UTILITY-BASED APPROACHES TO UNDERSTANDING THE EFFECTS OF URBAN COMPACTNESS ON TRAVEL BEHAVIOR: A CASE OF SEOUL, KOREA

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LIST OF ABBREVIATIONS

3D	Density, diversity, and design
AGFI	Adjusted Goodness-of-Fit Index
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CR	Critical Ratio
EFA	Exploratory Factor Analysis
GFI	Goodness-of-Fit Index
GIS	Geographic Information Systems
MHTS	Korean Metropolitan Household Travel Survey
MI	Modification Index
MRS	Marginal Rate of Substitution
NHTS	National Household Travel Survey
PCA	Principal Component Analysis
PSTP	Puget Sound Transportation Panel
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling
SMC	Squared Multiple Correlations
SRMR	Standardized Root Mean Square Residual
TAZ	Traffic Analysis Zone
TTB	Travel Time Budget

VMT	Vehicle Miles Traveled

SUMMARY

Decisions to use the automobile or its alternatives, including walk, bicycle, and public transit, are believed to be associated with urban form. In particular, researchers have hypothesized that compact urban form reduces automobile travel. However, previous studies reported only a modest effect on travel behavior. These studies, largely built on microeconomic utility theory, are not sufficient for assessing the effect of compactness, for several reasons: (1) The studies postulate that travel invokes only disutility, but travel may also provide intrinsic utility or benefits insomuch as people travel for its own sake; (2) the studies have traditionally focused on how urban compactness reduces trip length and accordingly reduces trip time, but urban compactness also increases congestion and reduces trip speed, and thus increases trip time; and (3) the studies have mostly examined automobile commuting, but people travel for various purposes, using different travel modes, and the impact of urban compactness on the utility of non-automobile non-commuting travel has not been duly examined.

On this ground, to better explain the effects that urban compactness has on travel behavior, this dissertation refines the concept of travel utility using two additions to the microeconomic utility theory: activity-based utility theory of derived travel demand and approaches to positive utility of travel. Travel utility is defined by costs and benefits associated with a trip. The costs are represented by trip time and the benefits are evaluated using a psychometric measure. Accordingly, this research designs a conceptual model that specifies travel utility as an intermediary between urban compactness and travel behavior. Thus, a unique feature of this research is that while earlier studies

examined the urban compactness–travel relationship based on the assumption that urban compactness alters travel behavior by changing trip time, this research (1) explicitly incorporates the trip time variable into its analytical model and (2) further considers the benefit side of the utility. Then, this research accumulatively tests whether urban compactness changes the cost and benefit sides of travel utility and whether the utility changes brought about by urban compactness, not by other variations, alter travel behavior [i.e., urban compactness --> travel utility (trip time and travel benefits) --> travel].

To test the conceptual model, this research conducted a structured sample survey in 24 neighborhoods in Seoul, Korea. The survey quantified travel utility using a psychometric measure. Considering unique urban and transportation settings in Seoul, this research modified the measure through a mixed methods approach that consisted of 24 semi-structured interviews and subsequent exploratory factor analysis.

The interviews also functioned as a pre-test, that is, based on the outcomes of the interviews, this research improved the questionnaire of the structured survey. It employed a hand-delivered survey method, financial incentives, and reminder calls for the quality of the survey, which accordingly achieved a very high response rate (86.9%).

Based on a total of 1,032 effective responses from the survey and GIS datasets from secondary sources, this research tested the conceptual model through structural equation modeling (SEM) according to three purposes of travel (commuting, shopping, and leisure). To check the degree to which SEM results based on the sample are transferrable to the population (all neighborhoods in Seoul), it conducted thorough statistical tests. Subsequently, it confirms the representativeness of the sample (using chi-square goodness-of-fit tests and one-sample *t*-tests), construct validity of the psychometric measure (through confirmatory factor analysis), and configural invariance of urban compactness measures (in SEM models).

This research identified a total of 20 individual models to test the degree to which the utility concept is useful in explaining the effect of urban compactness. All of the models had good fit to the data, while those considering the utility had better fit. By comparing the individual models, this research clearly demonstrates that the urban compactness effect on travel behavior, represented by trip frequencies, is better explained when travel utility is considered.

In contrast to the earlier explanation based on microeconomic utility theory—urban compactness changes travel behavior by reducing trip time (according to shortened trip length)—this research found that urban compactness changes the behavior, measured with trip frequencies and mode shares, mainly by increasing travel benefits. When urban compactness altered trip time, it primarily increased (not reduced) the trip time. This effect was limited to automobile commuting.

This research contributed to the theory by refining the activity-based utility theory and positive utility approaches. While the activity-based utility theory simplifies the complex urban form–travel relationship, this research separately showed that people's behavioral response to urban compactness is to shift modes of commuting travel, decrease travel for shopping, and increase travel for leisure. For the positive utility approaches, this research clarified how travel benefits change according to urban form variations and by travel purpose. Urban compactness strongly increases intrinsic travel benefits for commuting and primary benefits (density, variety, quality, and uniqueness of local alternatives) for shopping and leisure. (Intrinsic travel benefits are caused by an individual's internal drivers that make the individual travel "for its own sake" while primary travel benefits are located in the travel destination and the travel is "derived" for reaching the destination.) Then, people increase non-automobile commuting mainly because of the intrinsic benefits; they save shopping trips because their shopping needs can be satisfied by a smaller number of trips; and they increase leisure trips for more leisure benefits.

For planning practitioners, this research presented that urban compactness strategies work better when their purpose is to alter shopping and leisure travel rather than commuting that are spatially and temporally inflexible, that is, insensitive to urban form variations. In comparison, shopping and leisure travel is strongly affected by primary travel benefits: Shopping trips are reduced and leisure trips increase. Thus, for public health planners who attempt to encourage people's active walking and for transportation planners who plan to encourage non-automobile travel, an effective strategy is to locate more, diverse, quality, and unique leisure and shopping venues in residential neighborhoods; it would serve their respective purposes. By comparison, non-automobile commuting increases particularly when intrinsic benefits are increased. Thus, the planners should consider improving convenience, comfort, and safety of non-automobile travel and publicizing its environmental friendliness.

CHAPTER 1.

INTRODUCTION

Urban sprawl has forced people to rely on the automobile for travel. Automobile-centered travel subsequently brought about problems such as air pollution (Frank, Stone, and Bachman 2000) and obesity (Ewing et al. 2003, Lopez 2004, Plantinga and Bernell 2007, Frank, Saelens, et al. 2007). To address these problems, researchers have argued for urban compactness (Neuman 2005), defined by urban form components such as higher density, land use mix, connectivity of road networks, and availability of public transit, because they expected that urban compactness discourages automobile travel while encouraging travel by public transit and nonmotorized modes (e.g., walking and biking), as would be done in neo-traditional neighborhoods (Duany and Plater-Zyberk 1991, Frank and Engelke 2000, Neuman 2005).

However, empirical studies delivered mixed results concerning the effect of urban compactness (Crane 2000, Hall 2001). Subsequently, some researchers (Garcia and Riera 2003, Hall 2001, Jenks and Burgess 2000) argued that urban compactness is ineffective in changing travel behavior. In contrast, others (Holden and Norland 2005, Næss 2005) highlighted the majority of the significant study outcomes on the urban compactness–travel relationship. The debate on the mixed results led to systematic reviews of the empirical studies' results. Whether based on qualitative synthesis of the study conclusions (e.g., Badoe and Miller 2000, Cao, Mokhtarian, and Handy 2009, Handy 2005b, Saelens, Sallis, and Frank 2003) or on quantitative synthesis of the statistical summaries (e.g., Ewing and Cervero 2001, 2010, Leck 2006), review studies consistently suggested that the effect of urban compactness is modest or moderate at best.

Neither the empirical studies nor their reviews are sufficient for such a definitive conclusion inasmuch as these studies did not explain how urban compactness affects travel behavior. Planning studies typically explained travel behavior using microeconomic utility theory. This theory postulates that people are forced to travel because activity locations, the source of the utility, are dispersed across space, and accordingly assumes that the reason for travel is fixed and that travel demand is “derived” from participating in activities (Small 1992), that is, for reaching destinations. From this perspective, travel itself only invokes disutility or costs, so it should be minimized. Then, they argued that urban compactness reduces the unit distance between trip origin and destination (i.e., trip length) (Zhang 2004), which subsequently reduces overall automobile travel (Ewing 1995), in the sense that people attempt to minimize cost consumption.

However, considering that travel is just a means to reach activity locations, microeconomic utility theory is insufficient for explaining people’s overall travel behavior. Indeed, people do not always use the shortest route to travel destinations. A survey of about 1,900 residents in the San Francisco Bay Area (Mokhtarian and Salomon 2001, Redmond and Mokhtarian 2001) found that only 3% of the respondents wanted a teleporter (a mode in which travel takes 0–2 minutes) for commuting, and on average, they regarded 16 minutes as an ideal one-way commuting time. Likewise, based on data from 201 visitors to an Alaska pink salmon fishery, Larson and Lew (2005) reported that 64% of the sample experienced positive utility (i.e., benefits) from travel to the fishery (mean value of the travel = 1.64 U.S. dollars/hour), aside from benefits at the destination. Furthermore, people do not always use a travel mode that minimizes trip length. Some people use the automobile even in the case that public transit provides shorter and cheaper travel (Mokhtarian and Salomon 2001). Others deliberately choose nonmotorized modes even when the automobile obviously minimizes trip length (Ory and Mokhtarian 2005). Travelers optimize for more than just reaching destinations (Van Exel, de Graaf, and Rietveld 2011).

At this juncture, the question of this dissertation research emerges as follows:

> How does urban compactness affect the utility of travel in relation to travel behavior, represented by trip frequencies, according to travel modes and purposes?

To answer the question, this research analyzes urban compactness, travel utility, and trip frequencies in Seoul, Korea, using data from geographic information systems (GIS), a psychometric survey, and a one-week trip diary, respectively.[1] For statistical testing of the relationship among the three concepts, this research employs structural

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[1] Regarding the current term "travel utility," this research investigates people's internal driver according to which they choose a specific mode for travel. Some may refer to it as "travel demand," but it does not fully represent the driver focused on in this research. While the demand is accompanied by willingness to pay, this research investigates auxiliary activities that people conduct while traveling (e.g., reading a newspaper and listening to music). The activities are synergistic in that they positively affect the choice of a particular travel mode, but people are not willing to pay for the auxiliary activities, as can be done otherwise. Then, others may name the driver "activity utility." However, the utility results not only from the auxiliary activities, but also on the quality of travel (e.g., getting fresh air and feeling speed). Thus, as conventionally labeled in the literature, the driver is called the utility of travel or travel utility.

equation modeling (SEM), whereby the utility can be specified as an intermediary between urban compactness and trip frequencies.

The main argument associated with the above question is: "The effects of urban compactness on travel utility and behavior are duly explained by changes in the utility that differ by the mode and purpose of travel," that is, urban compactness indirectly affects travel behavior by affecting travel benefits (utility) and costs (disutility) and the degree of the changes differ by the mode and purpose. Actually, the utility theory of derived travel demand "has been applied almost exclusively to automobile travel" (Handy et al. 2002, p. 71), particularly automobile commuting (Badoe and Miller 2000, Forsyth et al. 2007, Saelens, Sallis, and Frank 2003), so reviews of empirical studies may have reached a conclusion without due consideration of the possibility that the effect of urban compactness would differ according to travel modes and purposes.[2]

Regarding travel modes, although the reviews found that the effect is modest and trip length is reduced by only a small degree, the degree would act more strongly on nonmotorized travel because pedestrians and bicyclists are more sensitive to the same degree of the trip length reduction (e.g., one mile). With regard to travel purposes, most studies evaluated commuting, but urban compactness may be more strongly associated with other purposes of travel such as shopping and leisure because compared to commuting, which generally occurs at a specific time of the day and to the same workplace, shopping and leisure travel is temporally and spatially more flexible, so

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[2] In this view, the conclusion of the reviews—"urban compactness affects travel behavior only modestly"—may be attributed to their samples (i.e., the empirical studies) that were inclined to automobile commuting.

shopping and leisure travelers can benefit more from urban compactness.[3] Indeed, several exploratory studies suspected that travel for shopping (Handy and Clifton 2001) and leisure (Holden and Norland 2005, Næss 2005) may occur, at least to some extent, for its own sake (i.e., travel as intrinsic, not derived). McFadden (1974), a pioneer of the utility theory of derived travel demand, also acknowledged that travel behavior would be differentiated according to what people do at travel destinations (e.g., work, shopping, and leisure). On this ground, through empirical analysis, this dissertation research attempts to show that urban compactness changes travel utility (i.e., costs and benefits) differently according to travel modes and purposes.

More broadly, this dissertation research seeks to provide a template for explaining the effects that urban compactness has on travel behavior. To this purpose, this research will

(1) base the development of the template on the utility theory of derived travel demand,

(2) integrate two recent additions to the theory, each of which discusses both the increases (as well as the decreases) in travel costs as a result of urban compactness and the benefit side of travel utility: activity-based utility theory of derived travel demand (e.g., Maat, van Wee, and Stead 2005) and approaches to

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[3] An increasing number of studies employ the microeconomic utility theory to explain non-commuting or non-automobile travel (e.g., Boarnet and Crane 2001, Boarnet and Sarmiento 1998, Greenwald and Boarnet 2001, Handy and Clifton 2001). However, those that compare different travel modes and purposes in a single study are few.

positive utility of travel (e.g., Mokhtarian and Salomon 2001, Ory and Mokhtarian 2005), and

(3) advance the theory by examining urban compactness effects according to travel modes and purposes.

Based on the derived travel demand theory, the activity-based utility theory explains utility maximization in one's overall travel pattern (rather than in a single trip) by considering utility decreases according to compactness (or congestion) and slower trips, in addition to utility increases led by compactness and shorter trips. According to the positive utility approaches, three types of travel utility are considered: first, primary benefits by activities at travel destination (e.g., working, shopping, enjoying leisure), as advanced by derived travel demand theory, second, synergistic benefits by auxiliary activities associated with travel to the destinations, and third, intrinsic benefits afforded by travel for its own sake (or people's intrinsic desire for travel).

By explicitly analyzing the effects of urban compactness on variations in individual utility components (i.e., trip time, primary benefits, and secondary benefits), this research will show that the effects are more complex than previously reported, in the sense that by urban compactness, (1) trip time variations are often disagreed with those in trip length, a more popular measure due to its convenience for measurement, and (2) benefit variations are also controlled by different modes and purposes of travel that are in a competitive or complementary relationship.

For planners, this research will propose effective urban compactness strategies according to travel purposes, and specifically present that the most notable effect of the strategies lie in increases in non-automobile non-commuting travel (e.g., walking and biking for leisure), as opposed to decreases in automobile commuting, the topic that earlier studies were concerned with.

CHAPTER 2.

LITERATURE REVIEW

Research on the effect of urban compactness on travel behavior has a long history. The first book on this topic, *Urban Traffic: A Function of Land Use*, was published in 1954 (Mitchell and Rapkin 1954), and the first academic paper soon after (e.g., Levinson and Wynn 1963).[4] As the most influential model for transportation planners (Handy et al. 2002), the discrete travel choice model was proposed about 10 years later (Domencich and Macfadden 1975). This model was initially developed to predict future automobile travel demand in an area for the purpose of building new roads in line with the demand (Handy 2005a). Thus, not until the mid-1980s during which physical, financial, and environmental conditions began to limit road expansions (Nivola 1998) was the model widely examined because before then, planners did not feel a strong need to intervene in urban form to affect travel behavior (Handy et al. 2002). In this section, this dissertation research summarizes two major models of the microeconomic utility theory that planning studies have favored: the econometric trip-making model and discrete travel choice model. Then, it discusses issues of the models and recent additions to the theory that were proposed to address the issues.[5]

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[4] Levinson and Wynn (1963) reported that high population density in the neighborhood is significantly related to fewer automobile trips. Mitchell and Rapkin (1954) argued that the amount and nature of movement is derived from the amount and nature of activities; in this sense, they provided a ground for the development of the microeconomic utility theory that regards travel as a derived demand.

[5] In addition to transportation studies, those in behavioral medicine have shown a concern for how urban compactness affects travel behavior or regular physical activities (e.g., walking and biking). They typically

2.1 Overview of the Utility Theory of Derived Travel Demand

The utility theory of derived travel demand assumes that people embark on travel because their activity locations are dispersed across space. Specifically, researchers have used two economic models to explain travel behavior: (1) the econometric trip-making model and (2) the discrete travel choice model. The first model is usually employed to predict continuous variables such as number of trips and miles of travel, and the second dichotomous selection such as travel mode and destination (Handy 2005a, Khattak and Rodriguez 2005). Urban compactness variables tended to be more explicitly specified in the first model (Handy et al. 2002) as is shown below.

2.1.1 Econometric Trip-Making Model

In the econometric trip-making model, travel behavior is defined as a function of travel costs (or the price of travel), the income of the traveler (with the unit of analysis ranging from household and individual income to aggregate income for the entire city and metropolitan area), other sociodemographic characteristics of the traveler, and the characteristics of the urban form. Although there are some deviations,[6] in general, the

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employed behavioral theories including the Theory of Planned Behavior, social cognitive theory, and ecological models. These theories are not reviewed in this section, however, in the sense that they are interested in how people perceive urban form (Handy 2005a, McGinn et al. 2007). The medical studies accordingly measure perceived urban form, using a self-report survey (McCormack et al. 2004, Sallis et al. 1997). In contrast, interested in how to intervene in urban form, the planning studies evaluate urban form objectively, based on quantitative data (e.g., census and GIS data), large-scale maps, and field work (Handy 2005a, Handy et al. 2002, Hoehner et al. 2005, McGinn et al. 2007). Empirical studies (Ball et al. 2008, Boehmer et al. 2006, McCormack et al. 2004, McGinn et al. 2007) have found that perceived urban form is not in agreement with objective urban form.

[6] For example, Kitamura et al. (1997) included in the equation squared income (I^2) in addition to income (I) to consider that richer people may value trip time more highly and attempt to reduce it more strongly. (As to be discussed below, trip time is typically used to stand for overall travel costs.)

model is expressed as follows (Boarnet and Crane 2001, Boarnet and Sarmiento 1998, Crane 1996, Greenwald and Boarnet 2001, Handy 2005a, Handy et al. 2002, Handy and Clifton 2001, Ortúzar and Willumsen 1994).

$$T = f(c, I, S, U) \qquad \textbf{Equation 1}$$

where

T = number of trips or miles traveled by a traveler in total or in a particular mode

c = travel costs (e.g., trip time)

I = income of the traveler

S = sociodemographic characteristics of the traveler

U = characteristics of the urban form

Equation 1 is often reduced to specify the relationship between urban form and travel costs (Boarnet and Crane 2001, Boarnet and Sarmiento 1998, Crane 1996, Greenwald and Boarnet 2001). In Equation 2, the upper part of the reduced form shows the assumption that differences in urban form alter travel costs (Boarnet and Crane 2001, Boarnet and Sarmiento 1998). Using the lower part of the reduced form, one does not have to specify travel costs in the analytical model. As such, this becomes what planning studies have used for empirical analysis although many of them did not explicitly describe their theoretical framework (Handy 2005a).

$$c = f(U)$$

and

$$T = f(U, I, S) \quad \textbf{Equation 2}$$

Then, how does urban compactness affect travel costs? It reduces the physical distance between trip origin and destination (Zhang 2004), trip length, and finally trip time (also called trip duration). Accordingly, (although the microeconomic utility theory, including this model, is associated with only one trip), overall automobile travel would also decrease (Ewing 1995) or the level of the physical distance may decrease enough for walking, biking, and walking to public transit instead of driving the automobile (Maat, van Wee, and Stead 2005, Zhang 2004, 2006).

2.1.1.1 Travel Time Budget Theory

Conventionally, the microeconomic utility theory—both of this model and the discrete travel choice model to be discussed below—uses trip time to represent travel costs (Boarnet and Crane 2001, Handy et al. 2002). Especially when a study is conducted in a single city, trip time has been used without regard to which travel mode or purpose is studied, in the sense that no critical variations in fuel price (i.e., monetary cost) may exist within the city.[7]

[7] For example, Greenwald and Boarnet (2001) and Handy and Clifton (2001) used trip time to analyze walking travel, and Boarnet and Crane (2001) and Boarnet and Sarmiento (1996) used it for the relationship between urban compactness and non-work automobile travel.

Regarding trip time, the microeconomic utility theory assumes that people assign the number of trips or miles traveled to each travel mode to maximize the utility, considering their travel time budget or the maximum disposable time (Boarnet and Crane 2001, Crane 1996). The travel time budget theory is expressed as follows.

$$y = x + \mathbf{a}\mathbf{t}_a + \mathbf{p}\mathbf{t}_p + \mathbf{n}\mathbf{t}_n \qquad \textbf{Equation 3}$$

where

a, **p**, **n** = a vector of the number of trips or miles traveled by automobile (a), public transit (p), and nonmotorized modes (n) for each purpose

x = a composite of the time spent on other activities

$\mathbf{t}_i$ = the respective vector of time spent by each mode ($i = a, p, n$)

y = total available time

Then, why do travel costs have to be represented by trip time, not trip length? In practice, travelers care for the time rather than the length (Maat, van Wee, and Stead 2005). Besides, according to the travel time budget theory, the length cannot represent a budget. For example, people can travel more than 10 miles a day, but they are equally given 24 hours. Thus, between the two, the time has a limitation, and it is a budget. In support of this assumption, González (1997) found through a review of literature that the time is among the most important factors in showing that travelers have limited resources for travel.

2.1.2 Discrete Travel Choice Model

The choice of travel modes is discrete, not continuous, so to predict mode choice—the focus was mostly between automobile and public transit and sometimes among single occupancy vehicle, high occupancy vehicle, and public transit (Handy 2005a)—researchers need a discrete choice model. In relation to travel behavior, such a discrete travel choice model was pioneered by Domenich and McFadden (1975) and articulated by Ben-Akiva and Lerman (1985) and Train (1986), among others. Based on the utility-maximizing framework in microeconomics, this model assumes that each choice brings a certain utility to the traveler. The utility of each choice is determined by the characteristics of the choice, those of the traveler (e.g., sociodemographics), and the relative importance of the characteristics that the choice and traveler have. As in Equation 4, this model estimates the probability of a choice in terms of the utility of the choice relative to that of all choices in the choice set. In the equation, urban compactness is merely considered along with other characteristics of the choice that differentiate the utility.

$$P_k = e^{U_k} / \sum e^{U_k}$$

and

$$U_k = f(c_k, s, \alpha) \qquad \textbf{Equation 4}$$

where

P_k = probability that a traveler will choose alternative k (e.g., travel mode or destination)

U_k = utility of alternative k for the traveler

c_k = characteristics of alternative k for the traveler (e.g., urban compactness)

s = characteristics of the traveler (e.g., sociodemographics)

α = coefficients for the characteristics of the alternatives and traveler, indicating their relative importance

2.2 Issues of the Utility Theory of Derived Travel Demand

Notwithstanding their systematic ways of examining travel behavior, the two derived travel demand models have been critically reviewed. As constructed to predict gross demand for automobile travel in a given area (Badoe and Miller 2000, Boarnet and Crane 2001, Meurs and van Wee 2004, Saelens, Sallis, and Frank 2003, Zegras 2004), on the one hand, the models were fairly precise in predicting the travel demand of the area (Handy 2005a), but on the other hand, they were not effective in explaining the dynamics of travel behavior that exists among different people in the area (Handy et al. 2002, Mokhtarian and Cao 2008). Below, this research details issues that the derived travel demand theory faces and recent approaches that were developed to address the issues.

2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel

The most notable issue of the derived travel demand theory originates from the assumption that the utility or benefits of travel are only derived for accessing activity locations or travel destinations. From this perspective, travel to the destinations only produces costs, so it should be minimized (Handy et al. 2002). In practice, however, people sometimes travel for its own sake. At times, they use a longer route to destinations, called excess travel (Salomon and Mokhtarian 1998),[8] even though they are duly informed of a shorter one. Thus, the econometric trip-making model cannot always be supported (Ory and Mokhtarian 2005). At other times, they use the automobile although public transit is a cheaper and faster travel mode (Mokhtarian and Salomon 2001). In this vein, the discrete travel choice model does not fit, either. In fact, as early as 1982, Hupkes, known for his work on the fixed travel time budget theory, argued that travel utility is separated into derived and intrinsic types (Hupkes 1982, p. 41).

> “To my thinking [looking at man as utility-optimizing being] is only partly true. Man is mobile. He cannot easily stay indoors all day long. He wants to ‘exercise his legs’, ‘get a breath of fresh air’ and feels satisfaction in the mere act of moving, in taking his body and mind from one place to another. … This quality of travel can be called intrinsic utility.”

According to Hupkes (1982), both types of utility (i.e., derived and intrinsic utility) are positive with travel time at the beginning through a certain level, and then become negative beyond the level, which is set for each type: for derived utility, after benefits from a more distant activity location are less than travel costs to the location and for intrinsic utility, as boredom, monotony, fatigue, and satiation increase.

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[8] The term “excess travel” was coined during the urban compactness debate in the 1980s (Giuliano and Small 1993, Hamilton 1982, 1989, Small and Song 1992, White 1988). During the debate, excess travel, often referred to as “wasteful commuting,” was understood mainly in relation to jobs–housing mismatch.

Hupkes (1982) suspected that people may travel more often for derived utility than for intrinsic utility. In contrast, Marchetti argued that intrinsic utility is more important in explaining overall travel behavior (1994, p. 75).

> "Personal travel appears to be much more under the control of basic instincts than of economic drives. This may be the reason for the systematic mismatch between the results of cost benefit analysis and the actual behavior of travelers. … [M]an is a territorial animal [and] the *basic instinct* of a territorial animal is to *expand its territory*. [I]t shows the *quintessential unity of traveling instincts around the world*".

In the late 1990s, intrinsic utility has been articulated by Salomon and Mokhtarian (1998). They reviewed the literature—not only in transportation, but also in the fields of sports science, psychology, and medicine—and presented various hypotheses about why people do not minimize their travel (i.e., excess travel). Among other reasons, they identified some types of travel that occurs owing to people's intrinsic desire. In later theoretical studies (Mokhtarian and Salomon 2001, Ory and Mokhtarian 2005), they further explored intrinsic aspects of travel, that is, positive utility or secondary benefits of travel—on the basis of the assumption that primary travel benefits are reaching travel destinations—as would be produced during travel to the destinations and for its own sake. If so, travel is not only a byproduct of the activity at the destinations, but also it constitutes an activity per se. As such, people are expected to choose a destination at which the sum of primary and secondary benefits after travel costs are subtracted is the highest. According to Mokhtarian and Salomon (2001), benefits obtained from travel behavior are classified as follows.

- Primary travel benefit: utility at the final destination of travel, that is, utility led by activities at the destination
- Secondary travel benefits on the way to the destination: utility by activities (including anti-activity) while traveling and at stopovers
- Secondary travel benefits produced by traveling for its own sake: utility based on people's intrinsic travel desire

Benefits from activities on the route to travel destinations—also called synergy benefits—provides additional benefits, but probably people would forego the travel if they should or could. These types of secondary benefits consist of anti-activity and external activities.

- Anti-activity: relaxation, taking a rest/nap, clearing the head, and thinking
- External activities: While traveling, people can conduct auxiliary activities such as phone calls, internet browsing, online/offline shopping, talking with family/friends/colleagues/strangers, reading books/newspapers/magazines, listening to music/radio, and watching television/videos. Also, at stopovers, people can run errands at stores and leave/collect children at school.

The third type of travel benefits are brought about by people's intrinsic desire for travel. They include the sense of the following emotions.

- Adventure-seeking: Also called novelty-seeking, this is a mind of "getting there is half the fun" and "traveling just for the fun of it." It represents overall benefits based on the intrinsic travel desire.

- Variety-seeking: Owing to a desire of changing from usual routines, one would explore different routes or different destinations although such a change invokes additional travel costs or primary benefits at the new destinations are not higher than before.
- Buffer: It refers to the sense of transition between activities. From home to office, for example, one can get ready to work.
- Scenic beauty or other amenities (e.g., a pleasant view)
- Movement through and exposure to the environment: This sense is caused by a desire to escape from cabin fever, to experience the outdoors, to get fresh air, and to bask in the sun.
- Control over the travel as desired
- Independence: a desire to not be dependent on others for travel and to get around on one's own
- Status or identity expression: a desire of symbolizing a certain social class or lifestyle one favors, for example, a desire to show off a means of transportation (e.g., a luxury car) as a way of expressing power and prestige
- Convenience
- Comfort
- Privacy
- Safety

In the above list, the last four items (i.e., comfort, convenience, safety, and privacy) are typically differentiated by travel mode (Mokhtarian and Salomon 2001). The others hinge primarily on people's personality and thus, when desires for these types of secondary travel benefits are at work, people might not forego the travel (Mokhtarian and Salomon 2001, Ory and Mokhtarian 2005). In this occasion, the travel constitutes part or all of the travel demand, and reaching travel destinations is rather ancillary to the travel.

