1.** Alone **2.** With family member : ……....person(s) **3.** With other member : ….…...person(s)	**1.** Alone **2.** With family member : ……....person(s) **3.** With other member : ….…...person(s)
Address of Origin	☑ Previous Destination	☑ Previous Destination
Travel mode	**1.** Walk **2.** Bicycle **3.** Electric bicycle **4.** Motorcycle (as driver) **5.** Motorcycle (as passenger) **6.** Car (as driver) **7.** Car (as passenger) **8.** Taxi **9.** Motorcycle taxi **10.** Bus **11.** Others (……)	**1.** Walk **2.** Bicycle **3.** Electric bicycle **4.** Motorcycle (as driver) **5.** Motorcycle (as passenger) **6.** Car (as driver) **7.** Car (as passenger) **8.** Taxi **9.** Motorcycle taxi **10.** Bus **11.** Others (……)
If you travel by bus, please report additional information	(1) Access mode ……… (2) Access time ……… minutes (3) Waiting time ……… minutes (4) Egress mode ……… (5) Egress time ……… minutes	(1) Access mode ……… (2) Access time ……… minutes (3) Waiting time ……… minutes (4) Egress mode ……… (5) Egress time ……… minutes
Address of Destination	**1.** Inside **2.** Outside ☐ Home ☐ Others ………………………………………… …………………………………………	**1.** Inside **2.** Outside ☐ Home ☐ Others ……………………………………….. ………………………………………..
Estimate Distance	…………. Km	………….Km