Equipped with quantitative analysis, Ory and Mokhtarian (2005) augmented the above list through a more thorough literature review (see bullets below), and verified most of them using a mail survey of 1,358 residents in the San Francisco Bay Area.

- Escape: a desire of traveling just to be alone, whereby one can be temporarily relieved of obligations and routines at home and work
- Curiosity: Along with curiosity that drives the adventure-seeking and variety-seeking motives in the above list, it also refers to superfluous activities without explicit purpose (e.g., happening to explore other passengers or gather information for a later use).
- Conquest: This motive encourages traveling sportily (e.g., auto racing), lengthy biking, and exploration of an unfamiliar environment, and it is a detailed version of the control and independence motives and an extreme version of the curiosity motive in the above list. Regarding daily travel, it refers to the conquest of introversion and inertia, and it is accordingly related to the mental therapy motive to be shown below.
- Physical exercise: This motive is for improving health and fitness and it mainly leads to using nonmotorized modes over the automobile, parking intentionally farther from the destination, and making trips although not necessary.
- Mental therapy: as associated with the physical exercise and conquest motives, a desire for soothing or stimulative quality of travel

Notably, the above list indicates that secondary travel benefits are not mutually exclusive. Another example is that anti-activity such as relaxation and thinking is beneficial for the sense of escape and mental therapy (Ory and Mokhtarian 2005). Also, convenience to go or stop anywhere is related not only to the convenience of the travel mode, but also to the independence motive. Structural Equation Modeling (SEM), the main analytical technique for this research, allows these multiple relationships.

Other studies made a contribution by categorizing or grouping intrinsic travel benefits and by evaluating the magnitude of each benefit. Using a Bayesian model of mental maps and simulation analysis, Arentze and Timmermans (2005) found that the variety- and novelty-seeking motives are associated with "expected information gain," which refers to a desire to update knowledge (to reduce uncertainty), to make better-informed decisions at later times, and to evaluate the extent to which the choice of an alternative can satisfy the variety- and novelty-seeking motives and curiosity.

Based on Dittmar's model on the meaning of material possessions, Steg et al. (2001) classified intrinsic travel benefits into three categories as follows.

- Symbolic: This category includes self-expression, prestige, and power.
- Instrumental: benefits that differ among travel modes according to their mechanical characteristics (Mokhtarian and Salomon 2001) such as convenience, comfort, privacy, and safety
- Affective: It encompasses all other emotions evoked by travel.

Then, using two surveys conducted in the Netherlands (185 driver's license holders in Groningen and Rotterdam and 113 commuters to Rotterdam), Steg (2005) found that automobile commuting is strongly related to the symbolic and affective motives, not the instrumental motives. The same result was reported in another study (Gardner and Abraham 2007) although it treated the three categories of intrinsic travel benefits jointly, not separately: The study used semi-structured interviews with 19 automobile commuters who were employed at four different organizations in central Brighton and Hove, the U.K., and found that automobile commuting is associated with the symbolic and affective motives more strongly than the instrumental motives. In contrast, using two separate U.K. data—one from a work trip survey that sampled 286 residents in Surrey and the other from a leisure trip survey of 666 visitors to national heritage sites near Manchester—Anable and Gatersleben (2005) reached a different conclusion that between the instrumental and affective motives, the instrumental motives are more important for work travel and they are similar in magnitude for leisure travel.

One may note that most of the above-stated intrinsic travel benefits are exclusively available or biased to automobile travel. The benefits expected more from nonmotorized travel have been added recently. Through a survey of 1,708 commuters between Stockholm and Uppsala, Sweden, Johansson et al. (2006) expanded the list by including environmental concerns. (Other benefits they confirmed are convenience, comfort, safety, and flexibility). Using *Q*-methodology—also called by-person factor analysis because *Q* correlates persons instead of variables—Van Exel et al. (2011) grouped 39 survey items into four categories of intrinsic travel benefits: instrumental and reasoned (convenience, comfort, and safety as well as the synergy motive), symbolic and affective, control, and norms. That is, they identified the sense of meeting social norms as another category that is expected from nonmotorized travel.

- Normative: environmental concerns and social norms ("I do what my significant others expect me to do")

Social norms are usually transformed to personal norms (i.e., internalized) to affect travel behavior (Kallgren, Reno, and Cialdini 2000, Parker, Manstead, and Stradling 1995, Wiidegren 1998). While social norms refer to significant others' expectations about an individual's behavior, personal norms are defined as the individual's cognitive beliefs on the behavior: depending on whether it is performed, he or she comes to feel self-esteem or guilty.

Grounded on the current list of secondary travel benefits—on-the-way or synergy benefits (i.e., benefits from anti-activity/activities during the travel and at stopovers) and four categories of intrinsic benefits (i.e., the symbolic, instrumental, affective, and normative motives)—this dissertation research refines, confirms, and quantifies the benefits, using semi-structured interviews and a structured survey. Then, as with previous studies stated above, psychometrics is employed to load the quantified benefits onto the categories or factors.

2.2.2 Trip Length Reduction versus Congestion Increase: Effects on Trip Time

The utility theory of derived travel demand assumes that urban compactness lessens automobile travel by reducing the physical distance between trip origin and destination, which subsequently reduces trip length and trip time (as a representative of travel costs). However, urban compactness also increases congestion and reduces trip speed. Thus, inasmuch as the time cost of a trip consists of trip length and trip speed [i.e., trip time = f(trip length, trip speed)] (Boarnet and Crane 2001, Greenwald and Boarnet 2001), urban compactness affects the cost by increasing congestion. This effect is the opposite of that by trip length decrease because it increases, not reduces, the cost. Hence, the two opposite effects—cost decrease by trip length decrease and cost increase by trip speed decrease—complicates the ways urban compactness affects travel behavior.

2.2.2.1 Representative of Travel Costs: Trip Time

As shown in the function "trip time = f(trip length, trip speed)," trip time is a better measure of travel costs than trip length since the length merely evaluates the costs proportional to the distance. That is, increases in trip length invoke trip time increases, whereas increases in trip time by congestion do not affect trip length.

Also, because this research investigates different modes of travel together, it should particularly use trip time rather than trip length. Walk and bike are slower than the automobile, so if travel costs are evaluated by trip length, nonmotorized travel may be undervalued compared to the automobile that can achieve much more trip length in a given period in time. If people spent one hour for walking and driving, then this implies that they equally value the two modes of travel (i.e., the same amount of travel utility), but for the same one hour, they must have driven much farther. If they spent 30 minutes more for walking instead of driving—suggesting modal shift—the distance is much shorter, and their behavioral change measured by trip length is underestimated.

Lastly, as discussed in "2.1.1.1 Travel Time Budget Theory", the travel time budget theory highlights that between the two, the time has a limitation, and it represents a budget that travelers care for. In conclusion, if studies attempt to consider different modes of travel together, they may have to evaluate travel costs based on trip time. (If only one mode, especially the automobile, is under consideration, trip length may also be an appropriate measure.)

2.2.2.2 Effects of Congestion

Regarding the effect of congestion, not only its opponents, but also proponents of urban compactness regarded increases in congestion as a downside of urban compactness that should be prevented (Melia, Parkhurst, and Barton 2011). This point of view is reflected in support for mid-rise, medium-density development (Anderson, Kanaroglou, and Miller 1996, Banister 1992, Buchanan et al. 2006, Burton 2002, Holden and Norland 2005) as a preferred urban form.

Furthermore, for urban form researchers, density was not a "causal" component of urban compactness. They attributed the effect of density to other components such as land use mix, connectivity of road networks, and availability of public transit. That is, if population density is high, diverse land uses, well-connected road networks, and many transit stations are shown in a neighborhood (Ewing and Cervero 2001). When all the components are specified as explanatory variables in empirical analysis, the correlation is called spatial multicollinearity (Gim 2013). Because of this density-centered spatial multicollinearity, density was often used to refer to urban compactness (Burton 2002, Hall 2001). From a practical perspective, because density is relatively easy to measure and control (Forsyth et al. 2007), government-initiated surveys commonly included density data (Ewing, Pendall, and Chen 2003, Forsyth et al. 2007), and previous studies used density as a substitute for other less measurable components (Zhang 2004, Rajamani et al. 2003). Nonetheless, virtually all reviews of the literature on urban compactness reported that the effect of density is considerably smaller than the effects of other components (Ewing and Cervero 2001, 2010) or that if a research model considered other urban compactness components, the density effect tended to become weaker (Badoe and

Miller 2000, Ewing and Cervero 2001, Handy 2005b). Consequently, they argued that density serves only as a "proxy" (Handy 2005a) or "intermediate" (Ewing and Cervero 2010) for other, more causal components (Cao, Mokhtarian, and Handy 2009). However, although density may have little to do with trip length decrease, it does reduce trip speed through congestion.

Congestion by density may not be an explicit goal among urban compactness proponents (Meurs and van Wee 2004), but its effect is at work. In fact, the effect has been reported by studies that were more particularly concerned with the density–travel relationship or "intensification" strategies (e.g., Brownstone and Golob 2009, Gordon 1997). Using the California subsample of the 2001 NHTS (U.S. National Household Travel Survey), Brownstone and Golob (2009) found that if all other conditions are identical, households located in areas with 40% more housing units/mile^2 (= 1,000 housing units) travel just 4.8% fewer miles a year (= 1,200 miles). Similar results are shown in other studies. Gordon (2008) reported that a doubling of densities is related only to a 7% VMT (vehicle miles traveled) reduction in the U.K. Cambridge Systematics (2009) also estimated that an area of 7,000 persons/mile^2 density has just 15% less per capita driving than that of 3,000 persons/mile^2 density. Accordingly, through a review of such studies, Melia et al. (2011) argued that an increase in population density tends to reduce automobile travel, but the density–automobile travel relationship is less than proportional ("doubling population density does not halve the total distance or frequency of automobile trips")—and consequently, density increases worsen congestion. Named the paradox of intensification, their argument is summarized as follows (Melia, Parkhurst, and Barton 2011, p. 49).

> “Ceteris paribus, urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs.”

Firstly, however, studies focusing exclusively on the density (or intensification) did not explain how density reduces automobile travel per se. Without the explanation, one could suspect that contrary to their argument, increases in congestion make automobile travel unfavorable and people turn to alternative modes such as public transit, walk, and bike. Secondly, in an attempt to resolve the paradox of intensification, Melia et al. (2011) highlighted the ceteris paribus qualification and proposed that intensification strategies be accompanied by policy tools such as parking restrictions and car-free zones. However, as stated above, density increases do not occur independently; they are typically entailed by increases in land use mix, road connectivity, and transit availability (i.e., density-centered spatial multicollinearity), so in truly compact neighborhoods—high density accompanied by high levels of land use mix, road connectivity, and transit availability—automobile travel would be strongly substituted by alternative mode travel, as suspected by Bento et al. (2005) and Zhang (2004). Studies on intensification have also suggested that to be successful, density increases be in line with expansions of public transit (Jenks and Burgess 2000) and roadways (Cambridge Systematics 2009).

Thirdly, empirical studies on urban compactness have been substantiated for cities in the U.S. and Europe (Giles-Corti and Donovan 2002, Schwanen, Dieleman, and Dijst 2004, Sultana and Weber 2007, Vance and Hedel 2007) because the cities have experienced urban sprawl and needed to verify the effectiveness of urban compactness strategies (Nivola 1999) and because urban form data were relatively available for the cities (Handy et al. 2002, Zegras 2004, Hoehner et al. 2005). However, several studies (Schwanen, Dieleman, and Dijst 2004, Van de Coevering and Schwanen 2006) questioned geographical transferability of the findings of the U.S. and European studies to other areas such as those in Asia because Asian cities are generally denser (Huang, Lub, and Sellers 2007), so the effects of urban compactness possibly differ (Næss 2005, Zegras 2004). That is, because Asian cities may more explicitly show the effect of congestion, if urban compactness is studied in the cities, we can have fuller knowledge of how urban compactness affects travel behavior. Below, this research discusses the way that congestion affects travel behavior, using the activity-based utility theory.

2.2.3 Single Trip versus Overall Travel Behavior: Activity-Based Utility Theory of Derived Travel Demand

Because the utility theory of derived travel demand focuses on how to achieve maximum utility in a single trip, it is inherently incapable of explaining what happens after urban compactness alters travel costs, namely, trip time. In fact, people attempt to maximize their utility in consideration of their entire activity patterns (Van Acker and Witlox 2010). Thus, time savings according to urban compactness may or may not be consumed for further travel—more distant travel for higher utility or additional travel for extra utility—that increases the total utility (Maat, van Wee, and Stead 2005, Mokhtarian and Salomon 2001). If further travel occurs by the automobile, the effect of the trip time decrease will be offset.

From a similar perspective, Gordon and Richardson (1997) argued that although urban compactness reduces daily automobile travel, people would later embark on extra automobile travel because living in compact neighborhoods, they would desire to compensate for limited access to green and open space—called compensatory travel (Næss 2005)—and because they are also given extra time for the travel.[9] This possibility raises the need to examine how changes in travel utility (i.e., benefits and costs of travel) by urban compactness affect people's entire travel behavior, not just a single trip.

As opposed to trip-based economic models (i.e., the econometric trip-making model and discrete travel choice model), activity-based utility theory of derived travel demand (Maat, van Wee, and Stead 2005) considers a traveler's entire activity pattern. One of its main arguments is that time savings produced by urban compactness can be used not only for more activity time, but also for further travel that increases the utility. As such, it explicitly considers that the traveler's aim is not just to minimize travel costs, but to maximize the utility.

The activity-based utility theory assumes that if urban compactness reduces trip time to the same destination, people would retain time savings or embark on further travel depending on which option increases the utility more strongly. This theory also considers what would happen if urban compactness increases congestion and trip time.

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[9] The compensatory travel hypothesis was empirically tested by Holden and Norland (2005). They analyzed if decreases in daily automobile travel owing to urban compactness are canceled out by later automobile travel. They showed that such compensatory automobile travel does not occur, but did not explain why. As to be discussed in relation to the fourth issue of the utility theory of derived travel demand, this research will consider the possibility that the compensatory travel, if any, occurs by alternative modes instead of the automobile.

This effect is assumed to differ by travel mode. Specifically, trip time changes by urban compactness bring about behavioral changes in three ways as follows.

- More activity time: People can use time savings by doing the same activities for a longer time or other activities that do not require travel (e.g., at their residence). This leads to less travel.
- Further travel: With time savings, people can travel to a more distant activity location for a higher benefit or conduct more travel-involved activities for additional benefits once the marginal benefit of the travel outweighs its cost (i.e., trip time). These two types of responses to urban compactness cause further travel. They are often called "latent" demand because within travel time budget or limited time resources, people deliberately optimize their activities and unselect other activities (latent demand), but with more time, they could conduct those with a lower priority.
- Modal shift: Urban compactness changes the relative travel cost of each mode—not only by trip length reduction, but also by trip speed reduction according to congestion increases—and people choose the optimal mode at the given urban settings.

Regarding the second bullet point, one distinction of this theory is that unlike the microeconomic utility theory that is concerned only with the cost side (Maat, van Wee, and Stead 2005), it also considers the benefit side regarding additional activities and more distant activities (i.e., higher-quality or cheaper-price activities). In this theory, utility is defined as benefits ("positive utility" as derived from the demand to participate in activities) after travel costs ("disutility" or the price of travel) are subtracted (i.e., utility =

benefits − costs). As with the microeconomic utility theory, travel costs are represented by trip time.

In Figure 1, the horizontal axis stands for trip time as representative of travel costs and the vertical axis benefits derived from reaching activity locations (i.e., all benefits people gain from the activity). The label “net” means that the benefits come from a single activity or destination. The S-shaped utility curve is formed by the law of diminishing returns, namely, decreasing benefits of trip time increases (i.e., more distant trip).

People’s behavioral responses to urban compactness depend on whether it reduces trip length or trip speed (i.e., congestion increase). Regarding the trip length reduction, the utility graph in Figure 1 moves from the right to the left, and people’s behavioral change would be one of three: (1) less travel, (2) more distant travel, and (3) additional travel. Less travel (from point A to point B) means that people reduce trip time and conduct activities that do not require travel. More distant travel (from point A to point C) occurs for accessing, for example, cheaper and larger shops for higher utility. Thus, the net utility increases from U_1 to U_2. Additional travel occurs because with time savings, people decide to do other activities that cause travel. In this case, the time savings (= $T_1 - T_2$) are canceled out (i.e., the path of A–B–A). (As stated above, the net utility is based on a single trip. Thus, for example, if the same destination was chosen for the later additional travel, the total utility is A multiplied by 2).

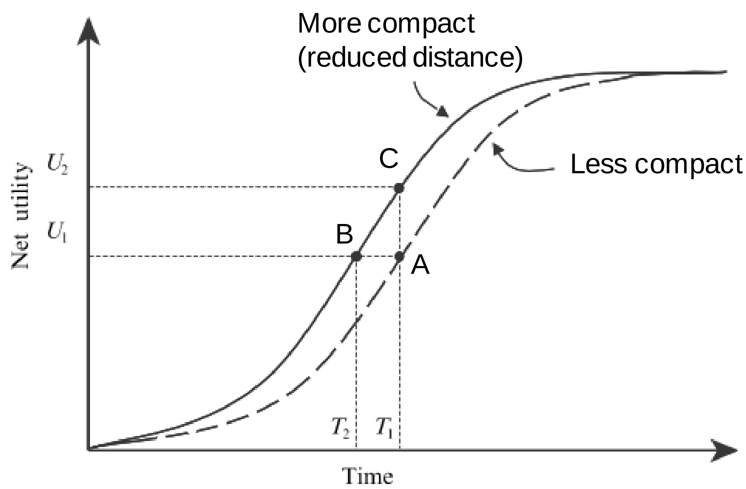

Figure 1 Urban Compactness Effects on Automobile Trip Frequency and Distance Traveled
Source: Maat et al. (2005, p. 39)

Figure 1 separates peoples' behavioral responses to lessened trip time into further activities that do and do not require travel, but it does not explain, of the two types of the activities, what is likely to occur. This research suspects that in practice, the two take place "together", that is, time savings would not be used wholly for either type of activities. In a similar vein, Marchetti (1994) argued that not only is "man … a territorial animal … whose … *basic instinct* … is *to expand its territory*" (p. 75), that is, to travel, but also "*man has a cave instinct*" (p. 75) and would like to "[*spend*] *much of his time in his cave*" (p. 80), "in [the] beloved cave, with family, cultural, and status symbols in place" (p. 82).

Figure 2 shows a change in an indifference curve that assumes two goods (here, activities that do and do not require travel). The curve is convex to the origin, which denotes the fact that the marginal rate of substitution (MRS) is decreasing. (Strictly speaking, it differs from the above-noted law of diminishing return.) The shape of the convex depends on the "personality" of a traveler and the slope of the budget line stands for relative "prices" of two goods as determined in the market, that is, the neighborhood in this study. Typically, the two goods are assumed for the simplification of people's choices (e.g., apple and orange), but in this research, all activities are categorized into ones that require travel and the others that do not require travel. Thus, the indifference curve shown in the figure is rather a generalization of the choices.

Under the current budget condition (dotted line B_1), people choose point M_1, not M_1', because it is the utility-maximizing point; utility increases as the curve moves outward from the origin, that is, $U_1 > U_1'$. At this point, people's activities that do and do not require travel amount to T_1 and N_1, respectively. Urban compactness reduces trip time, that is, travel-required activities become cheaper. Subsequently, the slope of the budget line becomes shallower (i.e., change from B_1 to B_2). This change indicates extra time for further activities. Then, the utility-maximizing point is likely to move from M_1 to M_2 rather than to M_2' (see the A–B movement in Figure 1, meaning that the extra time is used solely for activities that do not require travel) and to M_2'' (in Figure 1, A–C and A–B–A, suggesting that the extra time is used only for travel-required activities) because both of M_2' and M_2'' produce less utility than M_2. Consequently, time savings due to shorter trip lengths in compact neighborhoods would increase both travel-required activities (change from T_1 to T_2) and those with no travel required (change from N_1 to N_2).

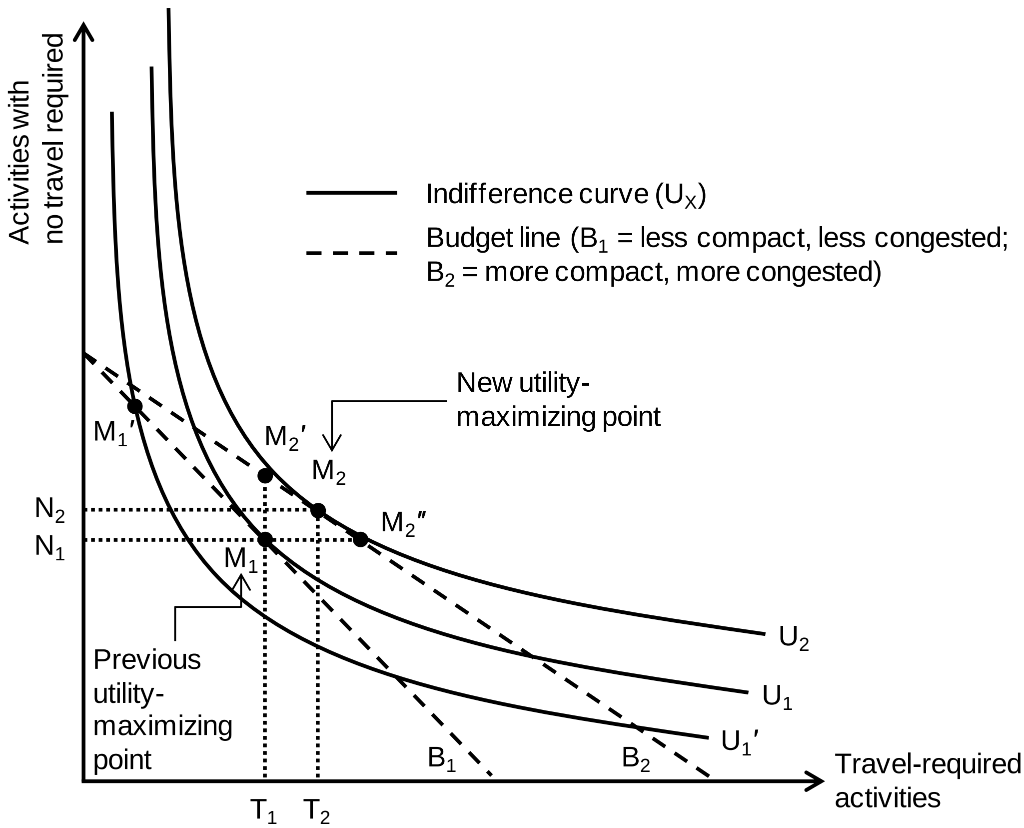

Figure 2 Urban Compactness Effects on Activities: Change in Indifference Curve

People's responses to the speed reduction are either less travel or modal shift. First, the responses would be the opposite of the trip length reduction (i.e., in Figure 1, the utility curve changes from the left toward the right, and in Figure 2, the slope of the budget line becomes steeper, that is, it changes from B_2 to B_1) because the speed reduction means increased trip time (in Figure 1) and more expensive travel-required activities (in Figure 2).

Another possible response to the trip speed reduction is modal shift. Modal shift occurs because congestion is applicable only to automobile travel. As in Figure 3, the shape of the utility curves for walking and biking differs from that for automobile travel, which is strongly S-shaped. The utility graph for walking is assumed to be linear due to both its very low initial costs and its invariable speed (which is slow but constant). At the same time, its maximum walkable time is the shortest among the three modes of travel in the figure. (The assumption that the utility graph is linear may be problematic. This theory considers travel utility only at destinations, but as stated in "2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel", pedestrians also expect positive utility, particularly from short walks. Also, although the theory assumes that the cost is a function of trip length and speed, it does not consider the law of increasing costs. For example, fatigue may increase exponentially with both of them.) Relatively, biking is faster than walking, so it obtains higher utility at a given trip time.

Overall, the graph shows which travel mode is optimal for different ranges of trip time: The maximum utility is achieved by walking between 0 and T_1 and by biking between T_1 and T_2. Because congestion and subsequent speed reduction applies to automobile travel, urban compactness moves the automobile utility curve from the left to the right. Then, the maximum utility range achieved by biking expands from T_1–T_2 to T_1–T_3. Notably, the scale of modal shift is no more than T_2–T_3. It is intuitively acceptable because urban compactness strategies are bounded at a certain urban area, and the speed reduction occurs mainly over short distances. Thus, without regard to urban compactness and congestion increases in the area, the two automobile utility curves become parallel after a certain trip length and time (T_3). In summary, this figure explains that congestion changes the probability of choosing a specific mode, and particularly, it makes nonmotorized travel more attractive.

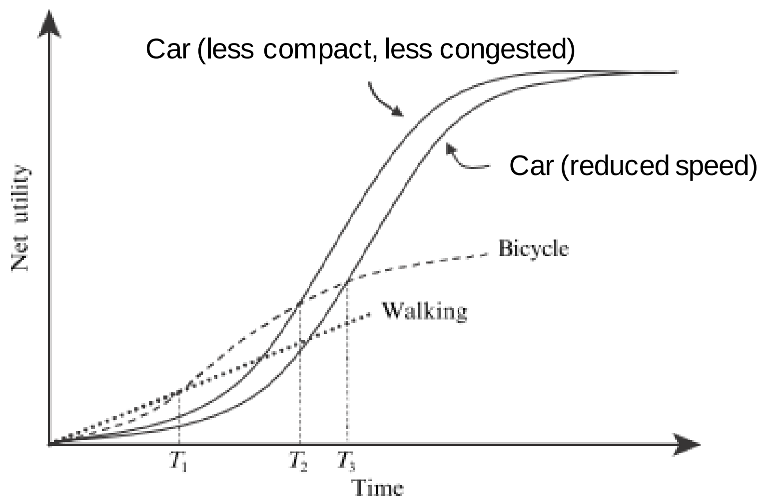

Figure 3 Urban Compactness Effects on Mode Choice
Source: Maat et al. (2005, p. 42)

As with most economic theories, this activity-based utility theory simplifies the effects of urban compactness as if trip length reduction and congestion increase (i.e., trip time reduction and increase) occur separately. However, urban compactness causes the two effects concurrently. By comparison, this research empirically examines how the two effects interact. Furthermore, while the theory assumes travel as derived and explains only cost changes, this research also considers intrinsic travel that is brought about by secondary benefits of travel. Presumably, secondary benefits would add to the probability of choosing a certain travel mode and lead to modal shift for a particular travel purpose.

As Maat et al. (2005) suspected, trip length reduction and congestion increase may affect travel behavior differently according to travel purposes. Regarding the trip length reduction, most people go to the same workplace for fixed times a week whether or not the commuting distance is reduced. Thus, when people decide to travel to more distant locations or to add travel, they will do so for shopping and leisure, but in general, they will not change to a more distant job that pays more or go to workplace more often than before.[10] Regarding the congestion increase, people would experience it more during commuting than during shopping and leisure travel because congestion usually takes place at commuting hours. Therefore, by examining travel behavior according to travel modes and purposes, this research can sufficiently explain how urban compactness affects travel utility and behavior.

2.2.4 Automobile Commuting versus Other Modes and Purposes of Travel

The fourth issue of the utility theory of derived travel demand is that the theory has been applied almost always to automobile travel (Handy 2005a, b, Handy et al. 2002), especially automobile commuting (Forsyth et al. 2007), and few investigated whether it fits well to alternative mode travel for other purposes.[11]

As several exploratory studies reported, travel for shopping (Handy and Clifton 2001) and leisure (Holden and Norland 2005, Næss 2005) may occur, at least to some degree, for its own sake. This less derived travel may be more important for nonmotorized travel than for automobile travel (Handy et al. 2002). Thus, secondary travel benefits would be larger for non-commuting, nonmotorized travel. In this vein, this research will consider different modes and purposes of travel, including automobile

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[10] In exceptional cases, if travel increases the utility per se, someone would possibly take a more distant job or add another job, which would require more travel since it increases the utility of doing so.

[11] An increasing number of studies employ the microeconomic utility theory to explain non-commuting or non-automobile travel (e.g., Boarnet and Crane 2001, Boarnet and Sarmiento 1996, Greenwald and Boarnet 2001, Handy and Clifton 2001). However, those that investigate different travel modes and purposes in a single study are few.

commuting as a reference, and examine how utility changes by urban compactness affects travel behavior differently according to the modes and purposes.

CHAPTER 3.

ARGUMENTS AND HYPOTHESES

3.1 Arguments

The question of this dissertation research is: "How does urban compactness affect the utility of travel in relation to travel behavior, represented by trip frequencies, according to travel modes and purposes?" The main argument associated with the question is: "The effects of urban compactness on travel utility and behavior are duly explained by changes in the utility that differ by the mode and purpose of travel," that is, urban compactness indirectly affects travel behavior by changing travel utility. This argument consists of three concepts: urban compactness, travel behavior (trip frequencies), and travel utility. This research derives minor arguments and hypotheses from these concepts, which are defined below.

3.1.1 Defining Urban Compactness

Urban compactness is defined as high degrees of four urban form components in a neighborhood, which is the spatial unit of this research:[12] population density, land use

[12] While urban compactness is evaluated at the neighborhood level, data on some sociodemographics (e.g., monthly income, numbers of individuals, children under school age, and private automobiles) should be obtained at the household level and those on the other sociodemographics (e.g., age, gender, driver's license, and employment type) as well as on travel utility and behavior at the individual level. Thus, technically, this research employs three types of data collection levels. It ultimately examines travel behavior at the level of the individual and its relationship with urban compactness at the neighborhood level.

mix, connectivity of road networks, and availability of public transit.[13] As standardized (i.e., divided) by the neighborhood area, these components are operationalized as follows: (1) population density refers to the number of residents, (2) land use mix refers to the areal balance among different land uses such as residential, business, commercial, and leisure uses, (3) road connectivity refers to the number of road intersections (i.e., intersection density), and (4) transit availability refers to the number of subway stations and bus stops (i.e., the density of transit depots). This research obtains from public agencies micro-scale GIS data to evaluate the four urban form components. Years represented by the data are kept consistent and close to those represented by trip data for the purpose of minimizing temporal mismatch.

Among a total of four urban compactness components, population density has been treated differently from the other three, as discussed in "2.2.2.2 Effects of Congestion". On the one hand, it does not directly reduce the physical distance between trip origin and destination, but is correlated with the other components. On the other hand, urban compactness increases congestion, which supposedly is led by increases in density, not in the other three components. Thus, inasmuch as congestion is assumed to directly

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[13] A fifth component may be urban centeredness (Handy et al. 2002): whether urban form is monocentric (e.g., Seattle and cities in Scandinavian countries) or polycentric (e.g., Los Angeles, the western part of the Netherlands, and the Flemish part of Belgium). However, this component is useful for a comparative study, that is, when a study compares urban compactness among a multiple number of cities at the regional or national scale (Handy 2005b). Based on a single case of Seoul, this research does not consider urban centeredness in defining urban compactness. Among studies that used urban centeredness, Schwanen et al. (2004) judged it from 26 metropolitan areas in the Netherlands, Bento et al. (2005) compared population centrality among 26 cities in the U.S., and Ewing et al. (2003) used the degree of centering to evaluate urban compactness of all U.S. metropolitan areas.

affect people's travel behavior, this research deems population density a "definitional" component of urban compactness.

In fact, density, land use mix, and road connectivity have been referred to as fundamental components of urban form or 3D (density, diversity, and design) (Cervero and Kockelman 1997, Ewing and Cervero 2010). In comparison, although transit availability has been used in most empirical studies to evaluate urban compactness (Ewing and Cervero 2001, 2010, Ewing, Pendall, and Chen 2003, Handy 2005a, Stone et al. 2007), strictly speaking, this is not a definitional component, but a product of urban compactness. As another taxonomy, in their literature review, Frank and Engelke (2000) defined road connectivity and transit availability as transportation system variables and the others as built environment variables.

3.1.2 Defining Travel Behavior: Trip Frequencies and Mode Shares

Travel behavior is defined by the use of travel modes according to the purposes of travel whose origin is a traveler's residence. (Consistently, urban compactness is evaluated in his or her neighborhood.) The travel modes are either the automobile or its alternatives. The alternatives consist of public transit and nonmotorized modes such as walking and biking. The mode use refers to how often people travel by each mode in a given time, mainly, trip frequency. The travel purposes are defined as one of the following: commuting, shopping, and leisure.

This research measures trip frequencies (and travel utility) through a structured survey of about 1,200 residents in Seoul, Korea with funding from the Seoul Metropolitan Government. Seoul was selected for this research because the city offers a rich array of urban compactness (including congestion) and travel mode choices. While urban form GIS datasets are relatively less available for Asian cities compared to those in the U.S. and Europe (Handy et al. 2002)—thus making studies on the urban form–travel relationship biased to U.S. and European cities (Sultana and Weber 2007, Vance and Hedel 2007)—this research has obtained the datasets for the city.

Travel behavior is firstly evaluated by trip frequency by each travel mode and for each purpose. Arguably, this can show if urban compactness changes travel behavior. A reduction in the total travel distance (e.g., vehicular miles traveled when the mode is the automobile) without changes in the frequency—as argued by several studies (Ewing 1995, Ewing and Cervero 2001, Van Diepen and Voogd 2001)—indicates that just trip lengths decrease because of decreases in the physical distance. Then, it implies that people stick to the same mode regardless of urban compactness variations (Pipkin 1995) or interventions in urban form (Beatley 2000). Thus, to test behavioral change, that is, to see if people reduced automobile travel and increased alternative mode travel—suggesting modal shifts—this research evaluates travel behavior using trip frequencies.

Meanwhile, Ewing and Cevero (2001, 2010) found in their meta-analyses that urban form affects mode shares more strongly than trip frequencies. This research suspects that their finding can be attributed to the difference in the measures of travel behavior. Although trip frequency of a travel mode increases, its mode share could decrease if the frequencies of the other modes increase more strongly (and *vice versa*). For example, the difference of one trip and two and that of 100 trips and 101 are treated equally in terms of the variation in trip frequency [Δ(trip frequency) = 1], but according to mode share, the first change is highlighted because the mode share measure is based on the original share of each mode relative to the shares of the others. For example, assume that there are only two modes, Mode A and Mode B, and a person used Mode A once and Mode B twice. In this case, the share of Mode A is 33.3% (= 1 / 3). Then, if the person now uses each mode one more time, the share of Mode A increases to 40% (= 2 / 5) although the increase in trip frequency is the same for both modes (= 1). Thus, if a particular mode was previously underused, a modest increase in its use would be remarkable in terms of mode share. Presumably, such an increase deserves to be highlighted because it may indicate that the increase is more difficult than that of a more frequently used mode. From this perspective, this research uses the mode share as a supplementary measure of travel behavior.

Notably, the trip frequency measure still holds its importance because the mode share by itself does not show whether trips actually increased in number. For instance, 10% increase in the transit share and 20% increase in the automobile share could actually because people decreased their trips by both of the modes and they reduced more trips by automobile. Thus, this research uses this “relative” measure, which is incapable of showing the “absolute” increase or decrease, as a supplement to the measure of trip frequencies.

3.1.3 Defining Travel Utility: Costs and Benefits

Travel utility, the main concept of the dissertation research, is defined by total costs (i.e., disutility) and total benefits (i.e., positive utility) that result from travel behavior (i.e., travel mode use). The costs are measured by trip time and all of primary and secondary benefits by a psychometric technique. This split measurement is because the microeconomic utility theory and activity-based utility theory as well as the travel time budget theory are concerned with the cost side, and they measure travel costs with trip time while approaches to positive utility of travel examine the benefit side using psychometric techniques. (This research discussed the rationale for the use of trip time as a representative measure of travel behavior in "2.2.2.1 Representative of Travel Costs: Trip Time".)

The benefits of travel behavior are separated into primary and secondary benefits. Primary benefits are what the utility theory of derived travel demand assumes: benefits derived from participating in activities at travel destinations (i.e., reaching the destinations). Accordingly, primary benefits are produced only at the destinations in relation to the density, variety, quality, and uniqueness of the activities.

In contrast to primary benefits, secondary benefits are produced on the way to the destinations and from travel itself (i.e., intrinsic benefits). As discussed in "2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel", the on-the-way benefits result from anti-activity and extra activities during the travel and at stopovers. The intrinsic benefits may be further classified into such categories as symbolic, instrumental, affective, and normative benefits. As with Gardner and Abraham (2007), this research treats travel benefits as a whole and uses a psychometric technique to identify the underlying categories in line with urban and transportation settings in Seoul. (For the same purpose, it conducts interviews as a pilot test to refine and confirm the categories as well as individual benefits explored in the literature.) Psychometric is a preferred means to evaluate psychological variables such as attitude, preference, intention, perception, and cognition, and secondary travel benefits (Bohte 2010) and its quality has been verified in the planning and transportation literature (e.g., Handy, Cao, and Mokhtarian 2005, Johansson, Heldt, and Johansson 2006, Kitamura, Mokhtarian, and

Laidet 1997, Sohn and Yun 2009, Van Exel, de Graaf, and Rietveld 2011). Following the convention, this research designs the survey questionnaire to include a psychometric test.

A unique feature of the survey is that the questionnaire is formatted differently from that of previous studies that used psychometric techniques to measure travel benefits (e.g., Johansson, Heldt, and Johansson 2006, Mokhtarian and Salomon 2001, Ory and Mokhtarian 2005, Steg 2005, Van Exel, de Graaf, and Rietveld 2011). Although virtually none of the studies evaluated the benefits separately by travel purpose,[14] some secondary benefits (e.g., variety-seeking and scenic beauty) would be highlighted for a certain purpose of travel (e.g., leisure travel). From this perspective, the benefits are measured by travel purpose, using psychometric items. Then, this research assigns the items into two categories, primary and secondary benefits.

3.2 Propositions

This research aims to explain the dynamics of travel utility. To this aim, it specifically applies the following utility concepts to travel behavior: the utility maximization rule, substitute goods (or competitive goods), and flexibility.

According to the utility maximization rule, people attempt to maximize travel benefits within the maximum allowable costs. When urban compactness alters travel benefits and costs, behavioral changes follow if the marginal benefits by the changes are greater than the marginal costs (Maat, van Wee, and Stead 2005).

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[14] Anable and Gatersleben (2005) utilized datasets in different formats, one from a work trip survey and the other from a leisure trip survey. Accordingly, they could not duly compare travel benefits between the two purposes of travel.

Regarding substitute goods, the automobile and its alternatives are mutual substitutes and in a competitive relationship. Urban compactness changes travel costs and benefits differently according to travel modes. Subsequently, some modes become more competitive while others become less competitive. People select the more competitive modes for travel.

Travel purposes have different spatial and time flexibility. In terms of travel destinations and departure/arrival time, some purposes of travel change more flexibly to urban compactness, whereas others change less flexibly. In fact, the role of flexibility was first investigated by Goulias and his colleagues in the late 1980s (Goulias and Kitamura 1989, Goulias, Pendyala, and Kitamura 1990). They developed a typology of compulsory and discretionary trips.[15] The typology was based on a two-class typology of activities: mandatory activities (e.g., work and school) and discretionary activities (e.g., shopping and leisure). That is, the flexibility of the activities was suspected as a major reason for that of the trips (Goulias and Kitamura 1989, p. 60).

> "It is assumed that certain trips are compulsory while others are discretionary, depending on the types of activities for which they are made. [W]ork and school trips are assumed to be compulsory, and personal business, shopping, and social trips are considered to be discretionary. …

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[15] In the current literature, compulsory trips are often referred to as mandatory trips and likewise, discretionary trips are interchangeable with non-mandatory trips (because the trips are not or less mandatory) in meaning.

[U]nlike compulsory trips, a large degree of flexibility is often associated with the … timing, and destination locations of these (discretionary) trips."

3.3 Hypotheses

The three propositions based on the dynamics of travel utility drive testable arguments or hypotheses. The hypotheses are associated with changes in travel costs or benefits. Among a total of six hypotheses, the first two describe how urban compactness changes travel costs by travel mode. They provide a ground for the next four hypotheses that involve not only the costs of travel, but also its benefits as well as not only travel modes, but also travel purposes. After specifying the six hypotheses, this research combines them to indicate which modes and purposes of travel would be the most strongly affected by urban compactness. The hypotheses are summarized in Table 1 and Figure 5.

- H1a: (While compact urban form reduces the distance between trip origin and destination and reduces "trip length," this trip length reduction is meaningful particularly for travelers using alternative modes, and thus) urban compactness reduces trip time particularly by alternative modes.
- H1b: Urban compactness therefore makes alternative mode travel more competitive and increases it.

The first hypothesis, which will be detailed by the third hypothesis, is that urban compactness reduces the physical distance between the origin and destination of a trip, but the same degree of the distance reduction is hypothesized to reduce trip time by nonmotorized modes more strongly than by its substitute, the automobile. Consequently, the reduced distance is hypothesized to make alternative mode travel more competitive and increase its frequency (and mode share).

Regarding this hypothesis, a unique contribution of this research is that while previous studies “assumed” that urban compactness alters travel behavior by changing trip time and simply examined the urban compactness–travel relationship (without consideration of trip time), this research clearly incorporates the trip time variable into its analytical model. Thus, through the hypothesis that consists of two levels, this research accumulatively tests (H1a) whether urban compactness reduces alternative mode trip time and (H1b) whether the reduced trip time by higher urban compactness, not by other variations, increases alternative mode travel (i.e., urban compactness --> trip time --> travel).

In fact, urban compactness reduces the physical distance no matter which mode is taken for a trip. However, the marginal cost reduction by the same degree of the distance reduction is larger for alternative mode travel than for automobile travel because time savings according to the distance reduction (e.g., one mile) is larger for alternative mode travel.

Among urban compactness components, land use mix, road connectivity, and transit availability of a neighborhood may contribute to this hypothesis because they reduce the physical distance from trip origin to destination or to transit stations. If land use mix increases in a neighborhood, that is, if working, shopping, and leisure activity venues are balanced, walking and biking time from home to the venues decreases. Likewise, if road connectivity increases, the time to the venues is shortened. If transit stations increase in number, people come to have a closer station.

This hypothesis is conditional (i.e., it has a possibility to be rejected), in the sense that behavioral changes are realized above a certain level of urban compactness and trip time reduction. As assumed in the activity-based utility theory (Maat, van Wee, and Stead 2005), alternative modes (i.e., walking, biking, and walking to transit stations) reach their maximum trip time earlier than the automobile: That is, alternative mode travel is cheaper and more competitive over shorter trip length. In practice, Litman (2011a) reported that nonmotorized modes are preferred means for local trips. Particularly, in the U.S., of trips whose lengths are equal to or less than 0.5 mile (10% of the total trips), 61% were made by walking. Also, of trips whose lengths are 0.5–1.0 mile (19% of the total trips), 51% were walking trips.[16] Overall, about 12% of total trips were nonmotorized mode travel, and more than half of the trips were a mile or less. This shows that a critical mass of people will initiate alternative mode travel only if trip length and subsequent trip time is below a certain level (i.e., walkable and bikable distance). This condition indicates that to test H1, empirical analysis needs a case above a certain level of urban compactness.

- H2a: (While compact urban form increases congestion and reduces “trip speed,” the congestion is meaningful particularly for automobile travelers, and thus) urban compactness increases trip time particularly by automobile.

[16] This might imply a certain “threshold” of distance below which a critical mass of people initiates walking. This inflection point is not examined in this study. First, similar to linear regression analysis, structural equation modeling, the main analytical technique of this research, tests linear relationships between research variables. Second, the survey was not concerned with the distance between trip origin and destination (i.e., trip length), but it measured trip time. (Why trip time is used rather than trip length is described in “2.2.2.1 Representative of Travel Costs: Trip Time”.) Consequently, no hypotheses based on the distance can be empirically tested, and this research examines whether trip time changes according to urban compactness. (In a similar vein, this research does not evaluate “trip speed” variations, but those in trip time, in order to test hypotheses that involve the effect of congestion.)

- H2b: Urban compactness therefore makes automobile travel less competitive and decreases it.

The second hypothesis, which will be improved by a more detailed hypothesis (H4), is the opposite of the first in that according to the activity-based utility theory, it is associated with the increase, not decrease, of trip time. Because urban compactness increases congestion, it reduces trip speed and increases trip time. Insomuch as the theory assumes that congestion applies only to automobile travel (Maat, van Wee, and Stead 2005), this research hypothesizes that the congestion should increase automobile trip time and subsequently reduce automobile travel.

As with H1, this multi-level hypothesis is concerned with: (H2a) the effect of urban compactness on automobile trip time and (H2b) the effect of increased trip time according to higher urban compactness (not to other variations) on automobile travel. Thus, the first contribution of this research is that it explicitly incorporates the trip time variable into an analytical model and tests the accumulated relationship of urban compactness --> trip time --> travel. Secondly, as discussed in “2.2.2.2 Effects of Congestion”, previous studies on intensification strategies considered congestion a downside of urban compactness (as in its negative meaning). In contrast, this research attempts to suggest that congestion is actually effective in reducing automobile travel. Once this hypothesis is accepted, planners can view urban compactness strategies in relation to traffic-calming measures.

Actually, congestion increases trip time whichever mode people use, but supposing that one individual changes from automobile travel to walking and vice versa, motorists experience more congestion than do pedestrians. While congestion is associated with heavy traffic volumes, as in Figure 4, motorists occupy larger area on the road, so they are more likely to feel congestion.

Meanwhile, one may suspect that congestion makes it risky to walk and bike because of a high volume of automobile traffic. However, while congestion increases traffic volume, it reduces the speed, which encourages nonmotorized travel. Thus, the slower speed offsets risks associated with the higher traffic volume. Actually, through a review of the literature on road safety, Richter et al. (2006) found that urban sprawl, the opposite of urban compactness, increases safety issues, and congestion functions as a measure of speed calming and thereby “reduces” road risks. Similar to Richter et al., Ewing et al. (2003) found through regression analysis that a 1% increase in urban compactness reduces all-mode traffic risk by 1.49% and pedestrian risk by 1.47–3.56%. Particularly in the U.S., the riskiest metropolitan areas to walk are those experiencing urban sprawl (Ernst and McCann 2002) and road intersections in urban areas are less risky for pedestrians than those in suburban areas (Zegeer et al. 2001).

At the level of urban compactness components, the second hypothesis is associated with population density. If population increases in a given neighborhood, traffic volumes increase, so does congestion.

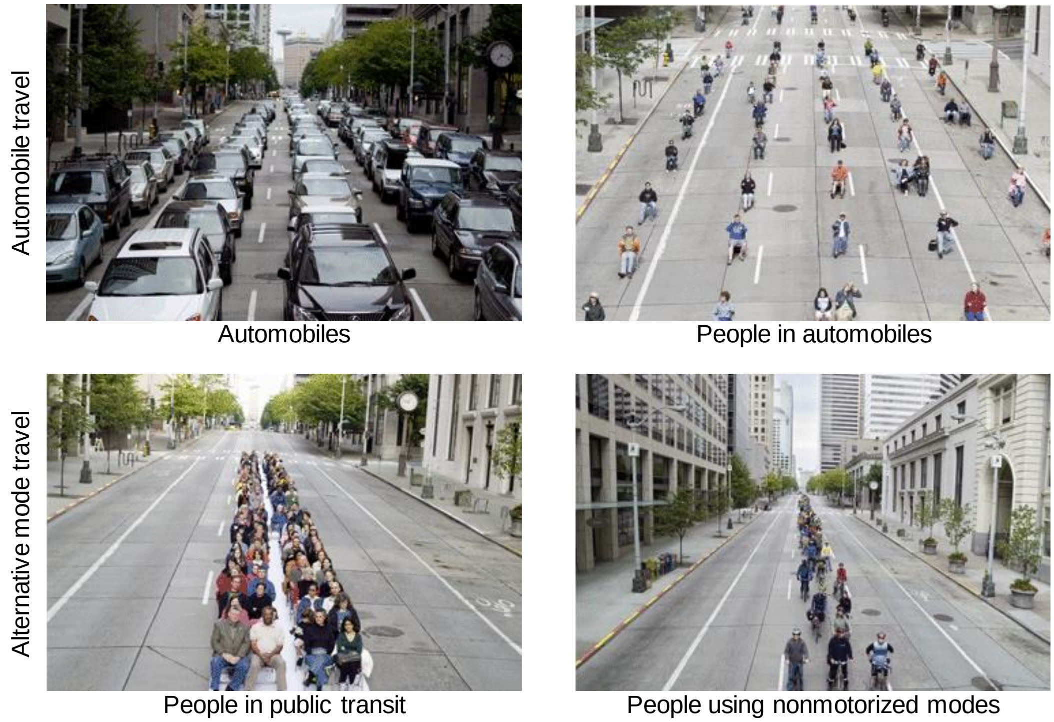

Figure 4 Road Occupancy by Travel Mode
Source: Seattle Department of Transportation (2011)
(http://www.cityofseattle.net/transportation/sdot_can.htm)

One condition to this hypothesis (i.e., a possibility to reject H2) is that behavioral changes are realized only above a certain level of urban compactness because the maximum allowable time is larger for automobile travel than for walking and biking, and walking to transit stations. That is, a critical mass of people will use alternative modes only if automobile trip speed decreases considerably. Thus, to test this hypothesis, empirical analysis needs a case above a certain level of urban compactness. Seoul, the case of this research, appears to meet this qualification. Overall, the mean traffic speed (2000–2008) is 14.19 miles/hour and in urban centers, it declines to 9.67 miles/hour (Traffic Operation Information Service 2009).

The first two hypotheses involve cost changes by travel mode. In comparison, the following four hypotheses detail changes not only in travel costs (H3–H4), but also in travel benefits (H5–H6) according not only to travel modes, but also to travel purposes. Specifically, travel purposes lead to the hypotheses in that spatial and time flexibility (changeability of activity locations and trip departure/arrival time and manageability of trip frequencies) is hypothesized to differ by purpose.

- H3a (elaboration of H1a): Urban compactness reduces alternative mode trip time *particularly for shopping and leisure*.
- H3b (elaboration of H1b): Urban compactness accordingly makes alternative mode travel more competitive particularly for shopping and leisure purposes and increases alternative mode travel for these purposes.

By detailing H1, this research hypothesizes that reduced trip time (i.e., cost savings) for alternative mode travel (H1) is used for utility maximization through further shopping and leisure travel because the travel has higher flexibility to urban compactness. According to the activity-based utility theory, people would consume the cost savings to increase travel benefits. People may choose more distant and additional destinations for purchasing higher-quality (or lower-price) and additional goods and services for shopping and leisure, but they are less likely to change to a more distant job that pays more or go to workplace more often. That is, because activity locations and frequencies for leisure and shopping are more manageable than those for commuting, the trip time reduction would encourage shopping and leisure travel by alternative modes that became cheaper.

At the level of urban compactness components, this hypothesis is concerned with land use mix, road connectivity, and transit availability, as with H1. Land use mix and road connectivity reduces trip time to local options, and they may contribute to walking/biking to more destinations. Transit availability reduces the time to transit stations, and it would encourage more walking/biking for distant travel.

- H4a (elaboration of H2a): Urban compactness increases automobile trip time *particularly for commuting purposes*.
- H4b (elaboration of H2b): Urban compactness accordingly makes automobile travel less competitive particularly for commuting and reduces automobile commuting travel.[17]

This hypothesis is based on H2, which is concerned only with travel modes (i.e., "automobile" travel), and extends it by further considering travel purposes (i.e., automobile "commuting"). Among different purposes, this research hypothesizes that automobile trip time increases more for commuting than for shopping and leisure.

Shopping and leisure travel has higher time and spatial flexibility to congestion than does commuting. Congestion occurs during a specific time of the day at which commuting usually occurs; also, most people can hardly decide their workplace on their own, that is, they should commute to the same place regardless of congestion. Thus, congestion would increase trip time particularly for automobile commuting and subsequently, reduce it. (Also, considering that most people still commute to their workplace, urban compactness will result in shifts of commuting modes.) In contrast, the departure/arrival time of shopping and leisure travel is more manageable and among

[17] Not only do urban form characteristics around residences affect commuting travel, those in and along the way to trip destinations may affect how it occurs. A limitation of this research is that it evaluated urban compactness only in trip origins. This and other limitations are presented in "7.1 Limitations".

multiple shopping and leisure options, people can choose one that meets their needs, so congestion will not act strongly on shopping and leisure travel.

To the degree to which this hypothesis is accepted, H2 may be rejected. That is, if automobile trip time increases only for commuting, overall automobile trip time (a composite of trip time for commuting, shopping, and leisure) is not likely to significantly increase, and then, neither are the number and share of overall automobile trips. At the level of urban compactness components, this hypothesis is associated with population density, as with H2.

- H5a (primary benefits): Urban compactness increases primary benefits of *alternative mode travel for shopping and leisure*.
- H5b: Urban compactness accordingly increases alternative mode travel for shopping and leisure.

This research hypothesizes that urban compactness increases primary benefits of alternative mode travel in a neighborhood (density, variety, quality, and uniqueness of activity locations). Then, people would change shopping and leisure destinations to those found in the neighborhood because shopping and leisure travel has higher spatial flexibility to urban compactness. Relatively, however, the benefits of commuting (i.e., work) are more difficult to replace, so they may not change to jobs newly situated in the neighborhood. In support of this hypothesis, Transport for London (2009) reported that in the Greater London area, more than 1/3 and around 1/4 of total local trips are for shopping and leisure, respectively.

At the level of urban compactness components, this hypothesis is based on the impact of land use mix. If land use mix increases in a neighborhood, that is, if shopping and leisure venues increase in line with residences in a neighborhood, people have more options for shopping and leisure, so they are more likely to find one that suits their needs.

- H6a (secondary benefits): Urban compactness increases secondary benefits of *alternative mode travel for shopping and leisure*.
- H6b: Urban compactness therefore increases alternative mode travel for shopping and leisure.

This research hypothesizes that urban compactness increases in a neighborhood (1) secondary benefits of "shopping and leisure travel," not those of commuting. Most people should commute to the same office and in time, so they would not strongly care for secondary benefits of travel, particularly exploring an unfamiliar route, feeling amenities (e.g., enjoying scenic beauty on a particular route), and experiencing the outdoors. In contrast, they have more chances to enjoy the secondary benefits during shopping and leisure travel because they can take advantage of time and spatial flexibility of shopping and leisure travel.

At the same time, urban compactness is hypothesized to increase (2) secondary benefits of "alternative mode travel" rather than those of automobile travel. Actually, urban compactness would rather reduce secondary benefits attached strongly to automobile travel (e.g., feeling convenience, comfort, privacy, and safety, showing off the social status, and feeling motion control and independence). Instead, it may increase the chance of enjoying secondary benefits of alternative mode travel (e.g., doing physical exercise and feeling that they promote environmental protection). Consequently, urban compactness is likely to increase secondary benefits (1) of shopping and leisure travel (2) by alternative modes, and then, it can make the particular travel more competitive, and increase it.

At the level of urban compactness components, land use mix, road connectivity, and transit availability are associated with this hypothesis. As land use mix increases, people can enjoy secondary travel benefits by walking or biking to shopping and leisure venues in their neighborhood. Highly connected road networks provide not only shorter but also more various routes to travel destinations, so people are allowed to choose those on which they can maximize the utility (= primary benefits + secondary benefits − travel costs). Transit availability would also be significantly associated with this hypothesis because it encourages people to walk to the stations of public transit and to use it for the above-given examples of secondary benefits: doing physical exercise and feeling environmental protection.

3.3.1 Combining Hypotheses

Put together, detailed hypotheses ranging from the third to the sixth (H3–H6) present the dynamics of travel utility according to urban compactness: Regarding travel costs, trip time decreases for alternative mode shopping and leisure travel (H3a) and increases for automobile commuting (H4a) while in terms of travel benefits, both primary benefits (H5a) and secondary benefits (H6a) increase for alternative mode shopping and leisure travel. Then, automobile commuting decreases (H4b) and alternative mode shopping and leisure travel increases (H3b, H5b, and H6b). Consequently, confirming the four hypotheses, this research attempts to argue that the effectiveness of urban compactness strategies can be best explained by strong increases in alternative mode shopping and leisure travel although they may modestly reduce automobile commuting.

Table 1 summarizes all of the six hypotheses this research raises, their hierarchical relationships (i.e., H1 and H2 are elaborated by H3–H6), and urban compactness components related to each hypothesis.

Table 1 Hypotheses

Types	**Utility**	**Hypotheses (effects of urban compactness)**	**Urban compactness components**
Initial (by travel mode)	Costs	H1a: Urban compactness reduces trip time by alternative modes (assuming that it reduces "trip length" by these modes).	Land use mix Road connectivity Transit availability
		H2a: Urban compactness increases trip time by automobile (assuming that it reduces "trip speed" by automobile).	Population density
		Behavior (H1b–H2b): According to urban compactness, alternative mode travel increases and automobile travel is reduced.	
Detailed (by travel mode and purpose)	Costs	H3a: Urban compactness reduces trip time by alternative modes for shopping and leisure.	Land use mix Road connectivity Transit availability
		H4a: Urban compactness increases trip time by automobile for commuting.	Population density
	Benefits	H5: Urban compactness increases primary benefits of alternative mode travel for shopping and leisure.	Land use mix
		H6: Urban compactness increases secondary benefits of alternative mode travel for shopping and leisure.	Land use mix Road connectivity Transit availability
		Behavior (H3b–H6b): According to urban compactness, automobile commuting is reduced and alternative mode shopping and leisure travel increases.	

Note: All hypotheses consist of two levels (H0a = hypotheses concerning utility changes and H0b = hypotheses concerning subsequent behavioral changes).

The relationships among research hypotheses could be clearly understood, beginning with urban compactness components in the far right column of Table 1. Figure 5 shows how the hypotheses are connected with and different from each other, along with measures and datasets required to test each hypothesis.

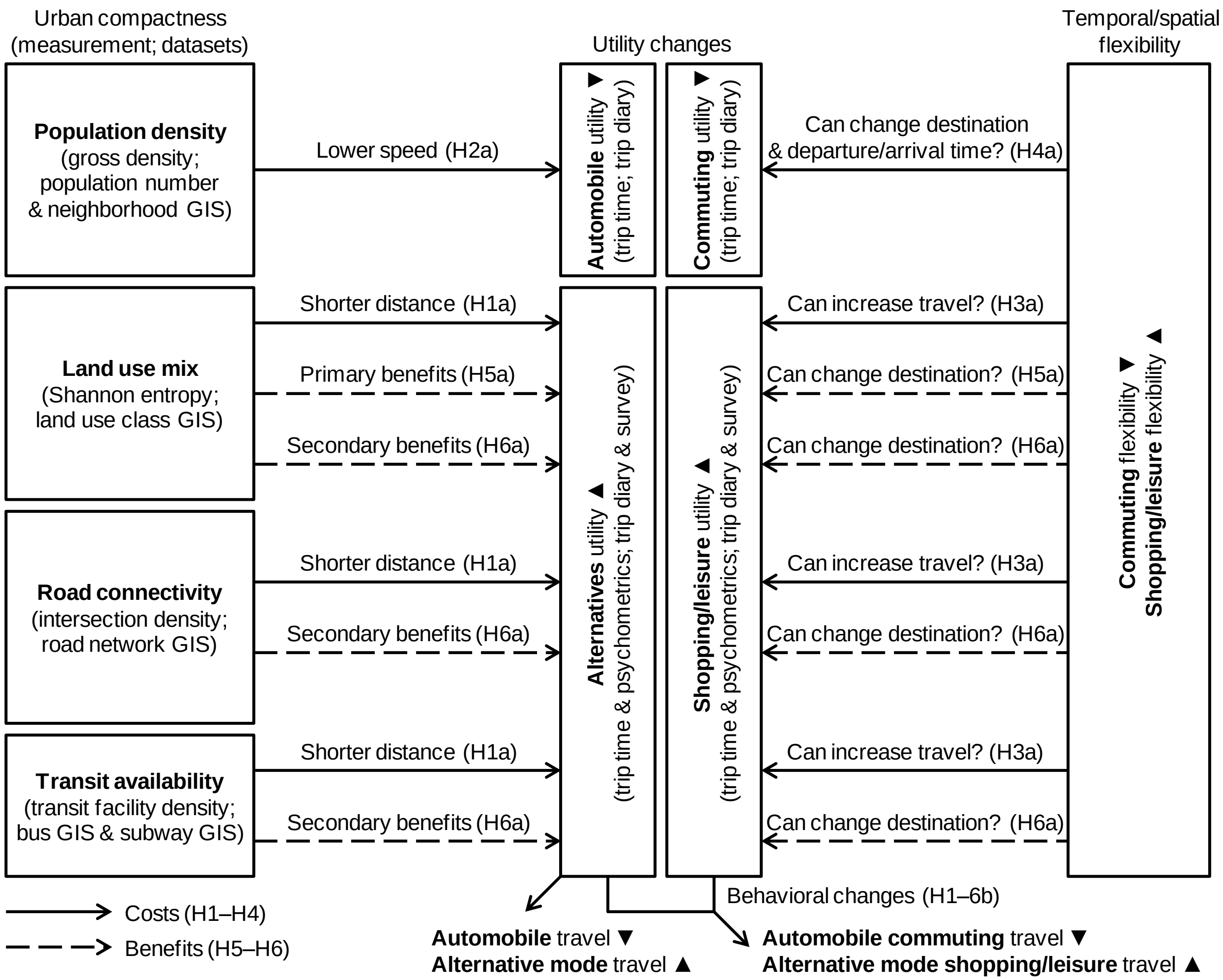

Figure 5 Hypotheses

3.4 Rival Hypotheses

Rival hypotheses fundamentally arise from issues of utility approaches. (1) People are incapable of choosing the optimal mode of travel that produces maximum utility. Furthermore, the choice is led not by the utility, but mainly by (2) habits and (3) temporal/spatial constraints. Although the rivals are accepted, however, the reason can be sufficiently explained by the utility approaches.

Firstly, the approaches assume the deliberate, rational behavior of people with complete information for the optimal decision that produces maximum utility. In practice, however, information people have is faulty or incomplete and because of a lack of conscious thought (e.g., habit and poor planning), their behavior is suboptimal (Handy et al. 2002). From the utility perspective, travel led by suboptimality (e.g., getting lost or reaching wrong destinations) increases its costs, that is, trip time. The time is larger for pedestrians, bicyclists, and transit riders than for motorists. Thus, if this rival hypothesis is the case, urban compactness may not significantly reduce trip time for alternative mode travel. Presumably, however, because such abnormal cases (e.g., getting lost or reaching wrong destinations) are limited, this hypothesis would not be supported.

Using utility approaches, this research assumes that one mode of travel is substituted by another. However, several studies (Beatley 2000, Ewing 1995, Ewing and Cervero 2001, Pipkin 1995, Van Diepen and Voogd 2001) argued that people tend to stick to a specific mode (i.e., habitual mode choice), especially the automobile. If this tendency is at work, urban compactness changes travel utility, but it may not bring about behavioral change (i.e., in the relationship of urban compactness–utility–travel, the latter link would be insignificant).

From the utility perspective, all travel modes are assumed to be fully available. From the time geography perspective proposed by Hägerstrand (1970), however, people face spatial and time constraints. That is, if a certain travel mode is not spatially or temporally available, people would use others. Regarding spatial constraints, if public transit is not provided near their residence, people have to use other modes to destinations or at least to transit stations. In this case, according to the utility perspective, people may put a high value on secondary travel benefits (e.g., convenience). However, because public transit is mostly within a walkable distance in Seoul, this rival hypothesis would not be a factor. Regarding temporal constraints, walking, biking, and riding transit may be risky or uncomfortable at a specific time of the day (e.g., at night). Furthermore, public transit is not available for out-of-service time. That is, a temporal variation among travel modes exists in their availability. Because this temporal constraint or variation is associated with secondary travel benefits (e.g., convenience, safety, and comfort), if the constraint is considerable, urban compactness may have an insignificant effect on the secondary benefits.

CHAPTER 4.

METHODOLOGY

4.1 Study Area

This dissertation research argues that urban compactness indirectly affects travel behavior by changing its utility. As in Figure 7, this argument carries three concepts—urban compactness, travel behavior, and utility produced by the behavior—each of which was defined in “3.1 Arguments”.

To verify its argument, this research selected a city with a high level of urban compactness, Seoul Special City, Korea, because all hypotheses drawn from the argument—especially, those based on congestion increases (H2 and H4)—can be tested. Besides, datasets on urban compactness and travel behavior are available for the city. Also, by evaluating urban compactness in a single city, this research can control for other major variables that are believed to affect travel behavior, but not examined in empirical analysis. They refer not only to fuel price that is assumed to be fixed according to the Travel Time Budget Theory (see 2.1.1.1 Travel Time Budget Theory), but also to social and cultural settings and lifestyles (Mindali, Raveh, and Salomon 2004) as well as to land use and transportation policies (subsidies, taxes, and grants) that affects the lifestyles (Bohte, Maat, and van Wee 2009, Schwanen 2002, Snellen, Borgers, and Timmermans 2002, Stead and Marshall 2001, Van de Coevering and Schwanen 2006).

The spatial unit for the analysis of urban compactness is the (administrative) neighborhood, the smallest administrative unit in Seoul. The mean area of a total of 522 neighborhoods is 0.45 square mile,[18] which is slightly smaller than the 2000 U.S. Census Block Group (median = 0.48 square mile). Transportation studies often used 0.5 square mile to operationalize the area of the neighborhood (Cervero and Kockelman 1997). In Korea, population censuses (i.e., population data) are represented at the level of the neighborhood and above, and the finest scale on which population density can be measured is the neighborhood. Besides, it is the smallest traffic analysis zone (TAZ) of the Korean Metropolitan Household Travel Survey (MHTS) used in this research. Accordingly, to minimize spatial mismatch, the research uses the neighborhood as the spatial unit in evaluating urban compactness components.

Table 2 Administrative Units of Seoul

Names (Korean)	**N**	**Mean areas (miles^2)**
City (*Shi*)*	1	233.75
District (*Gu*)	25	9.35
Neighborhood (*Dong*)	522	0.45
Block group (*Tong*)	13,832	
Block (*Bahn*)	103,762	

* Similar with the City of Chicago and 1.7 times bigger than the City of Atlanta
Note: Administrative units are defined by the population, not by the area, and the lowest administrative unit—with an administrative body—is the neighborhood.
Source: 2006 MHTS (2008)

[18] Korea has two types of neighborhoods: the legal and administrative neighborhoods. Compared to legal neighborhoods that are predefined by law for historical consistency, administrative neighborhoods are set by population (as with U.S. census units) and each is equipped with the neighborhood office for administration purposes. (As of 2005, Seoul has 472 legal, 522 administrative neighborhoods.)

Inasmuch as spatial data cannot be measured at a single point, they should be bounded at an appropriate spatial unit (Openshaw 1996) to prevent boundary problems from occurring (in the sense that the selection of an arbitrary unit distorts values in spatial data) (Gim 2012). The coordinator of the MHTS—City Transportation Headquarters for the 1996 and 2001 surveys and the Metropolitan Transportation Authority for the 2006 survey—consistently identified the administrative neighborhood as an appropriate TAZ that sufficiently delineates areas of homogenous trip generation and attraction. Besides, by using the smallest TAZ, this research can reduce errors, if any, brought about by the boundary problem. In his simulation analysis, Ding (1998) found that errors in the estimation of the land use–travel relationship are significant particularly when the number of TAZs is small (i.e., when their sizes are large). From a similar perspective, considering that errors in evaluating urban form can be minimized by using a fine resolution, Sultana and Weber (2007) selected the smallest spatial zone among other predefined ones. The size of the zone was a bit smaller than the U.S. Census Block Group, that is, similar with the spatial unit of this research. This research described in full the ways that it sampled neighborhoods, chose interviews in each of the sampled neighborhoods, and distributed and retrieved the survey in "APPENDIX A".

- Neighborhood sampling: Using a multilevel stratified sampling strategy, this research sampled 24 neighborhoods and made their urban form variations wide enough for inferential statistics. It particularly considered two dimensions: density and the other three urban compactness components (i.e., land use mix, road connectivity, and transit availability). Also, to prevent the final sample from spatially biased, this research sampled from the urban center outward according to six buffer rings as shown in Figure 6.

- Interviewee sampling: In each neighborhood, this research sampled one resident considering (1) gender, (2) marital status, (3) age group, (4) household size, (5) household income, and (6) automobile ownership.
- Survey method: To increase the rate and quality of the responses, this research employed hand-delivered survey, financial incentives, and reminder calls.

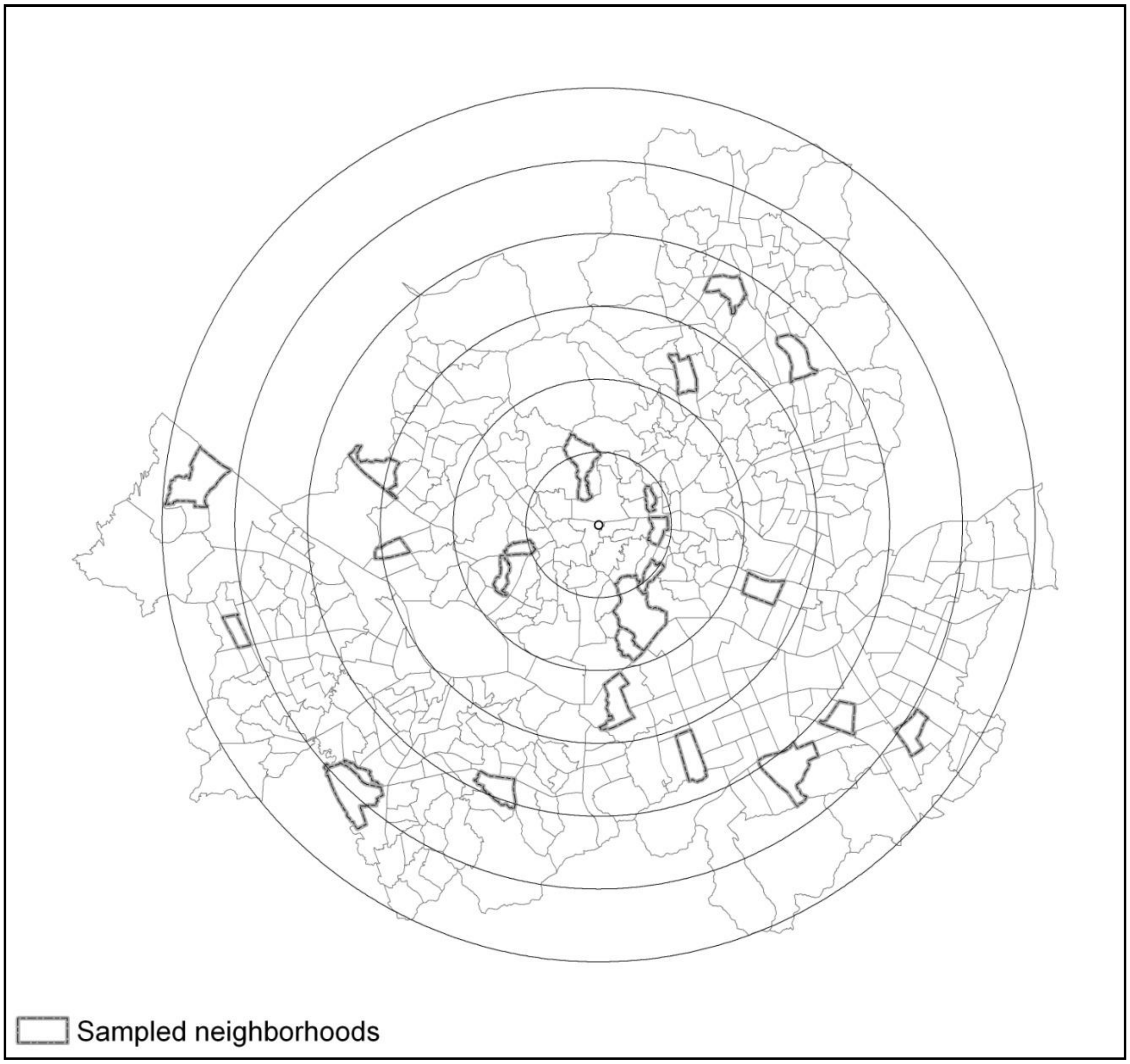

Figure 6 Sampled Neighborhoods (*N* = 24)

4.2 Conceptual Models

4.2.1 Model Specification by Competition Approach

Structural Equation Modeling (SEM) updates its conceptual model in two ways: the modification (or respecification) approach and competition approach. Through the modification approach, SEM removes paths that are not significant (e.g., $p > 0.05$) and adds paths if the modification index (MI) of a proposed path is greater than a critical value (4 or 10). Accordingly, SEM can identify a model that provides the best fit in the context of the current data (Gim 2011a, b). However, without theoretical support of the removed/added paths, the model guided by the *p*-value and MI moves away from the theory-testing purpose of SEM (Grace 2006). Accordingly, this approach is used mainly for exploratory purposes. For confirmatory purposes, SEM can be structured around competitive models. A researcher initially constructs multiple conceptual models and chooses one that best addresses the issue at hand.

This research employed the competition approach because its main purpose was to examine if the introduction of travel utility better explains travel behavior. It developed two models, each of which represented a proposed model (a model with a utility factor) and a reference model (a model without the factor). The reference model was based on the utility theory of derived travel demand—particularly, the econometric trip-making model because the outcome factor, trip frequencies or mode shares, was continuous—as in Figure 7. As such, by comparing its proposed model with the reference model, this research can show the degree to which an alternative explanation by the proposed model is superior to that of the econometric model.

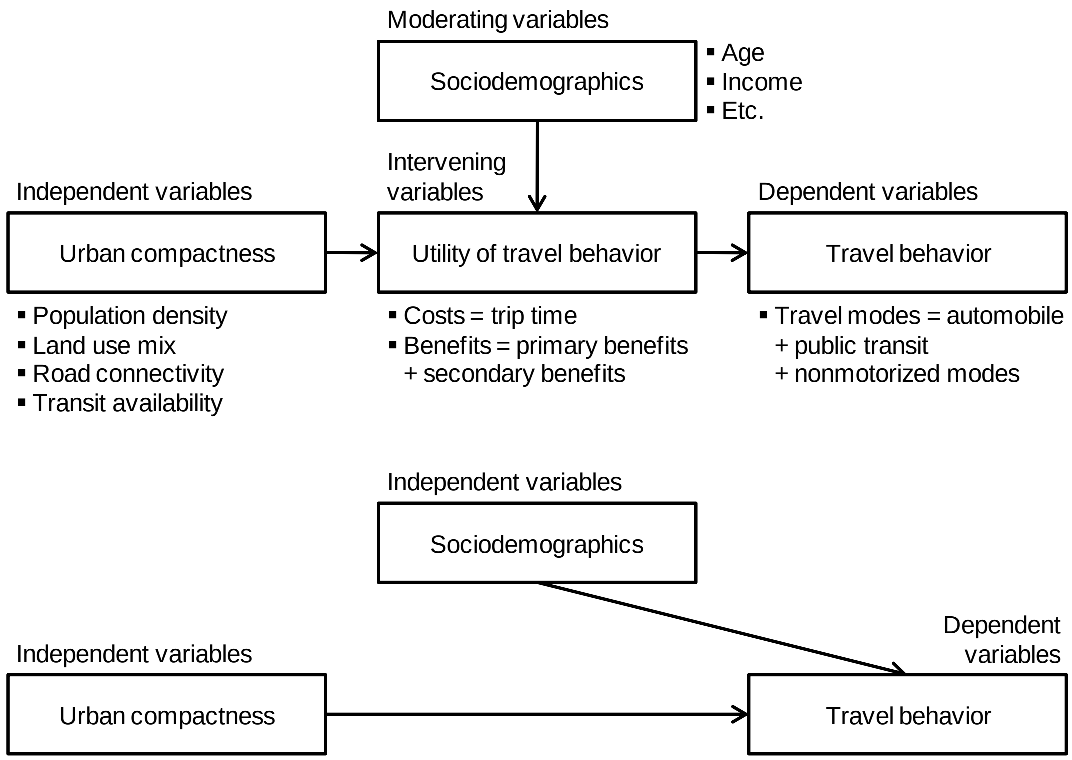

Figure 7 Conceptual Models: Proposed Model and Reference Model
Note: Conceptual models are analyzed by travel purpose (commuting, shopping, and leisure) and for overall travel. The reference model represents the reduced form of the econometric trip making model.

4.2.2 Data Collection for Model Testing

Of a total of four factors in the proposed model of Figure 7, this research evaluated urban compactness using GIS data it obtained from secondary sources. All other factors were measured through a structured survey. Meanwhile, the utility factor consists of three components (i.e., costs, primary benefits, and secondary benefits) among which secondary travel benefits have geographical variations, that is, what the benefits are (i.e., types) and how they are grouped (i.e., categories) differ according to urban and transportation settings in the study area (Maddison et al. 2009). Thus, to confirm or refine the types and categories of secondary travel benefits, this research conducted semi-structured personal interviews. Then, including the confirmed benefits, it quantified all utility components through a structured survey in several neighborhoods in Seoul (to be discussed). Particularly, as discussed in “3.1.3 Defining Travel Utility: Costs and Benefits”, the survey included a psychometric test to evaluate primary and secondary benefits and measured trip time as representative of travel costs. Along with trip time, it counted trip frequency by travel mode and purpose. Information on the other factor, sociodemographics, was also obtained in the survey.

The interviews and survey were conducted as part of two research projects of The Seoul Institute with full funding from the Seoul Metropolitan Government: the 2013 Seoul Pedestrian Survey (SPS) (no. 2012-ER-49; budget 620,000,000 won) and the Seoul Comprehensive Urban Transportation Plan (SCUTP) (no. 2012-ER-12; budget 302,000,000 won). The researcher of this dissertation volunteered for the SPS and as one of four investigators, he was in charge of its Urban Planning section; two other investigators administered the Transportation System section and the principal investigator administered the Future and Social Policy section. The researcher of this dissertation was also involved in the SCUTP until 7/31/2012 and has provided partial support since.

In particular, the researcher had full responsibility for the interviews and survey used in this research. He designed and refined research models, sampled neighborhoods and interviewees, and conducted and analyzed interviews. Regarding the subsequent survey, his responsibilities included questionnaire design and refinement, process management, and data processing and analysis. He also trained and supervised coders and managed the quality of the coded data; the response coding and initial error checking were the only components that have not been done by the researcher himself.

4.2.3 Data Validation Strategy

Before testing research models, GIS and survey data were checked with regard to whether variations in the data are enough for inferential statistics. For statistical inference, the data should have good variations in research variables (Babbie 2004, Ory 2007). Notably, based on inferential statistics, this research seeks to build a sample that comprises a variety of people rather than in matching the population characteristics.[19] Since sociodemographic variables are used as control variables—people's sociodemographics such as gender, age, income, and number of children are exogenous to planners' efforts to intervene in urban forms—and if the control variables have limited variations, this research cannot duly control for sociodemographic effects in estimating the effects of urban compactness.[20]

On the other hand, this research attempts to test the representativeness of the sample in terms of the degree to which statistical inference based on the sample is transferrable to the entire population (i.e., all neighborhoods in Seoul). In this attempt, this research analyzes the reference model in Figure 7 using the 2006 Metropolitan

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[19] In contrast, a sample for descriptive statistics is expected to represent the population, and thus, the best descriptive statistics equal population parameters.

[20] For instance, if one collects a sample of people that is the same in every sense as the population in a retirement community, the variation in age is necessarily low. This means that the effects of urban compactness are estimated without due control for the age variable. Then, the estimates can hardly be used to evaluate the effects in other neighborhoods with various age groups, whether or not urban forms in the neighborhoods are the same as those of the retirement community.

Household Travel Survey (MHTS) in that it investigated trip frequencies from all of the neighborhoods. By comparing model outcomes based on the entire MHTS with those based on the sample, which comprises the same neighborhoods selected for this research, it can show whether the survey sample is representative of the population (i.e., configural invariance). In addition to the configuration invariance, this research directly checks the similarity of sociodemographics and trip frequencies between the entire MHTS and its sample through the χ^2 goodness-of-fit test (i.e., comparison of their distributions) and one-sample *t*-test (i.e., comparison of their means). For the other factor that was not measured in the MHTS, the utility factor, this research tests its construct validity through confirmatory factor analysis (CFA).

Measures and datasets required for research models to test hypotheses are summarized in Figure 5 of the section "3.3.1 Combining Hypotheses" and described below. In the next section, this research firstly presents how it processed urban form datasets. Then, it gives an overview of the MHTS, which was used for the reference model (i.e., a model without consideration of travel utility). Lastly, it shows the MHTS processing procedure.

4.3 Urban Compactness

4.3.1 Selecting Urban Form Datasets

To evaluate urban compactness components, this research used multiple types of empirical data. GIS and GPS data on urban form were available from different public agencies and numerical data on population in an annual census. As shown in Table 3, years represented by urban form datasets were made to be consistent. Specifically, while datasets of 2013 and 2006 were not available for the survey and MHTS, this research used 2012 datasets for the survey and 2007 datasets for the MHTS in order to minimize temporal mismatch, that is, because these datasets stand for urban forms that are the most similar to those of the survey periods: The survey was conducted in March 2013 (trip diary: 4/18/2013–4/24/2013) and the MHTS on 11/1/2006 (or 10/31/2006). From the same perspective, among a multiple number of bus stop datasets available for the respective years, this research selected those whose representative dates are the closest to the periods of the two surveys. In this process, it found that a relevant bus stop dataset for the 2013 survey does not exist in a GIS form, and instead, raw GPS data were obtained and transformed into a GIS dataset.

Consequently, time periods that urban form datasets represent may not bring about an issue of temporal mismatch with those stood for by the MHTS and survey because urban form difference of 2–5 months would be negligible. In fact, urban form is quite stable and its significant changes occur over several decades (Hall 2001, Jenks and Burgess 2000, Boone-Heinonen et al. 2011, Transportation Research Board 1995, 2009).

Table 3 Urban Form Datasets

Urban compactness components	Data for the 2013 survey	Data for the 2006 MHTS	Sources
Population density	Registered Population (12/31/2012)	Registered Population (12/31/2006)	Korean Ministry of Public Administration and Security
Land use mix	Land Characteristics Map (2012)	Land Characteristics Map (2007)*	The Seoul Institute Urban Data and Information Center
Road connectivity	Street Centerlines (2012)	Street Centerlines (2007)	Highway Management System
Transit availability	Subway Lines (2012) and Bus Stops (12/2012)	Subway Lines (2007) and Bus Stops (3/2007)	Korean New Address System and Bus Management System

* The Land Use Map was also available, but the map was made only for the year of 2006. Another issue was that commercial and business land uses in the map were categorized into one class, "Commercial or Business".
Note: Data on administrative units (neighborhoods and districts), Administrative Unit Boundaries for Census, were obtained from Statistical Geographic Information Service at Statistics Korea.

4.3.2 Urban Form Variations

According to the ways that urban compactness was defined in "3.1.1 Defining Urban Compactness", this research processed urban form datasets. The process is fully described in "APPENDIX A". Figure 8 gives an overview of urban compactness levels that urban compactness components evaluated. No particular patterns or hot spots are noticeable across the components. This suggests that urban compactness could not be perfectly evaluated by any single component. Meanwhile, several neighborhoods have significantly larger area (μ = 0.45 mile^2; σ = 0.55, range = 0.05–4.90 miles^2) because similar to U.S. Census Block Groups, these have fewer residents.

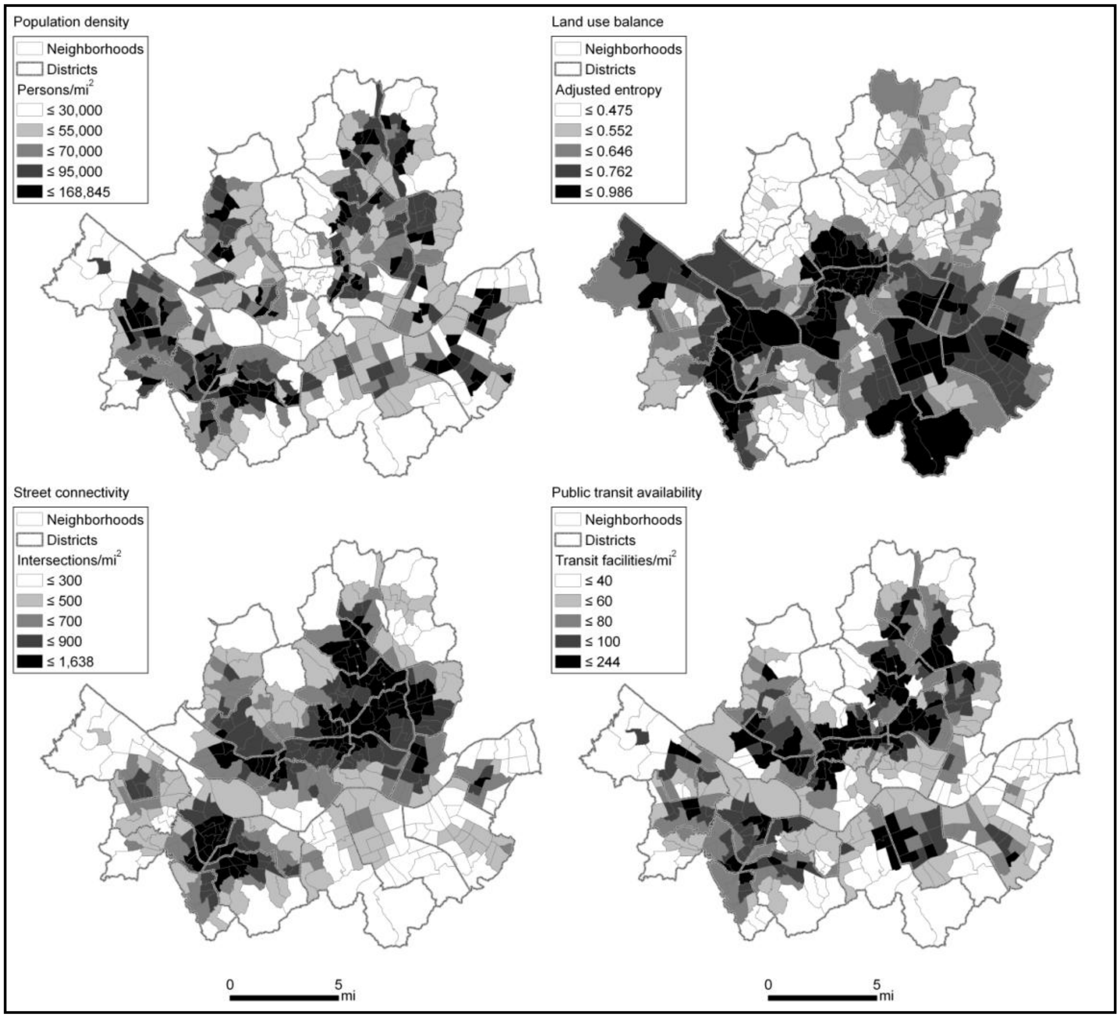

Figure 8 Urban Compactness by Neighborhood

4.4 Metropolitan Household Travel Survey

The MHTS is a semi-decadal travel survey that is postulated by National Transport System Efficiency Promotion Act and Urban Traffic Readjustment Promotion Act. The survey has been conducted four times in 1996, 2002, 2006, and 2011 among which the 2011 survey is in its draft form.[21] Open to the public in 2008, the 2006 MHTS differed from its predecessors because it expanded its coverage from Seoul to its neighboring areas (see Figure 9).[22] Although the Metropolitan Transportation Authority, an ad hoc agency, coordinated the 2006 MHTS, each of the areas (i.e., city/provincial governments) was in charge of surveying household travel behavior in its own jurisdiction and employed slightly different survey methods. Particularly, the Seoul section of the MHTS was administered by The Seoul Institute.

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[21] The 2011 Korean NHTS was available but not used in lieu of the 2006 MHTS mainly because it was in its draft form (i.e., error checking and manual correction were in process). (As an associate, the researcher of this dissertation participated in the Seoul section of the 2011 survey.) Besides, the NHTS faced a lack of appropriate land use dataset. Actually, for the year of 2011, the 2010 Seoul Biotope Maps—made every five years from 2000—were available and they contained a map named the Land Characteristics Map. However, it accidently had the same name with that employed in this study. Developed as a basis for evaluating the urban ecological status in Seoul, the 2010 map had a smaller number of classes (a total of 11 classes), that is, its classification system was less precise. In addition, it was in a coarse grain (a total of 38,170 polygons in comparison to 1,018,271 in the 2012 map used for this research). Also, a largest portion in the 2010 map was classified as “Open Space” (18,887 polygons out of the total 38,170), which is typically unconsidered in entropy calculation (Kockelman 1997, Zhou and Kockelman 2008). Most importantly, while this research aimed to separately examine travel behavior by its purposes (e.g., shopping and commuting), the 2010 map did not differentiate business and commercial land uses, but combined them into “Commercial and Office”.

[22] According to areas covered by the surveys, their official titles differ as follows: 1996 Seoul Transportation Census and 2001 Seoul Household Travel Survey—both were coordinated by City Transportation Headquarters, the Seoul Metropolitan Government—2006 Metropolitan Household Travel Survey whose spatial range was Seoul Special City and its neighboring metropolitan city and province, that is, Incheon Metropolitan City and Gyeonggi Province—this was coordinated by the Metropolitan Transportation Authority—and 2011 National Household Travel Survey (i.e., the entire nation), which was coordinated by the Korea Transport Institute.

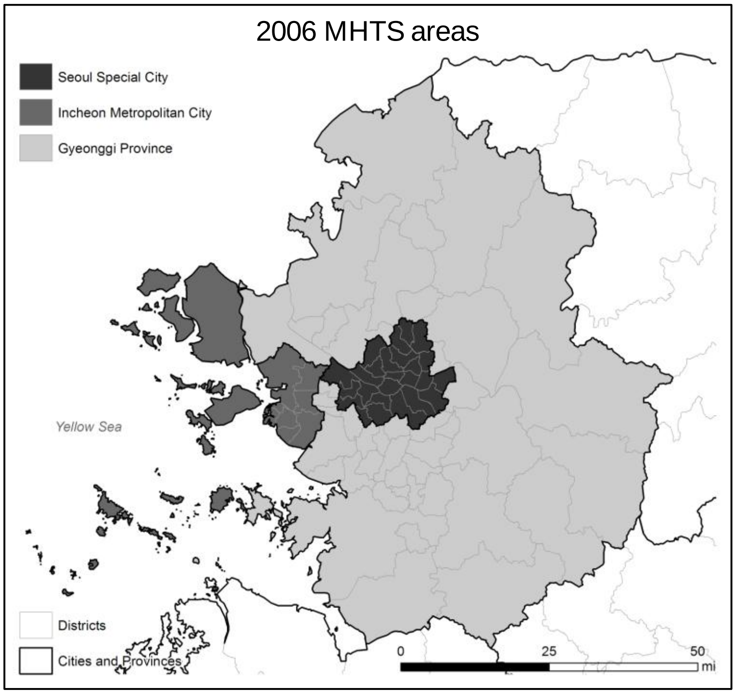

Figure 9 MHTS Spatial Range

The Seoul section of the 2006 MHTS investigated trips made on one weekday (10/31/2006 or 11/1/2006). For the Seoul survey, two levels of TAZs were defined by the homogeneity of trip generation and attraction and socioeconomic characteristics such as income class and job type: macro and micro TAZs. Each was consistent with administrative units, district and neighborhood, respectively. Hence, micro TAZ was the same as the spatial unit that this research used for the analysis of urban compactness.

To secure a similar number of households from each neighborhood, the Seoul survey applied different sampling rates to micro TAZs: 3.6% for TAZs of 5,000 residents or less, 3.3% for 5,000–10,000 residents, and 3.0% for 10,000 residents or more. Then, the survey chose several block groups from each neighborhood (total = 5,331 block groups out of 13,832 = 38.5%). In each of the selected block groups, it randomly sampled

25 households while considering the sociodemographic composition of the whole population in the neighborhood (mean = 239 households per block group). On average, 195 households were sampled in each neighborhood.

The target sample size was 3.1% of the total households. To increase the response rate, the Seoul survey additionally conducted a phone survey (= 7,615 calls) and personal interviews (= 1,073 visits). The response rate was 94.1% (= 95,698 households out of a total of 102,000 sampled households or 2.9% of the population). Overall, the survey collected data of 618,408 trips made by 327,796 people from 95,968 households (≈ 628 people in each neighborhood).

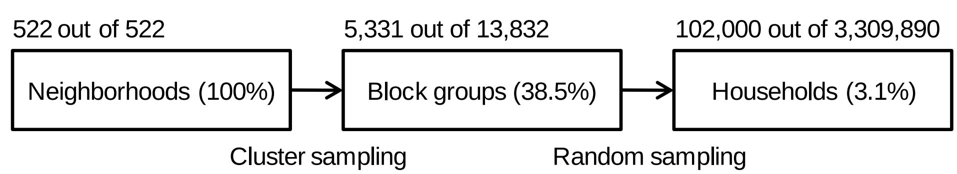

Figure 10 MHTS Seoul Survey Sampling Rates

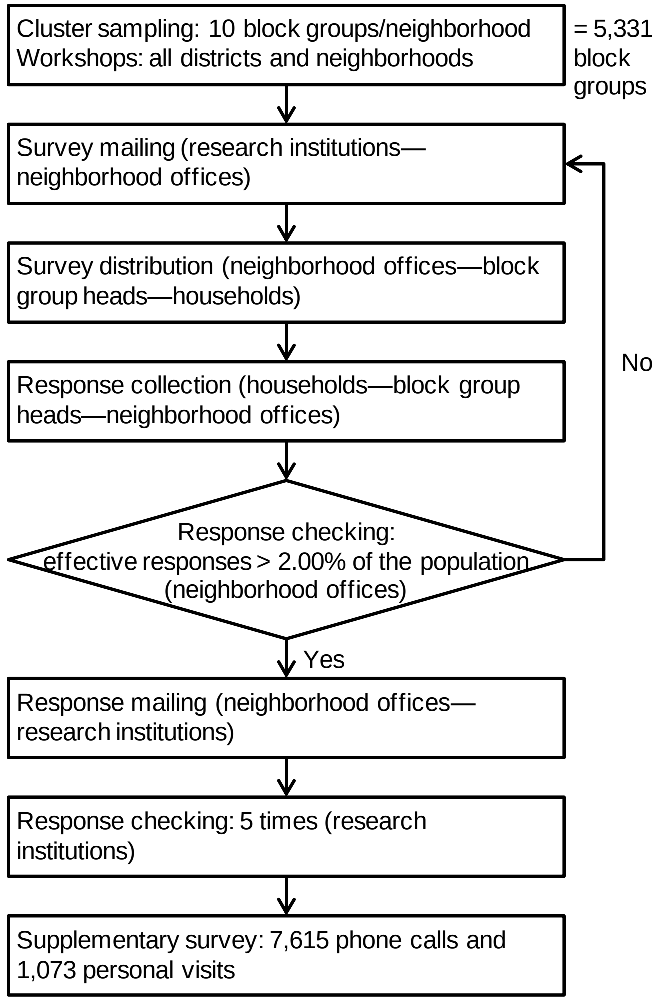

Figure 11 MHTS Seoul Survey Process

Table 4 MHTS Survey Items

Sections	Items
Household	Household ID* (address), household size, number of children under school age, vehicle (ownership, type, and number), housing (ownership, type, and ownership in other areas), and household monthly income
Person (= household member)	Personal ID* (address), relationship with household head, living together with household head, birth year, gender, driver's license, job type, employment type (telework, full-time, part-time, and others), working days per week, and travel on survey day (yes/no)
Trip	Trip origin, trip destination, final destination (final/transfer), travel purpose, travel mode, transportation card use (for transit trip, yes/no), parking fee payment (for automobile trip, yes/no), and toll payment (for automobile trip, yes/no)

* The 2006 MHTS assigned to each household member an ID of 12 digits (= 2 digits * 6 categories): city (2), district (2), neighborhood (2), block group (2), household (2), and household member (2).

The data of the three tables had one-to-many relationships: One household could have multiple members and one member could make multiple trips. In the combined table, each case represented a trip, not a household member. Thus, this research programmed a VB script to transform the data at the trip level into the level of the individual, the unit for SEM. Also, because different cases (i.e., trips) in the combined table had the same ID if they were made by the same individual, this research computed trip frequencies by counting the occurrences of the same personal ID. Detailed process of data screening and transformation are shown in “APPENDIX A”.

4.5 Pilot and Preliminary Tests: Interviews

4.5.1 Interview Format

As a "pilot" test, the purpose of the interviews was to revise and confirm travel benefits in the unique settings of Seoul. Also, using the interviews as a "preliminary" test, this research attempted to identify errors and to validate the content of the survey questionnaire. In addition to its content (question simplicity, clarity, and neutrality), the style of the questionnaire (questionnaire length, size, format, layout, and question arrangement) was a concern because it also helps to increase the response rate and to reduce the number of omitted and distorted responses (Kanuk and Berenson 1975). To identify issues with the questionnaire draft, this research asked interviewees to actually answer questions in the draft of the questionnaire.

This research used two sets of interview instruments: an interview protocol and a self-administered interview form (for the instruments written in Korean and translated into English, see "APPENDIX C"). The interview form was offered to inform interviewees of what travel benefits are. Using the form, this research also aimed to help the interviewees prepare for probes that would be solicited (1) to provide their experience concerning the benefits, (2) to think about those of others such as family, friends, and colleagues, and (3) to give answers to retrospective and hypothetical questions about the benefits in different urban settings. To this aim, this research delivered the interview form (along with the questionnaire draft) right after each interviewee was selected. He or she was asked to fill out the form beforehand, and the interview was performed on the basis of the completed form.[23]

4.5.2 Interview Outcomes

As a pilot test, interviews were conducted (1) to explore travel benefits that are uniquely present in Seoul in relation to its urban and transportation settings, in the sense that travel benefits shown in the literature were based exclusively on Western cases and (2) to exclude those that would not apply to Seoul. Possibly, people in Seoul have less diverse desires for secondary travel benefits than Americans who are strongly attached to the automobile (Nivola 1998). For instance, they would not expect the sense of conquest or auto racing considering the well-arranged speed-camera system as well as high traffic volumes and subsequent congestion; as shown in “3.3 Hypotheses”, the mean traffic speed in Seoul is just 14.19 miles/hour. Indeed, Diana and Mokhtarian (2009) noted differences in the types and levels of the secondary benefits across countries that are in part attributed to urban form, transportation, and cultural settings. Last, this research (3) checked if travel benefits are considered duplicates; then, it may either exclude or incorporate them into other components. In summary, the purpose of the interviews was to confirm the list of travel benefits and if necessary, to expand or reduce the list.

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[23] Actually, in 2010, this research interviewed with eight people who were assisted by a document that listed secondary travel benefits as found in the literature. During a 20-minute interview, no additional inputs were provided probably because people do not seriously consider such “non-primary” benefits in their daily travel.

4.5.2.1 General Settings of the Interviews

Interview venues were chosen by interviewees from one of the following: their homes, coffee shops nearby, and the lobby or conference rooms of the research institution. Interviews lasted an average of 37.3 minutes (σ = 9.3; range = 20.2–53.4). They were longer than the expected 20 minutes (originally calculated based on the researcher's preliminary interviews with eight people in 2010 to develop the dissertation proposal). The interviews were longer partially because every interview began with an ice breaking about the current issues of the particular neighborhood. Other differences between the 2010 interviews and the current ones (i.e., possible sources of the increase in interview lengths) were that current interviewees were given (1) the self-administered interview form and questionnaire draft before the interviews (to allow due time to think about interview topics) and (2) a financial incentive for the interviews. The wide range and high standard deviation can be attributed to cases in which interviewees were more cooperative in sharing personal stories. (Regardless of whether the stories were related to the interview topics, the researcher stayed attentive.) For details of the interview settings, see "APPENDIX D".

4.5.2.2 Organizing Interview Data

Interview data were voluminous, and to extract useful information from them, this research made an interview note. The note carried two tables according to the two purposes of the interviews: (1) exploring travel benefits to be added, removed, or combined and (2) understanding issues with the questionnaire draft. For the original version of the note (in Korean) and its English translation, see "APPENDIX D".

As shown in Figure 12, the first table of the interview note, titled "Utility", had four columns. The first column showed a category into which the interviewee's remark was classified. The category was defined by the point of time at which the very remark was provided; the interview followed the order of the topics in the interview protocol and self-administered interview form. The second column carried excerpts from the interviews. They were descriptive and in the interviewee's language. As in the third column, this research processed the excerpts to make them better suit the purpose of exploring travel benefits.[24] The last column showed the SEM representation of each strategy, if applicable.

The second table of the interview note, titled "Questionnaire", had two columns. The column of "Interview excerpts" included an interviewee's direct suggestions about ways to improve the content and style of the questionnaire. The second column, "Notes", had the researcher's strategies about how to respond to the suggestions.

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[24] At times, interviewees read answers that they provided in the self-administered interview form, but for more times, they delivered their personal experience in which answers were implied in relation to a topic. To prevent distortion, this research interpreted the answers by comparing what the interviewee said before and after the very remark and by referring to a category into which the remark was classified (i.e., the title of the first column). In addition to the researcher's interpretation, this column carried strategies that he would take to deal with the remark in revising the questionnaire.

Interview 19: BA (5) (Gongneung, Nowon)

Name: XX, XXXX (Occupation: part-time freelancer while studying for civil service exams)				
Neighborhood	(1) Type: high compact / unplanned / <u>new town</u> / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / <u>≤ 8.5</u> / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 1	Members: 3
	(2) Individual	Gender: male / <u>female</u>	Marriage: married / <u>single</u>	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	While traveling a long distance for an hour or two, people can do many things together, like studying and eating. Using the time, they can have a meal, students can study for an exam, and it becomes a meeting place for those who have an important business meeting, so they (the means of transportation) are like becoming a "particular place" that busy city people can use their precious time while traveling. Actually, (when I read the examples of the benefits shown in the interview form) it seems like nothing missing.	The interviewee highlights the importance of the on-the-way benefits.	
Instrumental benefits	Can offering a particular place (as stated above) go here (to the instrumental benefits category)? Is it one of the convenience benefits?	She considers on-the-way benefits under the influence of instrumental benefits (i.e., mechanical characteristics of travel modes).	Instrumental benefits (factor) --> all on-the-way benefits

Questionnaire

Interview excerpts	Notes
It may be easier to understand if you make survey items in sentences like "do you think …?", different from the current format.	Items will be given in phrases.
Because questions are kind of abstract, I have to think long.	This research will revise items by using clearer and fuller terms that are accessible to a wider public. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.

Figure 12 Interview Notes (Example)

Note: For a total of 24 interview notes (in Korean and in English), see "APPENDIX D".

4.5.2.3 Pilot Test: Revising the Survey

This research excluded or transformed an item if more than 15% of the interviewees (i.e., at least four) recommended so and if it was confirmed at a group meeting with six experts at The Seoul Institute. This research finally removed one item, conquest, because as expected, interviewees suspected the conquest desire, which encourages competitive forms of travel, is insignificant or at the very least, its magnitude may be negligible in Seoul due to its congestion. This research considered that it can be safely removed because as discussed in “2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel”, it overlaps with four other affective benefits: independence, control, curiosity, and mental therapy. According to the interviewees, other affective benefits are also related to the conquest desire, including physical exercise, variety-seeking (destinations and routes), and exposure to outdoors.

Regarding the transformation of travel benefit items, this research combined seven items with other analogous items or with each other: (1) potential for auxiliary activities, (2) carrying capacity, (3) social norms, (4) personal norms, (5) adventure for fun, (6) variety-seeking—routes, and (7) variety-seeking—destinations (for details, see “APPENDIX D”).

In conclusion, out of a total of 29 secondary benefit items, 7 items were either excluded or incorporated into others. Along with the remaining 22 secondary benefit items (= 29 − 7), the final questionnaire retained all of the 4 primary benefit items. Thus, the questionnaire comprised three sets of 26 psychometric items (= 4 primary benefits + 22 secondary benefits), and items about the respondent’s sociodemographics and trip frequencies and durations.

4.5.2.4 Pre-Test: Refining the Questionnaire

As a preliminary test, the purpose of the interviews was to identify issues with the survey questionnaire so that they can be addressed before the full-scale survey. Overall, out of a total of 24 interviewees, 6 people or 25.00% (Interviews 1, 2, 6, 7, 18, and 21) accepted the questionnaire as is, but the other 18 interviewees provided one or two inputs. Table 5 summarizes issues raised by the interviewees and updates this research made to address the issues. The issues and updates are fully described in “APPENDIX D”.

Table 5 Pre-test: Issues of and Updates to the Questionnaire

ID	Issues (suggestions)	Updates
1	—	—
2	—	—
3	Lengthy questions	N/A
4	Abstract questions: low practicality	Described the survey contribution (to provide a basis for policy development)
5	Lengthy survey	Excluded or combined with others a total of seven items (21 questions = 7 items * 3 purposes); designed a hand-delivered survey, regular reminders, and financial incentives
6	—	—
7	—	—
8	Unclear term: comfort (suggested an alternative term, "pleasantness")	Updated to "pleasantness or comfort"
9	Unclear terms: comfort and privacy (suggested the form of description)	Updated to "pleasantness or comfort" and "privacy (not being bothered by others)", respectively
10	Unclear terms: destination density vs. destination variety	Added to the variety item "(whether dense or not)"
	Unclear term: physical exercise (suggested describing the meaning of "fitness")	Updated to "good physical condition"
11	Unclear terms: privacy and carrying capacity*	Updated the privacy item to "privacy (not being bothered by others)"
	Unclear term: buffer (suggested describing the meaning of "transition between home and the destination")	Added "(and get ready to work/shop/enjoy leisure)"
12	Ineffective design (suggested yes/no questions)	N/A
13	Ineffective design: no link of commuting–going to a new place	N/A
	Lengthy survey	Excluded or combined with others a total of seven items (21 questions = 7 items * 3 purposes); designed a hand-delivered survey, regular reminders, and financial incentives
14	Lengthy survey	Excluded or combined with others a total of seven items (21 questions = 7 items * 3 purposes); designed a hand-delivered survey, regular reminders, and financial incentives
	Ineffective design (suggested different surveys by age group)	N/A

Table 5 (continued)

ID	Issues (suggestions)	Updates
15	Ineffective design: similar answers for different travel purposes	N/A
	Ineffective design (suggested extending the travel survey period)	N/A
16	Abstract questions: low practicality	Described the survey contribution (to provide a basis for policy development)
	Similar questions	Combined six items with others
17	Unclear terms: comfort and privacy (suggested describing their meanings)	Updated to “pleasantness or comfort” and “privacy (not being bothered by others)”, respectively
18	—	—
19	Unclear terms (suggested the form of description)	Described in a phrase
	Abstract questions: long survey duration	Used clearer terminology; designed a hand-delivered survey, regular reminders, and financial incentives
20	Missing example: external activities—at stopovers (suggested another example, “having meals or snacks”)	Added the given example
	Unclear term: safety (suggested a more direct—not twisted—description than “no worries about my safety when I travel”)	Updated to “feeling safe while going to the place of the destination”
21	—	—
22	Unclear terms: destination variety vs. destination uniqueness (suggested adding qualifiers)	Added “in type” and “that are not found elsewhere”, respectively
23	Similar questions	Combined six items with others
	Abstract questions: long survey duration	Used clearer terminology; designed a hand-delivered survey, regular reminders, and financial incentives
24	Unclear term: comfort (suggested using a lay term)	Updated to “pleasantness or comfort”

— = no suggestion (the original format is satisfactory); N/A = not applied (the current format is kept.)

* In the final questionnaire, the carrying capacity item was combined with the convenience item.

4.5.3 Test of the Psychometrics

Although not intended in the first place, a considerable number of suggestions were given in relation to the relationships between factors (benefit categories; e.g., instrumental benefits) and items (e.g., control) that this research had regarded as items of different factors (e.g., affective benefits). Specifically, 15 interviewees of the total 24 (62.50%) identified one or more items that should be loaded onto different factors than those that defined according to Western studies.[25] As interviews continued, the researcher had more confidence that the fit of the conceptual categorization between a factor and its items should be tested.

As discussed in "2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel", items are not mutually exclusive, that is, one item can be related to multiple factors. Nonetheless, the item should be categorized into a factor that has the strongest characteristic of the item. Thus, the fact that a majority of the interviewees suggested different groupings may be because the internal mechanism of the travel benefits in Seoul or in Korea differs from the findings of previous studies, as argued by Diana and Mokhtarian (2009). Indeed, empirical studies conducted in different areas have differently categorized travel benefits: Anable and Gatersleben (2005) classified them into instrumental and affective (2 factors), Steg et al. (2001), Steg (2005), and Gardner and Abraham (2007) into instrumental, affective, and symbolic (3 factors), and Van Exel et al. (2011) into instrumental and synergy, symbolic and affective, control,

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[25] See interview notes: Interviews 1, 3, 4, 9, 10, 11, 13, 14, 15, 17, 18, 19, 20, 22, and 24.

and norms (4 factors). In this vein, this research tested the factor–item relationships and redefined them, if necessary.

4.5.3.1 Mixed Methods Approach

A potential for the different categorization of travel benefits made this research employ a mixed methods approach; this approach combines qualitative and quantitative data that are individually collected (Creswell and Plano Clark 2007).[26] In particular, this research used an embedded design strategy.[27] It makes one type of data (typically qualitative) included in the other type (often quantitative). The "including" type of quantitative data has a primary role and the "included" qualitative data a supportive role.

Based on the embedded design strategy, this research reclassified travel benefit items into different factors rather than keeping the predefined relationships, if and only if quantitative analysis (exploratory factor analysis: EFA) supported the reclassification. The same approach has been employed by Oh (2007) for her dissertation research: She extracted factors through EFA. A difference is that in her research, the factors were then tested through regression analysis, whereas this research reaffirmed the factors through

[26] The combination occurs in the stage of data analysis or interpretation, and this research combined the two types of the data (qualitative data from the interviews and quantitative data through the survey) in the data analysis stage.

[27] The mixed methods approach consists of four types of strategies, and the other three types are as follows (Creswell and Plano Clark 2007). (1) The triangulation design is to directly compare the results of the qualitative and quantitative analyses in order to confirm the conclusion validity of the respective results. (2) The explanatory design is a two-stage strategy: It adds interviews or case studies to explain or interpret patterns in quantitative results. In contrast, according to (3) the exploratory design, qualitative analysis is followed by quantitative analysis and it is relevant to studies for developing new indicators, concepts, and taxonomies: Using qualitative data, one develops an indicator or taxonomy and then, quantitative analysis is used to test it or to describe its characteristics.

confirmatory factor analysis (CFA)—to check construct validity, that is, to see if a survey item measured what it intended to measure—and tested them using SEM.

In summary, as with empirical studies on the categorization of travel benefits (e.g., Anable and Gatersleben 2005, Gardner and Abraham 2007, Steg 2005, Steg, Vlek, and Slotegraaf 2001), this research firstly grouped travel benefit items into factors through EFA. Then, one step further, interview outcomes were used as supportive evidence for the confirmation or reclassification of the factor–item relationships. Detailed outcomes of the interviews and subsequent factor analysis are as follows.

4.5.3.2 Potential for Different Categorization of Travel Benefits

In total, 15 interviewees provided 12 suggestions for the tailoring of the factor–item relationships according to Seoul settings. Table 6 shows the suggestions with five columns: (1) a factor suggested by the interviewees and (2) that conceptually defined through the review of the literature as well as (3) an indicator variable (i.e., survey item) concerned with the factors (suggested and predefined), along with (2) the IDs of the interviewees who provided the very suggestion. (5) The last row, "Confirmed", shows cases in which EFA confirmed the suggested factor–item relationship, which were accordingly used in CFA and SEM. For example, in the first case, while the item of curiosity for information had been defined as an item of the affective benefit factor, one interviewee (Interview 22) suggested it as a primary benefit; in the factor analysis of the survey responses, this suggestion was not confirmed, which indicates that the suggested relationship is not applicable to the general population (represented by survey respondents).

Table 6 Suggestions for Modification of the Factor–Item Relationships

Factors (suggested)	Factors (predefined)	Indicator variables (= survey items)	Interview ID	Confirmed*
Primary benefits	Affective benefits	Curiosity for information	22	
On-the-way benefits	Affective benefits	Curiosity for information	17	
		Amenities	17, 20	
		Physical exercise	18	
Instrumental benefits	On-the-way benefits	All on-the-way benefits	19	
	Normative benefits	Environmental concerns	1, 9, 13	Confirmed
	Affective benefits	Control	9, 24	Confirmed
		Independence	11, 15	Confirmed
		Physical exercise	3, 4, 14	Confirmed
		Mental therapy	3	
Affective benefits	On-the-way benefits	Anti-activity—thinking	10	
	Instrumental benefits	Comfort	20	

* Confirmed through exploratory factor analysis; the other eight suggestions were not supported.

As shown in Table 6, EFA (to be shown below) verified four relationships among those suggested by interviewees. Among them, three items (control, independence, and physical exercise) were originally defined in the literature as affective benefits and the other one (environmental concerns) as a normative benefit. Interviewees suggested all of the four items as instrumental benefits as follows.

First, through the literature review, this research classified the control item—defined as controlling the movement as desired, it was given in the questionnaire as "Possibility of having control over my journey"—as an affective benefit, but two interviewees (Interviews 9 and 24) considered it an instrumental benefit since controlling the movement ultimately depends on the “mechanical characteristics” of travel modes, a decisive feature of instrumental benefits.

Second, as with control, the independence item was considered an instrumental benefit rather than an affective benefit. Specifically, two other interviewees (Interviews 11 and 15) argued that using public transit as riders or cars as passengers means people are dependent for travel, and thus, independence is determined by a mode taken for travel, that is, its mechanical characteristics.

Third, regarding the item of physical exercise, people often face different distances to walk according to which mode they use; also, the chance they can take a seat differs by the mode (Interview 4). On purpose, people ride a bicycle and take a walk instead of driving, considering the mechanical characteristics of travel modes (Interview 14). In this sense, physical exercise may be an instrumental benefit rather than an affective benefit.

Last, three interviewees (Interviews 1, 9, and 13) considered that travelers' environmental concerns and friendliness hinge on a mode that they take and particularly, automobiles are less environmentally friendly than bicycles (Interview 1) and public transit (Interview 9) owing to their mechanical characteristics. Also, because of the same reason, gasoline vehicles are inferior to those based on electricity and fuel cell (Interview 13). That is, according to the interviewees, those driving conventional automobiles (with an internal-combustion engine) can be deemed less concerned for the environment than those driving cleaner vehicles and using public transit and nonmotorized modes. Thus, the item of environmental concerns may be not a normative benefit, but an instrumental benefit.

4.5.3.3 Exploratory Factor Analysis (EFA) of the Psychometrics

A full-scale SEM allows modeling similar variables (i.e., survey items) using a factor, that is, the variables are classified into the same factor. In this research, not only may urban compactness variables be correlated because of spatial multicollinearity, but also psychometric variables are somewhat similar to each other. However, SEM is feasible only if the conceptual similarity of the variables is indeed significant (i.e., construct validity). Considering the conceptual similarity, this research categorized travel benefits into primary benefits and secondary benefits and the secondary benefits were further classified into on-the-way benefits and intrinsic benefits (e.g., symbolic, instrumental, and affective benefits). Meanwhile, as discussed above, 15 interviewees suggested different conceptualization of the factor–variable relationships (i.e., different groupings of the benefits from those predefined according to the literature). This raised the need to test the relationships. Thus, this research conducted EFA of all of the 26 psychometric variables (26 survey items asked three times for three travel purposes) to identify the degree to which the interviewees' suggestions are supported.[28] [The EFA also functions as a preview of the construct validity of the psychometric measure; in a later part, this research legitimately tested the validity using confirmatory factor analysis (CFA).]

This research conducted four sets of factor analysis of the psychometric variables. Each of the first three sets used survey responses given for a specific travel purpose (i.e., commuting, shopping, and leisure) and the last set (i.e., benefits for overall travel) used

[28] Detailed outcomes of the survey are provided later.

the arithmetic mean of the three-time responses; for instance, if a respondent gave 1, 2, and 6 for commuting, shopping, and leisure, respectively, this research used the value of 3 [= (1 + 2 + 6) / 3]. Factors were extracted based on the eigenvalue of one—this is a convention that makes one factor work better than one variable—and oblique rotation (direct oblimin). The reason for the choice of the oblique rotation instead of other methods (e.g., varimax) is that it is preferred when factors are considered to be correlated.

In Tables 7–10, variable names used for each factor analysis differ by a prefix (“c_” for commuting, “s_” for shopping travel, “l_” for leisure travel, and “mean_” for overall travel). Variables loaded onto the same factor are grouped together; from left to right and from top to bottom, factors and variables are arranged in descending order of their magnitudes (i.e., eigenvalues and factor loadings). Since this research used an oblique rotation method, the percentage of the explained variance shown in each table should be taken for reference, only.

Table 7 Exploratory Factor Analysis of Psychometric Items: Commuting

Items (variables)	**1 (Affective)**	**2 (Primary)**	**3 (Instru-mental)**	**4 (Symbolic)**	**5 (On-the-way)**
Amenities (c_amnt)	.771	−.047	.073	.085	.049
Variety-seeking (c_diff)	.747	.054	−.046	−.014	.056
Exposure to outdoors (c_outdr)	.717	−.044	−.009	−.014	.167
Curiosity for information (c_curis)	.672	.079	−.156	−.131	.112
Mental therapy (c_thrpy)	.588	−.024	.289	.017	.075
Buffer (c_buffr)	.565	−.050	.140	−.070	.123
Escape (c_escp)	.507	−.052	.081	−.208	−.089
Destination variety (c_dvari)	−.052	.910	.014	−.017	−.013
Destination quality (c_dqual)	.006	.886	−.051	.011	.013
Destination uniqueness (c_duniq)	.068	.849	.040	.042	−.034
Destination density (c_ddens)	−.028	.847	.034	−.024	.010
Control (c_ctrl)	.235	.020	.757	.052	−.146
Independence (c_indep)	.150	−.095	.723	−.044	−.159
Safety (c_safe)	−.181	.016	.690	−.012	.242
Comfort (c_cmfrt)	−.128	.001	.628	−.104	.289
Convenience (c_cnvc)	.009	.000	.597	.013	.289
Environmental concerns (c_envrn)	.102	.125	.520	−.137	.007
Privacy (c_prvcy)	−.024	−.002	.494	−.246	.299
Physical exercise (c_exerc)	.401	.039	.473	−.095	−.181
Lifestyle expression (c_style)	.049	−.035	−.063	−.891	−.050
Status show-off (c_show)	−.036	.043	−.067	−.854	.041
Prestige symbolization (c_prstg)	.017	−.002	.210	−.730	−.039
Anti-activity—relaxation (c_relax)	.116	.032	.040	.087	.789
External activities—while traveling (c_acttv)	.149	−.098	.121	−.034	.665
External activities—at stopovers (c_actst)	.160	−.012	.058	−.088	.559
Anti-activity—thinking (c_think)	.346	.036	−.015	−.195	.485
Eigenvalues	8.317	3.159	1.806	1.457	1.222
Explained variance (%)	31.987	12.149	6.947	5.604	4.698
Rotation sums of squared loadings	5.913	3.137	5.567	4.401	3.830

Note: Factors were extracted through 13 rotations.

Table 8 Exploratory Factor Analysis of Psychometric Items: Shopping Travel

Items (variables)	**1 (Affective)**	**2 (Primary)**	**3 (Instru-mental)**	**4 (Symbolic)**	**5 (On-the-way)**
Amenities (s_amnt)	.808	.003	−.040	−.124	.040
Exposure to outdoors (s_outdr)	.784	.033	−.031	−.099	.139
Buffer (s_buffr)	.772	.020	.118	−.004	.163
Mental therapy (s_thrpy)	.715	−.044	−.122	.024	.007
Variety-seeking (s_diff)	.705	−.028	−.036	.018	−.133
Curiosity for information (s_curis)	.644	.051	.068	.090	.029
Escape (s_escp)	.501	−.061	−.049	.243	−.133
Destination variety (s_dvari)	−.052	.845	−.105	−.069	−.006
Destination quality (s_dqual)	.109	.813	.134	−.015	−.015
Destination uniqueness (s_duniq)	−.007	.752	.099	.163	−.023
Destination density (s_ddens)	−.036	.709	−.166	−.125	.030
Control (s_ctrl)	.219	−.009	−.695	.010	−.255
Convenience (s_cnvc)	.117	−.001	−.659	−.176	.225
Comfort (s_cmfrt)	−.002	−.071	−.652	.010	.299
Safety (s_safe)	−.129	.071	−.624	−.016	.170
Independence (s_indep)	.223	−.035	−.615	.009	−.280
Privacy (s_prvcy)	.023	−.014	−.574	.263	.183
Environmental concerns (s_envrn)	−.008	.167	−.451	.204	−.117
Physical exercise (s_exerc)	.204	.042	−.405	.402	−.204
Lifestyle expression (s_style)	.016	−.039	.073	.823	.091
Status show-off (s_show)	−.005	.046	.091	.739	.228
Prestige symbolization (s_prstg)	.041	−.039	−.251	.698	−.117
Anti-activity—relaxation (s_relax)	.103	−.064	−.051	.218	.699
External activities—while traveling (s_acttv)	.313	−.007	−.221	.070	.505
External activities—at stopovers (s_actst)	.160	.032	−.294	−.029	.475
Anti-activity—thinking (s_think)	.369	.025	.016	.253	.418
Eigenvalues	7.135	2.649	1.799	1.619	1.421
Explained variance (%)	27.442	10.187	6.920	6.225	5.466
Rotation sums of squared loadings	5.674	2.556	4.537	3.371	2.253

Note: Factors were extracted through 9 rotations.

Table 9 Exploratory Factor Analysis of Psychometric Items: Leisure Travel

Items (variables)	1 (Affective)	2 (Primary)	3 (Symbolic)	4 (Instru-mental)	5 (On-the-way)
Variety-seeking (l_diff)	.781	.019	−.004	−.017	−.015
Amenities (l_amnt)	.766	−.110	−.062	.055	.063
Curiosity for information (l_curis)	.732	.095	.037	−.131	.142
Exposure to outdoors (l_outdr)	.718	−.152	−.124	.037	.145
Mental therapy (l_thrpy)	.715	−.087	.046	.067	.011
Buffer (l_buffr)	.671	−.025	.032	−.025	.180
Escape (l_escp)	.646	.094	.111	.020	−.132
Destination quality (l_dqual)	.055	.896	−.034	−.061	.034
Destination density (l_ddens)	−.058	.889	−.005	−.022	.013
Destination variety (l_dvari)	−.045	.879	.020	−.024	.009
Destination uniqueness (l_duniq)	−.010	.828	−.074	.083	−.014
Lifestyle expression (l_style)	.030	.000	.849	−.109	.015
Status show-off (l_show)	.063	−.047	.786	−.163	.087
Prestige symbolization (l_prstg)	−.081	.003	.726	.239	.015
Comfort (l_cmfrt)	.017	.039	−.054	.677	.275
Safety (l_safe)	−.079	−.057	−.069	.670	.003
Convenience (l_cnvc)	.091	−.006	−.154	.637	.227
Independence (l_indep)	.324	−.033	−.008	.585	−.348
Control (l_ctrl)	.342	.044	.031	.550	−.159
Privacy (l_prvcy)	−.004	.025	.300	.548	.258
Environmental concerns (l_envrn)	−.043	.071	.176	.449	.005
Physical exercise (l_exerc)	.292	.091	.260	.416	−.237
Anti-activity—relaxation (l_relax)	.153	.032	.043	.017	.684
External activities—while traveling (l_acttv)	.266	.021	.059	.139	.535
External activities—at stopovers (l_actst)	.021	−.023	.154	.188	.532
Anti-activity—thinking (l_think)	.409	.062	−.001	.072	.449
Eigenvalues	6.901	3.255	1.810	1.691	1.352
Explained variance (%)	26.541	12.519	6.962	6.503	5.200
Rotation sums of squared loadings	5.759	3.199	2.801	4.155	2.559

Note: Factors were extracted through 8 rotations.

Table 10 Exploratory Factor Analysis of Psychometric Items: Overall Travel

Items (variables)	**1 (Affective)**	**2 (Instrumental)**	**3 (Primary)**	**4 (Symbolic)**	**5 (On-the-way)**
Amenities (mean_amnt)	.726	.217	−.114	.271	.071
Buffer (mean_buffr)	.710	.120	−.060	.292	.177
Mental therapy (mean_thrpy)	.704	.292	−.070	.237	.166
Variety-seeking (mean_diff)	.683	.180	−.030	.177	.214
Exposure to outdoors (mean_outdr)	.679	.162	−.103	.362	.113
Curiosity for information (mean_curis)	.645	.048	.069	.249	.236
Escape (mean_escp)	.576	.170	−.003	.039	.285
Control (mean_ctrl)	.299	.744	.047	.046	.102
Independence (mean_indep)	.305	.719	−.038	−.036	.073
Comfort (mean_cmfrt)	.006	.609	.031	.492	.102
Convenience (mean_cnvc)	.112	.587	.000	.515	−.012
Safety (mean_safe)	−.068	.572	.046	.340	.001
Privacy (mean_prvcy)	.083	.570	.032	.462	.352
Physical exercise (mean_exerc)	.359	.533	.125	−.038	.386
Environmental concerns (mean_envrn)	.137	.488	.217	.094	.200
Destination variety (mean_dvari)	−.084	.059	.904	−.009	.045
Destination quality (mean_dqual)	.021	−.040	.889	.003	.028
Destination density (mean_ddens)	−.099	.100	.843	.029	.045
Destination uniqueness (mean_duniq)	.014	.051	.831	−.014	.057
Anti-activity—relaxation (mean_relax)	.168	−.006	−.005	.772	.164
External activities—while traveling (mean_acttv)	.318	.182	−.044	.675	.174
External activities—at stopovers (mean_actst)	.212	.142	.031	.634	.105
Anti-activity—thinking (mean_think)	.470	.068	.047	.542	.247
Lifestyle expression (mean_style)	.135	.004	.031	.103	.860
Status show-off (mean_show)	.096	−.048	.069	.170	.790
Prestige symbolization (mean_prstg)	.124	.316	.065	.089	.754
Eigenvalues	8.074	3.304	1.934	1.527	1.436
Explained variance (%)	31.055	12.708	7.439	5.873	5.523
Rotation sums of squared loadings	4.013	3.374	3.133	3.087	2.668

Note: For overall travel, this research used the mean of the three-time responses, each of which was given for commuting, shopping, and leisure travel. Factors were extracted through 13 rotations.

Throughout the four sets of EFA, psychometric variables were consistently loaded onto the same factors as follows.

- Primary benefits (4 variables): destination density, destination variety, destination quality, and destination uniqueness
- On-the way benefits or synergy benefits (4 variables): anti-activity—relaxation, anti-activity—thinking, external activities—while traveling, and external activities—at stopovers
- Symbolic benefits (3 variables): status show-off, lifestyle expression, and prestige symbolization
- Instrumental benefits (8 variables): convenience, comfort, privacy, and safety; also, *environmental concerns, control, independence, and physical exercise*
- Affective benefits (7 variables): variety-seeking, curiosity for information, buffer, amenities, exposure to outdoors, escape, and mental therapy

The most notable result is that among those items that were suggested as indicator variables of different factors, four items were classified as suggested (see those in italic in the above lists): environmental concerns (initially a normative benefit), control, independence, and physical exercise (initially affective benefits). That is, these items turned out to share characteristics with other instrumental benefit items, that is, they all hinge on the mechanical characteristics of travel modes. Based on a larger number of survey respondents and four different sets of factor analysis, this result confirms the factor–variable relationships that nine interviewees suggested (Interviews 1, 3, 4, 9, 11, 13, 14, 15, and 24). Unlike these four relationships, the other eight suggested relationships (by Interviews 3, 10, 17, 18, 19, 20, and 22) were not supported. In fact, except the four items, all items were classified into the predefined categories.

In summary, the mixed methods approach (i.e., 24 interviews and 4 sets of EFA) firmly identified the existence of five categories of travel benefits in Seoul: primary benefits, on-the way benefits or synergy benefits, symbolic benefits, instrumental benefits, and affective benefits. These categories or factors comprised the same items for three different purposes of travel as well as for overall travel. Accordingly, this research used the five factors to represent travel benefits in the subsequent CFA and SEM. Meanwhile, it originally considered six factors, but out of a total of three normative benefit items, two items (social norms and personal norms) were incorporated into symbolic benefit items and through EFA, the other one (environmental concerns) was reclassified as an instrumental benefit. Accordingly, the normative benefit factor dropped all of its items, and this research did not consider the factor in the empirical analysis.

CHAPTER 5.

MAIN TEST: SURVEY

5.1 Descriptive Statistics

Among research variables, those for urban compactness, sociodemographics, and trip frequencies were available both from the survey and MHTS, and this research directly compared their descriptive statistics with each other and tested the representativeness of the sample. On the other hand, travel utility variables were measured only through the survey. Thus, their statistics are separately shown below.

5.1.1 Descriptive Statistics of Urban Compactness and Sociodemographics

Table 11 shows the means, standard deviations, and minimums and maximums of urban compactness and sociodemographic variables that this research calculated using data from the survey as well as those from the 2006 MHTS and its sample; the sample consisted of the same 24 neighborhoods chosen for the survey.

Variables c1–c4 are urban form components that this research employed to evaluate urban compactness. Descriptive statistics from the MHTS sample area are similar to those from the survey; this applies not only to the means, but also to their distributions (i.e., variations and ranges). A merely notable difference or change between 2006 and 2013 is that the population density of the least dense neighborhood (i.e., minimum) increased by 104.07 persons/mile^2.

In contrast, the descriptive statistics of the urban compactness components considerably differ between the sample and the entire MHTS. The difference is because this research has grouped all neighborhoods in Seoul into four types and deliberately sampled from each type the “same” number of neighborhoods, not “proportionally” according to the composition of the urban compactness components.

Although descriptive statistics differ between the MHTS and its sample in relation to urban compactness, sociodemographic compositions were expected to be similar because the MHTS made a random and representative sample of respondents from each neighborhood. As shown from s1 through s7 of Table 11, descriptive statistics between the MHTS and its sample are fairly comparable. Overall, based on the same sampling method of the MHTS, the survey constructed a sample that can represent the entire population in Seoul. (The sample representativeness is statistically examined below.)

Table 11 Descriptive Statistics: Urban Compactness and Sociodemographics

Variables*		MHTS sample (N = 1,664)			MHTS (N = 29,336)			Survey (N = 1,032)		
		Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range
c1	Population density (persons/mile^2)	75,985.19	32,208.105	7,266.36–132,919.40	68,143.05	53,010.797	97.26–411,117.75	75,954.93	32,236.260	7,370.43–132,980.80
c2	Road connectivity (road intersections/mile^2)	496.02	246.558	45.77–1,631.97	896.23	506.431	22.77–2,361.10	496.45	247.161	44.52–1,637.53
c3	Transit availability (transit facilities/mile^2)	77.24	28.628	20.26–146.71	65.88	28.399	3.20–196.60	77.28	28.068	20.56–148.05
c4	Land use mix (Shannon entropy; 0–1)	0.60	0.113	0.19–0.87	0.58	0.150	0.18–0.98	0.61	0.112	0.16–0.85
s1	Household—size (persons)	3.61	1.150	1–7	3.64	1.082	1–9	3.48	1.176	1–7
s2	Household—children (persons)	0.17	0.464	0–3	0.18	0.484	0–4	0.29	0.629	0–3
s3	Household—automobiles (sedans and vans)	0.83	0.656	0–5	0.84	0.613	0–5	0.85	0.600	0–4
s4	Household—income (million won/month)	2.99	1.697	0–6	3.00	1.805	0–6	3.77	2.538	0–19
s5	Individual—gender (1 = female)	0.43	0.495	0–1	0.42	0.512	0–1	0.53	0.499	0–1
s6	Individual—age (years)	39.33	12.916	18–76	39.77	13.140	18–93	40.03	13.036	19–89
s7	Individual—license (1 = yes)	0.12	1.335	0–1	0.14	1.543	0–1	0.68	0.467	0–1

* c0 = urban compactness variables; s0 = sociodemographic variables

5.1.2 Descriptive Statistics of Trip Frequencies

Table 12 presents the descriptive statistics of the trip frequencies that this research calculated from the survey as well as from the MHTS and its sample. In this cross-tab, the cell value was calculated by mode and purpose; for instance, the most upper left cell—the intersection of yA and yC—shows trip frequency by automobile for commuting. Subtotals were also independently calculated. For example, the bottom row shows trip frequencies by travel purpose, that is, trip frequencies for commuting (yC), shopping (yS), and leisure (yL) and the far right column by travel mode, that is, trip frequencies by automobile (yA), public transit (yT), and nonmotorized modes (yN). The bottom right cell, the intersection of two subtotals, carries the overall trip frequency.

Table 12 Descriptive Statistics: Trip Frequencies (One Weekday for the MHTS and Seven Days for the Survey) (Mean; S.D.; Range)

		yC (commuting)	yS (shopping)	yL (leisure)	Subtotal
MHTS sample		yC (commuting)	yS (shopping)	yL (leisure)	Subtotal
(N = 1,664)	yA (automobile)	0.25; 0.442; 0–2	0.02; 0.161; 0–2	0.03; 0.183; 0–2	0.30; 0.498; 0–2
	yT (public transit)	0.55; 0.631; 0–3	0.04; 0.203; 0–2	0.06; 0.288; 0–3	0.66; 0.662; 0–4
	yN (nonmotorized)	0.15; 0.375; 0–2	0.02; 0.155; 0–1	0.03; 0.168; 0–2	0.21; 0.430; 0–2
	Subtotal	0.96; 0.521; 0–4	0.09; 0.295; 0–2	0.12; 0.381; 0–3	1.17; 0.444; 1–5
MHTS		yC (commuting)	yS (shopping)	yL (leisure)	Subtotal
(N = 29,336)	yA (automobile)	0.26; 0.447; 0–2	0.03; 0.165; 0–3	0.03; 0.190; 0–3	0.32; 0.504; 0–4
	yT (public transit)	0.57; 0.672; 0–4	0.05; 0.227; 0–3	0.06; 0.269; 0–5	0.68; 0.703; 0–6
	yN (nonmotorized)	0.14; 0.357; 0–3	0.03; 0.180; 0–3	0.03; 0.194; 0–3	0.20; 0.438; 0–4
	Subtotal	0.98; 0.575; 0–6	0.10; 0.331; 0–3	0.12; 0.384; 0–5	1.18; 0.493; 1–6
Survey		yC (commuting)	yS (shopping)	yL (leisure)	Subtotal
(N = 1,032)	yA (automobile)	1.51; 2.669; 0–21	0.79; 1.651; 0–12	1.06; 3.129; 0–50	3.36; 5.385; 0–50
	yT (public transit)	5.26; 7.007; 0–60	2.17; 4.150; 0–40	1.72; 3.213; 0–30	9.15; 11.709; 0–130
	yN (nonmotorized)	4.65; 7.443; 0–50	2.93; 6.920; 0–60	3.33; 6.088; 0–40	10.91; 16.525; 0–100
	Subtotal	11.42; 11.399; 0–90	5.89; 9.790; 0–83	6.11; 8.622; 0–80	23.41; 25.003; 0–220

The MHTS and its sample have comparable descriptive statistics, which in addition to those of sociodemographic variables, suggests that the 24 sampled neighborhoods as a whole represent all neighborhoods quite well.

According to the one-weekday MHTS and its sample, the dominant mode of travel is public transit (mean = 0.66 trip/day in the sample and 0.68 trip/day in the entire MHTS) for any purpose of travel as well as on the whole (see the subtotal in the right end column). The public transit share is larger than or equal to the sum of the shares of the automobile and nonmotorized modes. However, this interpretation does not apply to the one-week survey. Nonmotorized trips (mean = 10.91 trips/week) outnumber automobile trips (mean = 9.15 trips/week) and transit trips (mean = 3.36 trips/week). The difference is mainly because the survey counted short-distance nonmotorized trips that the MHTS asked respondents not to report. This reason and others that made the difference are detailed below.

5.1.2.1 Differences in Measuring Trip Frequencies

This research does not directly compare statistical outcomes from the one-weekday MHTS and those from the one-week survey. One reason is that the survey also included weekend trips whose patterns differ from those of weekday trips (Holden and Norland 2005): On weekends, most people do not work, and commuting trips do not usually occur. Instead, they are given more time for unique and special shopping and leisure activities that are less likely to take place on weekdays. For the activities, people are more likely to use their preferred mode of travel than to choose a mode based purely on economic motives.

Furthermore, travel surveys administered by national governments and metropolitan planning organizations typically face methodological issues that this research has taken into account. The surveys ignore nonmotorized links that support motorized travel—for example, a trip of walk–automobile–walk is coded as an automobile trip—so they undercount nonmotorized trips (Forsyth, Agrawal, and Krizek 2012, Weinstein and Schimek 2005), in the given example, two walking links from and to parking lots are not counted even if they take considerable time. Litman (2011b) found that in the U.S., only 7% of commuting trips are made purely by walking, but around 20% involve walking links. In Germany, even though 22% of total trips are made entirely by walking, 70% include walking links (Litman 2003). According to Weinstein and Schimek (2005), around 12% of total trips in the U.S. involve nonmotorized travel and this is twice as high as the level that was previously reported. In this sense, these studies (Weinstein and Schimek 2005, Litman 2003, 2011b) raised a question about the measurement accuracy of metropolitan and national travel surveys, with respect to nonmotorized travel.

Also, most national and metropolitan surveys, including the MHTS, ask respondents not to report walk trips if they have taken less than a certain distance or time. These short-time trips are mostly made for shopping and leisure purposes (Greater London Authority 2010) and thus, shopping and leisure trips might be severely underestimated. Indeed, the MHTS requested respondents to ignore short- time trips “such as to go to local stores or restaurants and for transfer” and this undercounting issue has applied only to shopping and leisure trips because the respondents were asked to count short-time trips “if their purpose was commuting to work or school”.

In summary, the MHTS has issues regarding the measurement of (1) weekend trips (a possible source of the underestimation of shopping and leisure trips), (2) nonmotorized link trips, and (3) nonmotorized short-time trips for shopping and leisure. These issues may have resulted in the difference between descriptive statistics from the MHTS and those from the survey; they should explain why the survey showed that the dominant mode of travel is nonmotorized modes, as in Table 12.

5.1.3 Descriptive Statistics of Travel Utility

Indicator variables of the travel utility factor (i.e., primary benefits, secondary benefits, and travel costs as stood for by trip time) were collected only for the survey, particularly for SEM models in which the factor is specified.

To measure travel benefits, this research provided the same psychometric item three times for three travel purposes, on a 7-point Likert-type rating scale. Table 13 shows their descriptive statistics. Overall, respondents have been satisfied with transportation safety for any purpose of travel; the mean is higher than five for all travel purposes (1 = “Very unsatisfied” and 7 = “Very satisfied”). Also, particularly when traveling for leisure, they were happy with convenience (“Possibility of traveling where I want, when I want”), amenities (“A lovely view, a pleasant encounter, a surprising look”), exposure to outdoors (“Getting outdoors”), and control (“Possibility of having control over my journey”) (i.e., for the variables, mean ≥ 5).

For statistical analysis, all psychometric variables have good variations. That is, standard variations are sufficiently high and the maximum and minimum response options were taken for all of the variables.

Table 13 Descriptive Statistics: Travel Benefits

Factors	Variables	Variable descriptions	Commuting			Shopping			Leisure		
			Mean	**S.D.**	**Range**	**Mean**	**S.D.**	**Range**	**Mean**	**S.D.**	**Range**
Primary benefits	x_ddens	Destination density	3.20	1.572	1–7	4.59	1.586	1–7	3.20	1.569	1–7
	x_dvari	Destination variety	3.04	1.526	1–7	4.18	1.575	1–7	3.06	1.539	1–7
	x_dqual	Destination quality	3.03	1.509	1–7	3.85	1.453	1–7	3.13	1.563	1–7
	x_duniq	Destination uniqueness	2.90	1.548	1–7	3.47	1.549	1–7	3.11	1.645	1–7
Secondary benefits	x_actst	External activities—at stopovers	3.95	1.939	1–7	3.83	1.631	1–7	3.79	1.600	1–7
	x_think	Anti-activity—thinking	3.86	1.761	1–7	3.78	1.588	1–7	4.35	1.695	1–7
	x_relax	Anti-activity—relaxation	3.78	1.903	1–7	3.57	1.676	1–7	4.19	1.764	1–7
	x_acttv	External activities—while traveling	3.99	1.805	1–7	3.87	1.626	1–7	4.35	1.653	1–7
	x_cmfrt	Comfort	4.62	1.780	1–7	4.55	1.569	1–7	4.86	1.612	1–7
	x_prvcy	Privacy	4.36	1.815	1–7	4.32	1.689	1–7	4.51	1.729	1–7
	x_cnvc	Convenience	4.78	1.902	1–7	4.89	1.579	1–7	5.06	1.651	1–7
	x_safe	Safety	5.12	1.867	1–7	5.12	1.623	1–7	5.20	1.646	1–7
	x_show	Status show-off	3.25	1.718	1–7	3.28	1.582	1–7	3.32	1.633	1–7
	x_style	Lifestyle expression	3.60	1.807	1–7	3.41	1.631	1–7	3.33	1.610	1–7
	x_prstg	Prestige symbolization	3.92	1.812	1–7	3.75	1.645	1–7	3.70	1.681	1–7
	x_envrn	Environmental concerns	4.44	1.757	1–7	4.48	1.610	1–7	4.54	1.643	1–7
	x_diff	Variety-seeking	3.42	1.830	1–7	4.13	1.715	1–7	4.68	1.794	1–7
	x_curis	Curiosity for information	3.33	1.705	1–7	3.90	1.657	1–7	4.24	1.770	1–7
	x_buffr	Buffer	4.09	1.770	1–7	4.07	1.569	1–7	4.32	1.723	1–7
	x_amnt	Amenities	3.81	1.888	1–7	4.45	1.722	1–7	5.09	1.729	1–7
	x_outdr	Exposure to outdoors	4.04	1.849	1–7	4.58	1.670	1–7	5.14	1.603	1–7
	x_ctrl	Control	4.57	1.786	1–7	4.76	1.551	1–7	5.09	1.586	1–7
	x_indep	Independence	4.71	1.754	1–7	4.77	1.556	1–7	4.97	1.585	1–7
	x_escp	Escape	3.47	1.811	1–7	3.68	1.728	1–7	4.17	1.943	1–7
	x_exerc	Physical exercise	4.02	1.792	1–7	4.13	1.657	1–7	4.64	1.674	1–7
	x_thrpy	Mental therapy	4.18	1.841	1–7	4.30	1.653	1–7	4.87	1.744	1–7

Along with travel benefit variables, the utility factor is defined by trip time. In Table 14, cell values were calculated by mode and purpose. For example, the first row shows the mean, standard deviation, minimum, and maximum of automobile commuting time for the one-week survey period; it also carries the mean of the travel time per trip (i.e., trip time or trip duration). Subtotals present travel time consumed for each of the three purposes of travel and travel time by each travel mode is shown in a section named "Overall". The bottom line carries the descriptive statistics of the total travel time, without regard to travel purpose and mode.

Table 14 Descriptive Statistics: Weekly Travel Time in Minutes

		[Weekly travel time]			[Trip time]
		Mean	**S.D.**	**Range**	**Mean**
uC3	uA3 (automobile)	60.30	180.971	0–2,400	39.93
(commuting)	uT3 (public transit)	152.84	383.793	0–7,200	29.06
	uN3 (nonmotorized)	127.69	770.374	0–14,400	27.46
	Subtotal	340.84	872.522	0–14,400	29.85
uS3	uA3 (automobile)	40.70	129.851	0–1,800	51.52
(shopping)	uT3 (public transit)	64.34	154.908	0–1,800	29.65
	uN3 (nonmotorized)	125.32	392.933	0–5,400	42.77
	Subtotal	230.36	402.924	0–5,400	39.11
uL3 (leisure)	uA3 (automobile)	99.63	755.299	0–16,800	93.99
	uT3 (public transit)	64.33	145.746	0–1,800	37.40
	uN3 (nonmotorized)	84.73	199.817	0–1,800	25.44
	Subtotal	248.69	795.263	0–16,800	40.70
Overall	uA3 (automobile)	200.63	820.996	0–16,950	59.71
	uT3 (public transit)	281.51	486.077	0–7,290	30.77
	uN3 (nonmotorized)	337.74	396.117	0–5,430	30.96
	Total	819.88	413.341	0–16,950	35.02

Note: Trip destinations outside Seoul are considered; mean weekly travel time (mean trip time) = travel minutes per week (per trip) / all respondents including those who did not use the travel mode concerned; mean automobile traffic speed in Seoul = 14.19 miles/hour (Traffic Operation Information Service 2009).

For commuting, survey respondents traveled by public transit for the longest time (mean = 152.84 minutes/week), followed by nonmotorized modes (mean = 127.69 minutes/week) and the automobile (mean = 60.30 minutes/week). This is consistent with the result that public transit was the most frequently used mode (mean = 5.26 trips/week), followed by nonmotorized modes (mean = 4.65 trips/week) and the automobile (mean = 1.51 trips/week) (see Table 12).

In terms of the total time for shopping travel, nonmotorized modes were the most prominent (mean = 125.32 minutes/week). In contrast, the automobile was the least used mode of travel (mean = 40.70 minutes/week), but trip time by automobile was the longest (mean = 51.52 minutes/trip). This may be because nonmotorized modes are often used for daily shopping travel to local stores—almost none of the local stores in Seoul are equipped with parking lots—and the automobile is preferred for infrequent shopping travel, for example, to go to suburban-style shopping centers.

With regard to the total time for leisure travel, the automobile was the most important mode (mean = 99.63 minutes/week), and this was also the case in terms of trip time (mean = 93.99 minutes/trip). The mean values are similar, which implies that on average, survey respondents use the automobile for leisure travel about once a week. In contrast, although the mean trip time was shorter when they walked or biked for leisure (mean = 25.44 minutes/trip), such nonmotorized leisure trips occurred more frequently (mean = 84. 73 minutes/week). This may suggest that for usual travel to local parks and other leisure facilities in their neighborhoods, survey respondents tend to walk or bike.

Overall, the longest travel time was taken by nonmotorized modes for the one-week survey period (mean = 337.74 minutes/week and 30.96 minutes/trip). By comparison, the time for each trip was the longest when people drove the automobile although it was the least frequently used (mean = 200.63 minutes/week and 59.71 minutes/trip). This shows that in general, the highest trip costs were spent for automobile travel.

5.2 Sample Representativeness

Statistically, a sample is called representative if its characteristics of interest are approximately the same as those from the population. Then, the representative sample allows analytical results to be generalized from the sample to the population, adult residents in Seoul for this research. This research tested the sample representativeness in two ways: by the χ^2 goodness-of-fit test and by the one-sample *t*-test (Huizingh 2007). The *t*-test is used to see if a sample is representative of a population with a specific mean. In comparison, as a nonparametric test (i.e., no particular distribution in mind), the χ^2 test is used to determine whether a sample came from a population with a specific distribution.[29] That is, the one-sample *t*-test compares the mean of the sample with that of the population and the one-sample χ^2 test compares their distributions.

Seemingly, the χ^2 test may be preferred since it uses the full distribution instead of just the mean. However, insomuch as the test analyses if the observed frequencies of the categories of a variable agree with the expected frequencies (taken from the population), data must be "categorized." Also, if more than 20% of the expected frequencies have less than five counts, the test requires a grouping of the categories. Thus, this test cannot use

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[29] Thus, both of the χ^2 goodness-of-fit test and the one-sample *t*-test are available only if the population values are known as with the case of this research.

the data as they were collected. Indeed, the survey measured the age variable in the unit of year, but this research grouped them into decadal categories to conduct the χ^2 test. Also, because few respondents were more than 70 years of age (maximum = 89), the highest category was defined as "70 years or above." In contrast, the one-sample *t*-test analyzes the data as they stand, and thus, this research used it to complement the χ^2 test.

For both tests, the null hypothesis is that the observed distribution or mean (from the sample) is the same as the expected distribution or mean (from the population). They both test the representativeness of the sample with respect to one characteristic, that is, one variable at a time.

Table 15 shows the frequencies of each variable from the sample and from the population (MHTS); the column "Expected *N*" shows frequencies that are expected in the sample if its distribution is the same as that of the population; they were calculated based on the entire MHTS. The column "Residual" shows the degree to which categories are under- or over-represented [Residual = observed frequencies calculated from the sample (those in the "MHTS Sample" column) − Expected *N*]. Test values for the one-sample *t*-tests are the same as those shown in above Tables 11 and 12 [e.g., for the variable "Household—size (s1)", test value = 3.64].

Table 15 Tests of Sample Representativeness

	MHTS	%	MHTS Sample	%	Expected *N*	Residual
Household—size (s1)						
1 (living alone)	904	3.08%	63	3.79%	51.3	11.7
2	3,249	11.08%	190	11.42%	184.4	5.6
3	7,408	25.25%	421	25.30%	420.2	.8
4	13,008	44.34%	731	43.93%	737.8	−6.8
5	3,650	12.44%	197	11.84%	207.0	−10.0
≥ 6	1,117	3.81%	62	3.73%	63.4	−1.4
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(5) = 3.444$ ($p = 0.632$); $t(1,663) = -1.022$ ($p = 0.307$)					
Household—children (s2)						
0	25,149	85.73%	1,431	86.00%	1426.4	4.6
1	3,079	10.50%	178	10.70%	174.7	3.3
≥ 2	1,108	3.78%	55	3.31%	62.9	−7.9
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(2) = 1.068$ ($p = 0.586$); $t(1,663) = -0.503$ ($p = 0.615$)					
Household—automobiles (s3)						
0	8,029	27.37%	470	28.25%	455.4	14.6
1	18,162	61.91%	1,001	60.16%	1030.2	−29.2
2	2,983	10.17%	181	10.88%	169.2	11.8
≥ 3	162	0.55%	12	0.72%	9.2	2.8
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(3) = 2.997$ ($p = 0.392$); $t(1,663) = -0.627$ ($p = 0.531$)					
Household—income (s4)						
1 million won	2,807	9.57%	164	9.86%	159.2	4.8
2 million won	6,723	22.92%	410	24.64%	381.4	28.6
3 million won	7,145	24.36%	404	24.28%	405.3	−1.3
4 million won	9,359	31.90%	489	29.39%	530.8	−41.8
≥ 5 million won	3,302	11.26%	197	11.84%	187.3	9.7
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(4) = 6.083$ ($p = 0.193$); $t(1,663) = -0.173$ ($p = 0.862$)					
Individual—gender (s5)						
Male	16,968	57.84%	955	57.39%	962.5	−7.5
Female	12,368	42.16%	709	42.61%	701.5	7.5
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(1) = 0.137$ ($p = 0.711$); $t(1,663) = 0.502$ ($p = 0.616$)					

Table 15 (continued)

	MHTS	%	MHTS Sample	%	Expected N	Residual
Individual—age (s6)*						
10s	1,392	4.75%	90	5.41%	79.0	11.0
20s	6,477	22.08%	357	21.45%	367.4	−10.4
30s	6,810	23.21%	424	25.48%	386.2	37.8
40s	7,639	26.04%	425	25.54%	433.3	−8.3
50s	4,738	16.15%	244	14.66%	268.7	−24.7
60s	1,955	6.66%	111	6.67%	110.8	.2
≥ 70s	325	1.11%	13	0.78%	18.5	−5.5
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(6) = 9.568$ ($p = 0.144$); $t(1,663) = -1.392$ ($p = 0.164$)					
Individual—license (s7)						
Yes	21,288	72.57%	1,190	71.51%	1207.6	−17.6
No	8,048	27.43%	474	28.49%	456.4	17.6
Sum	29,336	100.00%	1,664	100.00%		
	$\chi^2(1) = 0.931$ ($p = 0.334$); $t(1,663) = -0.697$ ($p = 0.486$)					
Trip frequencies (y)						
Auto commuting	7,705	21.84%	421	21.67%	424.3	−3.3
Transit commuting	16,992	48.16%	922	47.45%	935.7	−13.7
Nonmotorized commuting	3,981	11.28%	257	13.23%	219.1	37.9
Auto shopping	747	2.12%	38	1.96%	41.2	−3.2
Transit shopping	1,400	3.97%	67	3.45%	77.1	−10.1
Nonmotorized shopping	897	2.54%	41	2.11%	49.3	−8.3
Auto leisure	890	2.52%	47	2.42%	49.0	−2.0
Transit leisure	1,706	4.84%	104	5.35%	94.0	10.0
Nonmotorized leisure	965	2.74%	46	2.37%	53.2	−7.2
Sum	35,283	100.00%	1,943	100.00%		
	$\chi^2(8) = 11.870$ ($p = 0.157$); $t(1,663) = -1.132$ ($p = 0.258$)					

* Originally measured in the unit of year, age data were grouped for statistical use.

Regarding the distributions of the individual variables, firstly, people in the population mean of age, that is, those in their 30’s were somewhat overrepresented (residual = 37.8; it suggests that about 38 people were oversampled), and instead people in other age groups, particularly in their 20’s (residual = −10.4) and 50’s (residual = −24.7) were slightly underrepresented. However, the degree of the departure from the population distribution (i.e., sampling bias) was ignorable as shown in the insignificant χ^2 statistic (9.568; $p = 0.144$).

In terms of trip frequencies, nonmotorized commuting was a bit overrepresented (residual = 37.9). However, its burden was not imposed on a specific category, but quite evenly transferred across the entire sample as shown in negative residual values for most categories. Also, the insignificant χ^2 statistic (11.870; $p = 0.157$) suggests that the age distribution in the sample duly represents the population distribution.

As stated in “A.3.1.2 Sampling Interviewees”, income and automobile ownership are arguably two most important sociodemographic variables that differentiate travel behavior. In terms of household income, people whose household income is 4 million won were somewhat underrepresented (residual = −41.8) and instead, those with 2 million won (residual = 28.6) and with equal to or more than 5 million won (residual = 9.7) were overrepresented. Regarding automobile ownership, people whose household has one automobile have been modestly underrepresented in the sample (residual = −29.2) and instead, those with no cars (residual = 14.6) or two cars (residual = 11.8) were overrepresented. For both of the income and automobile ownership variables, the underrepresented category was the majority group. That is, this tendency allowed other minor groups to be slightly oversampled. For example, about 62% of people in Seoul own one car in their household, and it may be desirable to slightly undersample those in this category. In any case, the χ^2 statistics—for automobile ownership, χ^2 = 2.997 (p = 0.392); for income, χ^2 = 6.083 (p = 0.193)—show that the distributions of the two variables duly reflect those in the population.

The single most important result is that in terms of their distributions and means, modest discrepancies between the sample and the population are negligible, insofar as the sample representativeness is statistically accepted for all of the variables available from the MHTS and survey: For all χ^2 tests and t-tests, $p > 0.1$. Thus, analytical findings of this research based on the sample may be transferrable to all neighborhoods in Seoul.

As discussed in "5.1.1 Descriptive Statistics of Urban Compactness and Sociodemographics", because a sample of neighborhoods was made through nonproportional sampling, its distributions and means in urban compactness components cannot be directly compared with those from the population, that is, neither χ^2 tests nor t-tests are available. To check the sample representativeness based on urban compactness, this research examined configural invariance (consistency of the effects of urban compactness components): If the effects estimated based on the sample are similar to those based on the entire neighborhoods, the configural invariance is confirmed (to be shown later).

5.3 Confirmatory Factor Analysis

This research performed confirmatory factor analysis (CFA) of variables on travel benefits to test the construct validity of the psychometric measure.[30] Byrne (2010) also recommended that CFA be performed before full-scale SEM to confirm that the measurement of each variable is psychometrically sound.[31] Thus, for both psychometric factors (i.e., primary benefits and secondary benefits), this research has independently undertaken factor analysis in a "confirmatory" fashion: CFA for primary benefits and higher-order CFA for secondary benefits. The reason for the use of higher-order CFA is that secondary benefits consist of four factors—synergy benefits, instrumental benefits, symbolic benefits, and affective benefits—as confirmed by a mixed methods approach (i.e., 24 interviews and 4 sets of EFA). Subsequently, as input values of primary and secondary benefits in full-scale SEM models, this research used their factor scores for the purpose of relaxing computational complexity: With an increasing number of factors, the complexity rises exponentially (Temme, Paulssen, and Dannewald 2007), which often makes SEM models unidentifiable (e.g., Scheiner and Holz-Rau 2007).

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[30] Construct validity should be checked through CFA rather than through EFA although the latter is still accepted in the literature owing to its historical importance, that is, because it has long been used to test the validity.

[31] Full-scale SEM is one that consists of the structural model (path analysis of the factor–factor relationships) and the measurement model (CFA of the factor–variable relationships). Sometimes, however, an analysis based only on the structural model is also called SEM (for such an analysis, SEM = path analysis).

5.3.1 Confirmatory Factor Analysis of Primary Travel Benefits

Primary benefit variables were extracted as a single factor through CFA (accordingly, factor scores are the same as those from the measurement model of respective full-scale SEM models). Figure 13 shows standardized path coefficients (factor loadings) of four sets of CFA that were returned from Amos, statistical software designed for CFA and SEM.

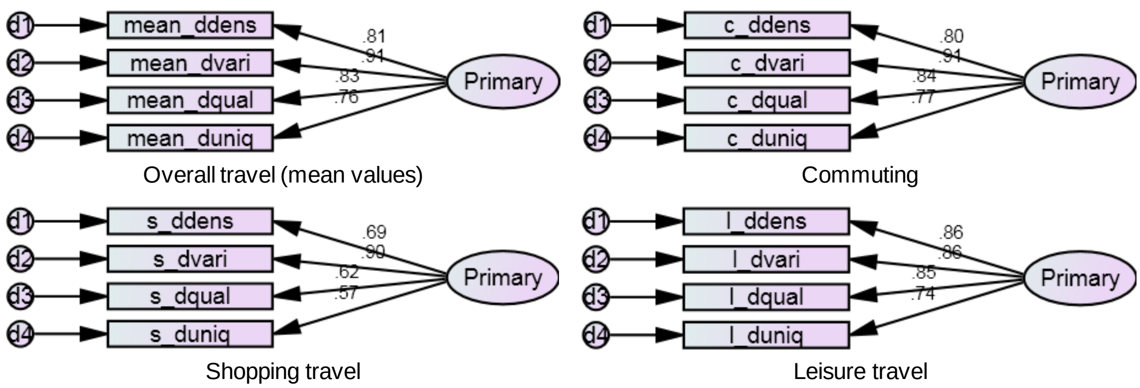

Figure 13 Standardized Path Coefficients: Primary Travel Benefits
Note: mean_ = mean value of the three responses given according to three travel purposes, c_ = response for commuting, s_ = response for shopping travel, and l_ = response for leisure travel; ddens = destination density, dvari = destination variety, dqual = destination quality, and duniq = destination uniqueness; the four diagrams were produced by Amos.

Standardized coefficients shown in the above figure are the same as those in Table 16. Although the table also shows unstandardized estimates, they do not carry meaningful information insofar as CFA (and SEM) requires one of the factor loadings to be fixed to one for the purpose of model identification. In the table, C.R. (critical ratio) is interpreted as *t*-values for regression analysis, that is, if C.R. is greater than 1.96, for example, it means that the path concerned is significant at the 95% level of confidence and if it is greater than 2.58, at the 99% level.

As shown, all coefficients in all of the four CFA models are significant. According to SMC (squared multiple correlations), which is the same as R^2 or the variance accounted for by a regression model, shows that in each model, the proportion of the explained variance in the four indicator variables is moderate to large (52.3%–82.1%).

Table 16 Confirmatory Factor Analysis: Primary Travel Benefits

	Indicators	**<---**	**Resultant factor**	**Unstandardized coefficients**	**Standardized coefficients**	**S.E.**	**C.R.**	***p***	**SMC**
Overall travel	mean_ddens	<---	Primary	1.000*	0.811				0.657
	mean_dvari			1.162	0.905	0.035	33.142	***	0.819
	mean_dqual			1.064	0.833	0.035	30.239	***	0.694
	mean_duniq			1.049	0.755	0.039	26.553	***	0.570
Commuting	c_ddens	<---	Primary	1.000*	0.796				0.633
	c_dvari			1.105	0.906	0.034	32.327	***	0.821
	c_dqual			1.015	0.841	0.034	29.893	***	0.708
	c_duniq			0.956	0.773	0.036	26.828	***	0.597
Shopping travel	s_ddens	<---	Primary	1.000*	0.688				0.673
	s_dvari			1.299	0.899	0.063	20.574	***	0.809
	s_dqual			0.830	0.623	0.047	17.790	***	0.588
	s_duniq			0.807	0.568	0.049	16.336	***	0.523
Leisure travel	l_ddens	<---	Primary	1.000*	0.862				0.743
	l_dvari			0.976	0.858	0.029	33.935	***	0.735
	l_dqual			0.978	0.846	0.029	33.311	***	0.716
	l_duniq			0.900	0.740	0.033	27.324	***	0.548

* For each factor, one factor loading should be fixed to 1 and this research fixed the factor loading of destination density [i.e., x_dden <-- Primary = 1, where x_ = mean_ (mean value of the three responses given according to three travel purposes), c_ (response for commuting), s_ (response for shopping travel), and l_ (response for leisure travel)].

*** $p < 0.001$

Note: ddens = destination density, dvari = destination variety, dqual = destination quality, and duniq = destination uniqueness

5.3.2 Higher-Order Confirmatory Factor Analysis of Secondary Travel Benefits

Primary benefits were extracted as a single factor, that is, it could be defined directly by indicator variables (i.e., survey items). In contrast, secondary benefits have four categories or factors to which indicator variables belong: synergy, symbolic, instrumental, and affective benefits. Thus, through higher-order CFA of the indicator variables of secondary travel benefits, this research extracted four first-order factors and then, these factors were again used to extract a single second-order factor, secondary travel benefits.

Figure 14 presents standardized path coefficients of four sets of higher-order CFA. For all travel purposes, synergy benefits and affective benefits turned out to be two of the most important first-order factors: Specifically, for shopping and leisure travel and on the whole, synergy benefits were more important than affective benefits, but for commuting, the opposite holds true. This implies that during commuting, people care more for external activities (e.g., reading a book or newspaper, studying for an exam, running errands at stores, and leaving/collecting children at school) and anti-activities (i.e., relaxation and thinking), but for shopping and leisure travel and overall, such activities and anti-activities are less important than people's internal motives to enjoy travel. In all cases, these two factors were more important than the instrumental benefit factor.

Accordingly, regardless of travel purpose, the factor of symbolic benefits contributed the least to secondary travel benefits. However, the level of the contribution differed by travel purpose. It was the most prominent for commuting (standardized path coefficient = 0.65) and the least for leisure travel (0.36). This implies that people's desires for showing off status, expressing lifestyle (i.e., expressing who they are, what they are), and symbolizing prestige are more important during commuting rather when traveling for leisure.

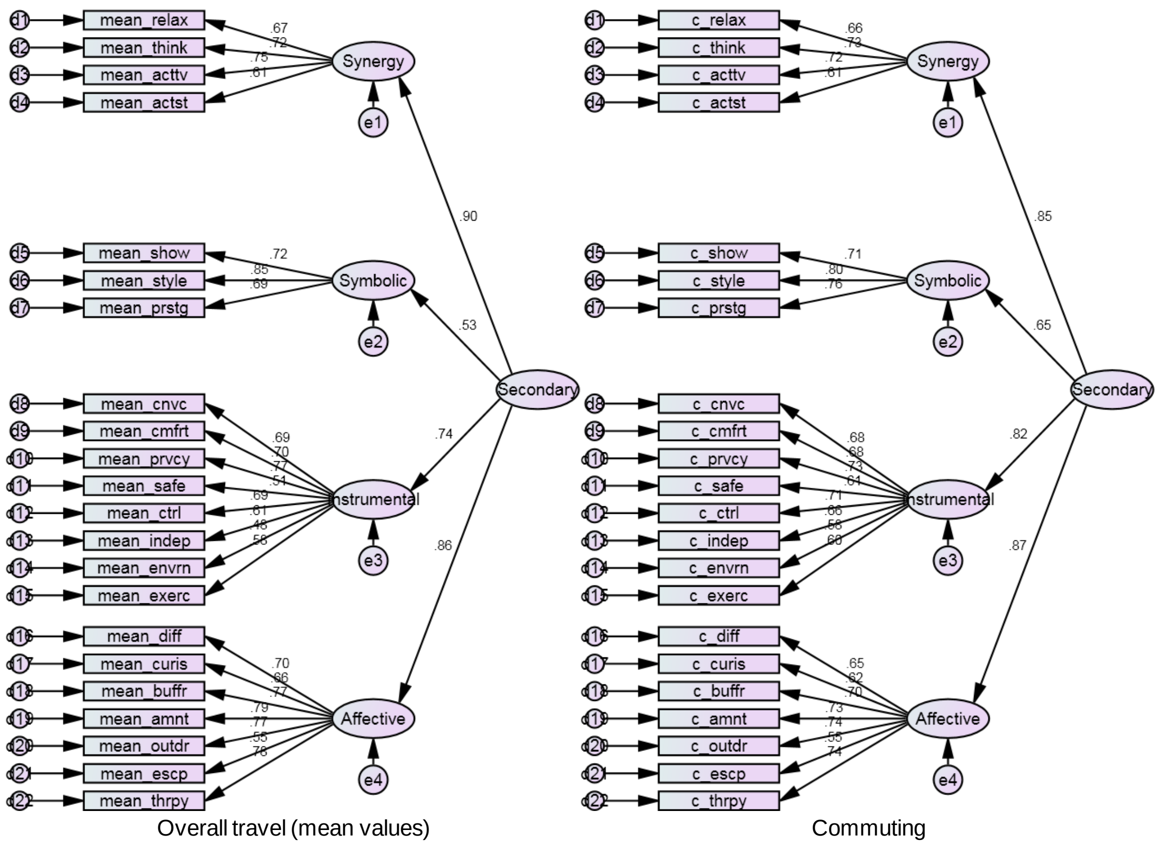

Figure 14 (A) Standardized Path Coefficients of Secondary Travel Benefits: Overall Travel and Commuting

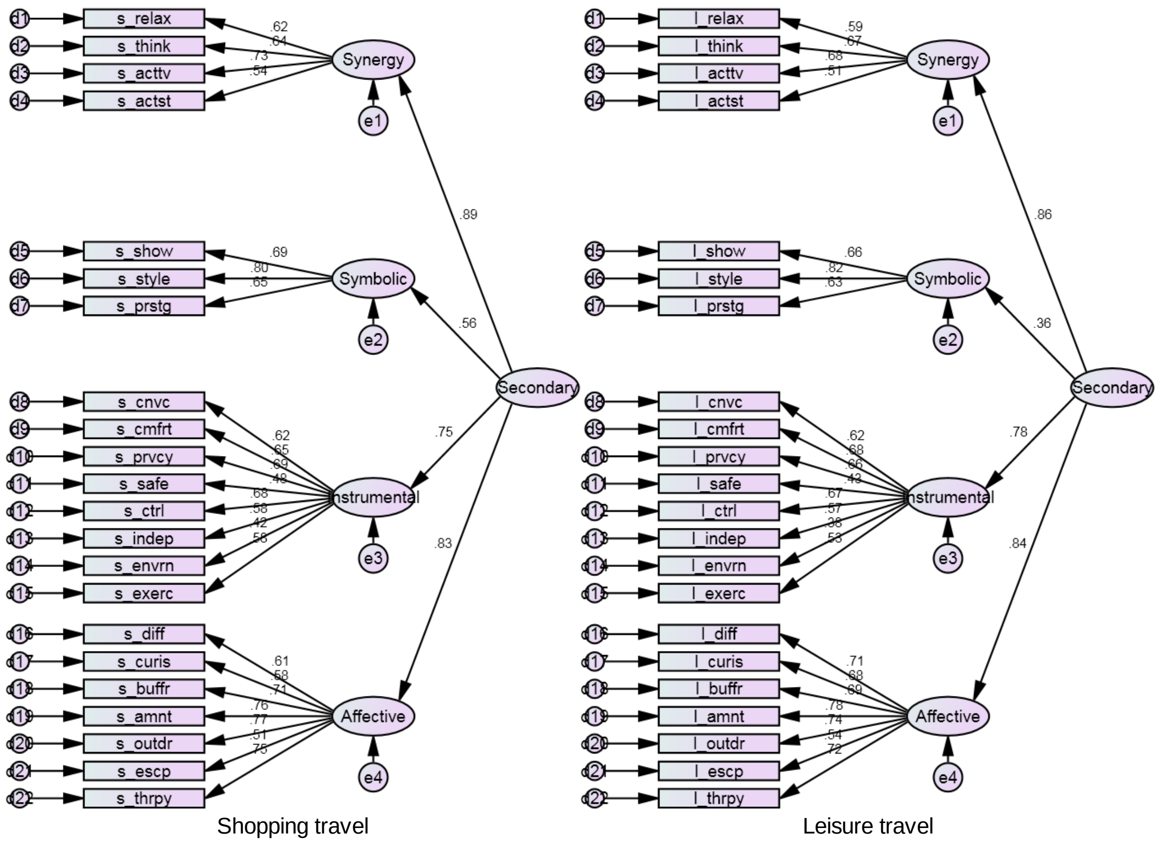

Figure 14 (B) Standardized Path Coefficients of Secondary Travel Benefits: Shopping Travel and Leisure Travel

Note: mean_ = mean value of the three responses given according to three travel purposes, c_ = response for commuting, s_ = response for shopping travel, and l_ = response for leisure travel; relax = anti-activity—relaxation, think = anti-activity—thinking, acttv = external activities—while traveling, actst = external activities—at stopovers, show = status show-off, style = lifestyle expression, prstg = prestige symbolization, cnvc = convenience, cmfrt = comfort, prvcy = privacy, safe = safety, ctrl = control, indep = independence, envrn = environmental concerns, exerc = physical exercise, diff = variety-seeking, curis = curiosity for information, buffr = buffer, amnt = amenities, outdr = exposure to outdoors, escp = escape, and thrpy = mental therapy; the four diagrams were produced by Amos.

Table 17 presents standardized path coefficients—same as those in Figure 14—along with their *p*-values.[32] All paths in all of the four models are significant at the 99% confidence level. SMC further shows that in terms of the explained variance, each indicator variable was sufficiently loaded onto their first-order factors (41.9%–78.7%), each of which was again loaded onto the second-order factor to a moderate to strong degree (41.3%–80.7%); among the first-order factors, the symbolic benefit factor was the one that was moderately explained in all of the four models.

This finding, along with that from CFA of primary benefit variables, confirms the construct validity of the psychometric measure developed in this research. That is, the structured survey can be deemed to have accurately evaluated the benefit side of travel utility.

[32] As with Figure 14, relax = anti-activity—relaxation, think = anti-activity—thinking, acttv = external activities—while traveling, actst = external activities—at stopovers, show = status show-off, style = lifestyle expression, prstg = prestige symbolization, cnvc = convenience, cmfrt = comfort, prvcy = privacy, safe = safety, ctrl = control, indep = independence, envrn = environmental concerns, exerc = physical exercise, diff = variety-seeking, curis = curiosity for information, buffr = buffer, amnt = amenities, outdr = exposure to outdoors, escp = escape, and thrpy = mental therapy

Table 17 Higher-Order Confirmatory Factor Analysis: Secondary Travel Benefits

		Indicators*	**<---**	**Factors**	**Unstandardized**	**Standardized**	**S.E.**	**C.R.**	***p***	**SMC**
Overall travel	Second order	Synergy	<---	Secondary	1.000**	0.898				0.807
		Symbolic			0.692	0.534	0.059	11.816	***	0.485
		Instrumental			0.856	0.743	0.059	14.608	***	0.552
		Affective			1.023	0.855	0.066	15.446	***	0.731
	First order	mean_relax	<---	Synergy	1.000**	0.665				0.442
		mean_think			1.025	0.719	0.054	19.116	***	0.517
		mean_acttv			1.107	0.755	0.056	19.816	***	0.570
		mean_actst			0.958	0.613	0.057	16.798	***	0.576
		mean_show	<---	Symbolic	1.000**	0.723				0.523
		mean_style			1.191	0.848	0.057	20.984	***	0.718
		mean_prstg			0.970	0.691	0.050	19.508	***	0.478
		mean_cnvc	<---	Instrumental	1.000**	0.689				0.475
		mean_cmfrt			0.968	0.704	0.048	20.089	***	0.496
		mean_prvcy			1.206	0.766	0.056	21.608	***	0.587
		mean_safe			0.781	0.511	0.052	14.946	***	0.462
		mean_ctrl			0.967	0.691	0.049	19.746	***	0.477
		mean_indep			0.872	0.609	0.050	17.603	***	0.571
		mean_envrn			0.744	0.481	0.053	14.088	***	0.431
		mean_exerc			0.881	0.581	0.052	16.862	***	0.538
		mean_diff	<---	Affective	1.000**	0.701				0.491
		mean_curis			0.931	0.659	0.047	19.768	***	0.434
		mean_buffr			1.075	0.768	0.047	22.870	***	0.590
		mean_amnt			1.136	0.788	0.048	23.417	***	0.621
		mean_outdr			1.080	0.772	0.047	22.982	***	0.596
		mean_escp			0.851	0.549	0.051	16.552	***	0.501
		mean_thrpy			1.136	0.783	0.049	23.285	***	0.614

* mean_ = mean value of the three responses given according to three travel purposes; ** for each factor, one factor loading was fixed to 1; *** $p < 0.001$.

Table 17 (continued)

		Indicators*	<---	Factors	Unstandardized	Standardized	S.E.	C.R.	*p*	SMC
Com-muting	Second order	Synergy	<---	Secondary	1.000**	0.854				0.729
		Symbolic			0.744	0.654	0.056	13.393	***	0.428
		Instrumental			0.991	0.824	0.066	15.094	***	0.678
		Affective			0.958	0.870	0.064	14.894	***	0.756
	First order	c_relax	<---	Synergy	1.000**	0.664				0.441
		c_think			1.019	0.731	0.054	19.049	***	0.534
		c_acttv			1.024	0.717	0.055	18.785	***	0.514
		c_actst			0.939	0.611	0.057	16.549	***	0.574
		c_show	<---	Symbolic	1.000**	0.714				0.509
		c_style			1.172	0.795	0.056	21.037	***	0.633
		c_prstg			1.127	0.762	0.055	20.628	***	0.581
		c_cnvc	<---	Instrumental	1.000**	0.682				0.465
		c_cmfrt			0.936	0.682	0.048	19.543	***	0.465
		c_prvcy			1.018	0.727	0.049	20.681	***	0.529
		c_safe			0.882	0.613	0.050	17.736	***	0.576
		c_ctrl			0.982	0.713	0.048	20.330	***	0.509
		c_indep			0.888	0.657	0.047	18.892	***	0.432
		c_envrn			0.785	0.580	0.047	16.858	***	0.536
		c_exerc			0.824	0.597	0.048	17.308	***	0.556
		c_diff	<---	Affective	1.000**	0.649				0.421
		c_curis			0.884	0.616	0.051	17.201	***	0.579
		c_buffr			1.050	0.704	0.055	19.237	***	0.496
		c_amnt			1.158	0.729	0.059	19.770	***	0.531
		c_outdr			1.156	0.743	0.058	20.068	***	0.552
		c_escp			0.840	0.551	0.054	15.619	***	0.503
		c_thrpy			1.144	0.738	0.057	19.968	***	0.545

* c_ = response for commuting; ** for each factor, one factor loading was fixed to 1; *** $p < 0.001$.

Table 17 (continued)

		Indicators*	<---	Factors	Unstandardized	Standardized	S.E.	C.R.	*p*	SMC
Shopping travel	Second order	Synergy	<---	Secondary	1.000**	0.887				0.589
		Symbolic			0.665	0.565	0.060	11.183	***	0.413
		Instrumental			0.795	0.747	0.062	12.820	***	0.538
		Affective			0.931	0.825	0.071	13.074	***	0.496
	First order	s_relax	<---	Synergy	1.000**	0.623				0.477
		s_think			0.977	0.643	0.061	16.012	***	0.637
		s_acttv			1.141	0.733	0.065	17.421	***	0.421
		s_actst			0.849	0.544	0.060	14.111	***	0.590
		s_show	<---	Symbolic	1.000**	0.691				0.419
		s_style			1.191	0.798	0.066	17.964	***	0.477
		s_prstg			0.977	0.649	0.058	16.807	***	0.426
		s_cnvc	<---	Instrumental	1.000**	0.624				0.456
		s_cmfrt			1.030	0.647	0.062	16.734	***	0.539
		s_prvcy			1.183	0.691	0.067	17.550	***	0.480
		s_safe			0.783	0.476	0.060	13.028	***	0.540
		s_ctrl			1.062	0.675	0.062	17.260	***	0.572
		s_indep			0.919	0.582	0.060	15.407	***	0.534
		s_envrn			0.692	0.424	0.059	11.775	***	0.506
		s_exerc			0.980	0.583	0.064	15.432	***	0.578
		s_diff	<---	Affective	1.000**	0.610				0.593
		s_curis			0.916	0.578	0.059	15.568	***	0.464
		s_buffr			1.067	0.711	0.059	18.210	***	0.557
		s_amnt			1.251	0.760	0.066	19.068	***	0.787
		s_outdr			1.230	0.770	0.064	19.239	***	0.519
		s_escp			0.849	0.514	0.060	14.152	***	0.559
		s_thrpy			1.179	0.746	0.063	18.835	***	0.681

* s_ = response for shopping travel; ** for each factor, one factor loading was fixed to 1; *** $p < 0.001$.

Table 17 (continued)

		Indicators*	<---	Factors	Unstandardized	Standardized	S.E.	C.R.	*p*	SMC
Leisure travel	Second order	Synergy	<---	Secondary	1.000**	0.862				0.554
		Symbolic			0.432	0.362	0.055	7.859	***	0.451
		Instrumental			0.882	0.783	0.071	12.359	***	0.457
		Affective			1.177	0.836	0.089	13.272	***	0.456
	First order	l_relax	<---	Synergy	1.000**	0.595				0.436
		l_think			1.086	0.672	0.070	15.456	***	0.673
		l_acttv			1.065	0.676	0.069	15.509	***	0.593
		l_actst			0.772	0.506	0.061	12.715	***	0.581
		l_show	<---	Symbolic	1.000**	0.660				0.462
		l_style			1.224	0.820	0.077	15.950	***	0.441
		l_prstg			0.977	0.627	0.062	15.771	***	0.488
		l_cnvc	<---	Instrumental	1.000**	0.617				0.446
		l_cmfrt			1.076	0.680	0.063	17.064	***	0.527
		l_prvcy			1.127	0.664	0.067	16.775	***	0.445
		l_safe			0.700	0.433	0.059	11.889	***	0.476
		l_ctrl			1.040	0.668	0.062	16.844	***	0.504
		l_indep			0.890	0.572	0.059	14.980	***	0.458
		l_envrn			0.614	0.381	0.058	10.606	***	0.483
		l_exerc			0.864	0.525	0.062	14.001	***	0.615
		l_diff	<---	Affective	1.000**	0.710				0.550
		l_curis			0.940	0.677	0.046	20.236	***	0.495
		l_buffr			0.940	0.695	0.045	20.765	***	0.517
		l_amnt			1.065	0.784	0.046	23.291	***	0.743
		l_outdr			0.933	0.742	0.042	22.096	***	0.431
		l_escp			0.828	0.543	0.051	16.324	***	0.613
		l_thrpy			0.984	0.719	0.046	21.455	***	0.698

* l_ = response for leisure travel; ** for each factor, one factor loading was fixed to 1; *** $p < 0.001$.

CHAPTER 6.

STRUCTURAL EQUATION MODELING

Although reviews of the travel behavior literature (Gim 2012, Meurs and van Wee 2004, Mokhtarian and Cao 2008) argued for SEM in analyzing the complex relationship between urban form and travel behavior, its application is relatively recent and scarce (Gim 2012, Van Acker, Witlox, and van Wee 2007). As such, the SEM models specified in this research need to be tested in terms of their goodness-of-fit. Beginning with a description of the model structure, this section shows in detail the extent to which the models are acceptable.

6.1 Analytical Models

This research assigned psychometric items into two factors, each of which stood for primary and secondary benefits. The constrict validity of the factors were verified through CFA and higher-order CFA, and their factor scores were subsequently computed so that the factors could be included as variables in full-scale SEM. Ultimately, this research estimated the utility of travel with three variables: primary benefits, secondary benefits, and trip time. On the lower part of Figure 15, CFA and higher-order CFA are expressed with non-bold lines.

On the upper part, Figure 15 shows an SEM model proposed in this research (i.e., a model with the utility factor), using SEM graphic objects. In SEM, the coefficients of the factor-to-variable relationships are separated into b^x and b^y according to whether variables are indicators (*x* variables) of an explanatory factor (in the figure, a total of three that are linked by solid lines, that is, urban compactness, sociodemographics, and travel utility) or indicators (*y* variables) of the outcome factor (i.e., travel behavior). Likewise, the coefficients of the factor-to-factor relationships are separated into *p* that is used for the relationships between explanatory factors and *q* for those between exploratory factors and the outcome factor. Notably, to be identifiable, one factor loading for each factor must be fixed to one in the measurement model (e.g., among $b^x{}_1$ to $b^x{}_4$ for the urban compactness factor, $b^x{}_1 = 1$). Thus, all estimates in SEM are meaningful when reported in the standardized form even though SEM also calculates unstandardized path coefficients.

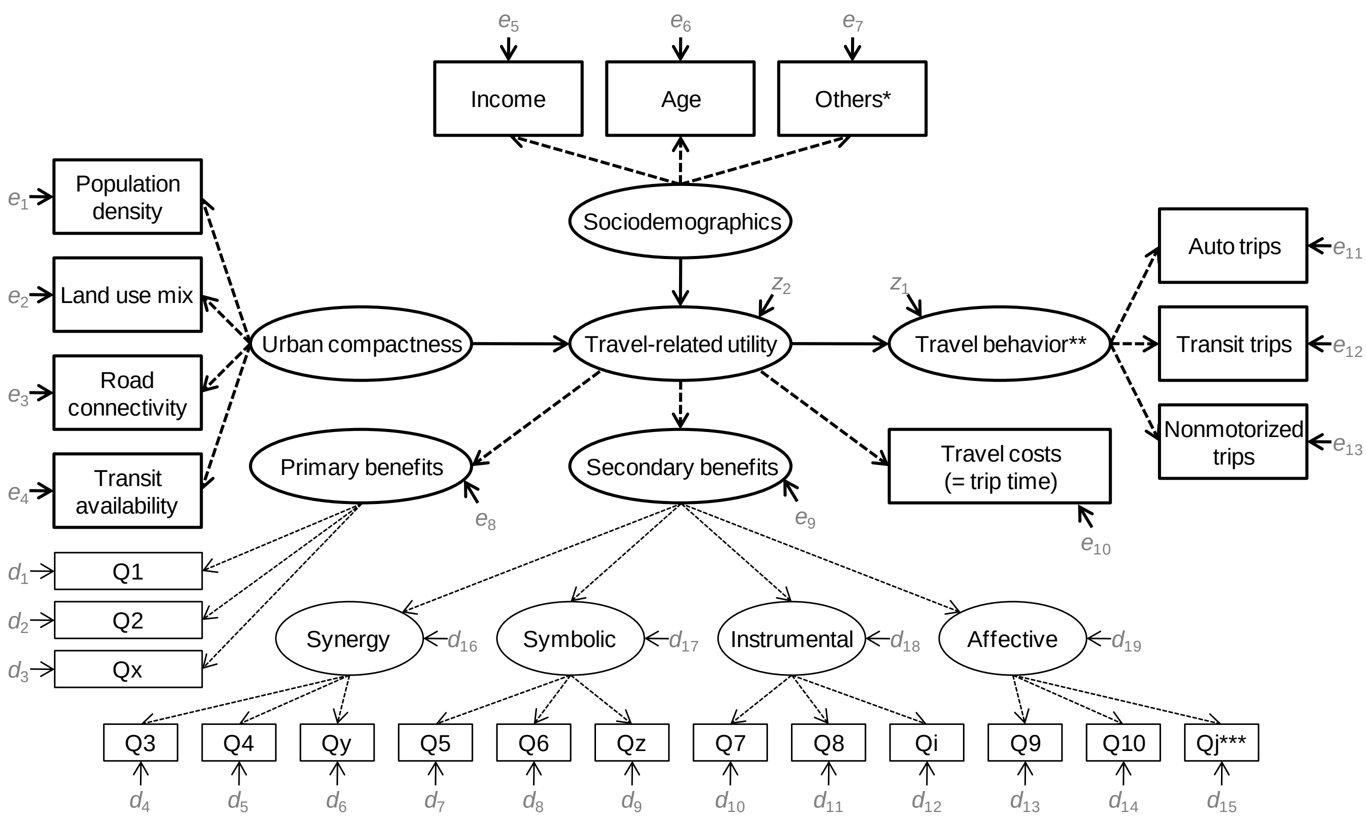

Figure 15 SEM Representation of the Conceptual Model

* Multiple variables, albeit represented in one box; ** trip frequencies or mode shares; *** j = number of psychometric items for measuring travel benefits

Note: As a convention, factors are in ovals and variables in boxes. For easy understanding, the measurement model (i.e., confirmatory factor analysis) is in dotted lines, the structural model (i.e., path analysis) in regular lines, and error terms in gray. In the measurement model, paths from a factor to its variables indicate that this research employs a multiple indicator model to specify measurement error.

As stated in "D.1.2 Pilot Test", unlike path analysis that has an implausible assumption that it is free from measurement error, SEM considers the error by specifying error terms—also called disturbances—for its variables and factors (i.e., all SEM objects pointed by arrows carry error terms). Error terms represent variables/factors that are not included in the SEM model, but associated with the outcome variable/factor. In Figure 15, for example, the factor of travel behavior (either trip frequencies or mode shares) are evaluated by trips in the automobile, public transit, and nonmotorized modes, and those by all other modes such as helicopter, yacht, and airplane are represented by the error term z_1. Besides, this research put the factor of travel behavior as a function of travel utility, and other variables that affect travel behavior (e.g. severe weather events and road conditions such as maintenance work and car accidents) are captured by the error term e_{26}–e_{28}.[33] Then, the SEM model in Figure 15 can be expressed with four equations in Equation 5.

---

[33] In fact, errors are "excluded" in the estimation, that is, because of the introduction of the error terms, SEM can use only the common variance for parameter estimation; this makes the estimated relationships free of measurement error (Hardy 2004).

$$\boldsymbol{m} = \mathbf{Q}\boldsymbol{n} + \boldsymbol{z},$$

$$\boldsymbol{n} = \mathbf{P}\boldsymbol{n} + \boldsymbol{z},$$

$$\boldsymbol{y} = \mathbf{B}^{y}\boldsymbol{m} + \boldsymbol{e},$$

and

$$\boldsymbol{x} = \mathbf{B}^{x}\boldsymbol{n} + \boldsymbol{e} \qquad \textbf{Equation 5}$$

where

$\boldsymbol{m}$ = vector of unobserved endogenous variable (i.e., the factor "travel behavior")

$\boldsymbol{n}$ = vector of unobserved exogenous variables (i.e., all factors but "travel behavior")

$\mathbf{Q}$ = matrix of coefficients for *n*-to-*m* relationships

$\mathbf{P}$ = matrix of coefficients for *n*-to-*n* relationships

$\boldsymbol{z}$ = vector of unexplained errors by *m* or *n* (i.e., vector of disturbance)

$\boldsymbol{y}$ = vector of observed endogenous variables (i.e., indicators of *m*)

$\boldsymbol{x}$ = vector of observed exogenous variables (i.e., indicators of *n*)

$\mathbf{B}^{y}$ = matrix of *m*-on-*y* factor loadings

$\mathbf{B}^{x}$ = matrix of *n*-on-*x* factor loadings

$\boldsymbol{e}$ = vector of measurement errors for *y* or *x*

According to Equation 5, travel utility is measured based on the factor loadings of primary benefits, secondary benefits, and trip time; the utility factor is extracted by the fourth equation. The relationships that the utility factor has with the urban compactness factor and sociodemographic factor are estimated by the second equation. The first equation is used to estimate the effect of the utility factor on the travel behavior factor.

Equation 6 declares the main argument of this research, that is, urban compactness "indirectly" affects travel behavior by "directly" affecting travel utility according to travel modes and purposes. The upper part shows that travel behavior is determined by the utility of the use of a specific travel mode for a particular purpose. The lower part presents that the utility is affected by urban compactness. Different from equations discussed before, it explicitly considers travel benefits and separates them into primary and secondary benefits.

$$t_{i\cdot j} = f(U_{i\cdot j})$$

and

$$U_{i\cdot j} = f(K_{i\cdot j}, L_{i\cdot j}, p_{i\cdot j}, S, C) \qquad \textbf{Equation 6}$$

where

$t_{i\cdot j}$ = trips of a traveler by travel mode i (= automobile, public transit, and nonmotorized mode) for travel purpose j (= commuting, shopping, and leisure)

$U_{i\cdot j}$ = utility of a trip by mode i for purpose j

$K_{i\cdot j}$ = primary benefits of the trip

$L_{i\cdot j}$ = secondary benefits of the trip

$p_{i\cdot j}$ = costs of the trip (= trip time)

S = sociodemographics of the traveler (= income, age, and others)

C = compactness of the urban form (= population density, land use mix, road connectivity, and transit availability)

6.2 Individual Models

Figure 16 shows the way that the proposed model and reference model (based on the econometric trip-making model) were expressed. These were drawn with Amos. The path of UC <--> SD (i.e., correlation between the urban compactness factor and the sociodemographic factor) is required for SEM. In the figure, one path from an oval object (i.e., factor) to its indicator variable shows the value of “1”, which means that the coefficient of the path was fixed for model identification;

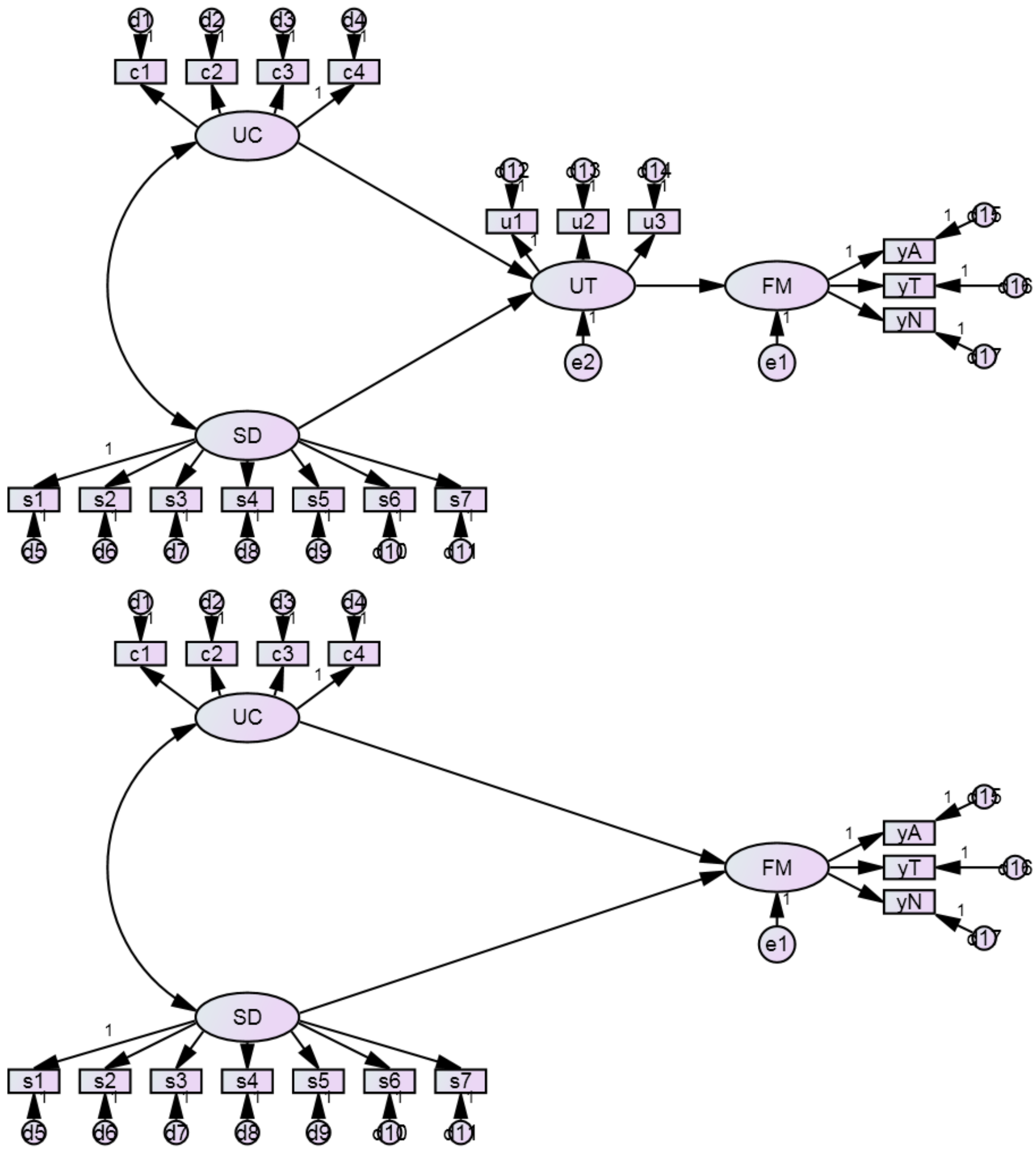

Figure 16 SEM Models (Example): Proposed Model and Reference Model
Note: The below model is a reduced form of the econometric trip-making model. Factor and variable names are as follows: urban compactness (UC) = population density (c1) + road connectivity (c2) + transit availability (c3) + land use mix (c4); sociodemographics (SD) = household—size (s1) + household—children (s2) + household—automobiles (s3) + household—income (s4) + individual—gender (s5) + individual—age (s6) + individual—license (s7); utility (UT) = primary travel benefits (u1) + secondary travel benefits (u2) + trip time (u3); trip frequencies (FM) = auto trips (yA) + transit trips (yT) + nonmotorized trips (yN).

Based on the proposed and reference models, this research identified 20 individual models as summarized in Table 18. The models differed by the travel purpose as well as by the measure of travel behavior (whether the behavior was defined as trip frequencies or mode shares) and type of travel survey (whether parameters were estimated based on the one-day 2006 MHTS, its sample, or one-week 2013 survey), and any modification to the conceptual model is attributed to the very differences; that is, all modifications were limited to matching each of the individual models to its respective data, for the purpose of model identification. For detailed outcomes, see "APPENDIX E".

Table 18 SEM Models

Model ID*	Data types	Model specifications	Measures of travel behavior
Model X1	Sample data of the 2006 MHTS**	Without the utility factor	Trip frequencies
Model X2	Entire data of the 2006 MHTS	Without the utility factor	Trip frequencies
Model X3	2013 survey data	Without the utility factor	Trip frequencies
Model X4	2013 survey data	With the utility factor	Trip frequencies
Model X5	2013 survey data	With the utility factor	Mode shares

* X = A (overall trips without consideration of travel purpose), C (commuting trips), S (shopping trips), and L (leisure trips)
** Data from 24 neighborhoods sampled for the 2013 survey
Note: total 20 SEM models = 5 sets (X1–X5) * 4 travel purposes (overall, commuting, shopping, and leisure)

As in Table 18, a total of five SEM models were specified for three travel purposes and for overall travel (20 individual models = 5 models * 4 travel purposes). The outcomes of the first model (Model X1; based on the MHTS data for 24 neighborhoods sampled for the 2013 survey) and those of the second (Model X2; based on the entire MHTS data) were compared to check if the sampled neighborhoods are representative of all neighborhoods in Seoul. Then, the first two models and the third model (Model X3; based on the 2013 survey data) were briefly compared to see if travel behavior based on a travel survey of one weekday (2006 MHTS) differs from that of one week, including one weekend (2013 survey).

Like the first two models (Models X1 and X2), the third model (Model X3) did not specify travel utility. In contrast, the fourth model (Model X4) did consider the utility (in the form of a factor that consists of primary travel benefits, secondary travel benefits, and trip time). Models X3 and X4 used the survey data, and this research tested whether the model considering the utility (Model X4) better explains travel behavior and how the outcomes of the two models differ. The comparison of the two models is the rationale for this research: This research aims to argue that travel behavior is better explained by considering the utility.

The first four models (Models X1–X4) defined travel behavior as trip frequencies according to travel modes. The last model (Model X5) had the same structure as the fourth one—both considered travel utility as an intermediary between urban compactness and travel behavior and both estimated parameters based on the survey—but it measured travel behavior with mode shares and thus, it supplemented the fourth model. Using the "relative" measure, this research can reveal what a model using trip frequencies as an "absolute" measure might miss. Differences between the two measures were discussed in "3.1.2 Defining Travel Behavior: Trip Frequencies and Mode Shares".

6.3 Goodness-of-Fit of Individual Models

In SEM, the goodness-of-fit of a research model refers to the degree to which it can reproduce the data, specifically, how well estimates implied by the model match the (1) covariances and (2) variances of the data; each is called (1) covariance fit (or model fit) and (2) variance fit. SEM researchers have developed a plethora of model fit indices among which several were entirely discredited and others acquired more popularity.

Studies using SEM approaches report a multiple number of model fit indices, and this often made SEM not accessible to the wider public (Hu and Bentler 1999). Accordingly, researchers on fit indices recommended a selective list of the indices to be reported. Kline (2011) recommended χ^2, RMSEA (Root Mean Square Error of Approximation), CFI (Comparative Fit Index), and SRMR (Standardized Root Mean square Residual). Along with these model fit indices, Boomsma (2000) recommended SMC (squared multiple correlations) for checking the variance fit. (SMC is the proportion of the variance explained for the resultant factor/variable; scaled 0.00 to 1.00, it indicates explanatory power.)

Different from Boomsma (2000), Hooper et al. (2008) suggested reporting one of the information criterion indices such as AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion). Hu and Bentler (1999) argued that the fit should be shown efficiently with two indices: SRMR and RMSEA or SRMR and CFI. Instead of these pairs, MacCallum et al. (1996) suggested RMSEA and CFI.

This research reports all of the model fit indices recommended by the above studies along with those that have established historical importance: GFI (Goodness-of-Fit Index) and AGFI (Adjusted Goodness-of-Fit Index). Also, while several fit indices have their own limitations, this research shows those that were developed to correct or circumvent the limitations.

Tables 19–22 present covariance fit indices of 20 individual models. The tables are separated according to travel purposes (i.e., overall trips, commuting trips, shopping trips, and leisure trips). Also, as stated above, this research made modifications to make the models identifiable according to differences in the purposes of travel, types of travel survey (MHTS sample, entire MHTS, and survey), and measures of travel behavior (trip frequencies and mode shares).

In the process of parameter estimation, several models faced the issue of "negative error variance." Some negative variances were related to error terms for factors and others to error terms for indicator variables (i.e., Heywood cases). Supposedly, negative variances either result from extreme multicollinearity (Chen et al. 2001)—this may be the case not only between urban compactness components (i.e., spatial multicollinearity), but also between sociodemographic variables (Gim 2011b) and between travel behavior variables that were measured by mode (suggesting modal shift)—or indicate that some indicators for the same factor "are sufficiently different, but nevertheless similar enough to measure the same concept" (Blunch 2013, p. 99).[34]

One solution to the issue of negative variances is to fix the variances to a small positive value, but this could distort the estimation of the parameters (Chen et al. 2001). Thus, this research explored up to 50 correlation paths among the error terms for the

[34] Other possible reasons for negative error variance include (1) small sample size and (2) large variation brought about by outliers in the data (Chen et al. 2001). Sample sizes for this research were sufficiently large and outliers were not identified in the data.

same factor until negative error variances are not present with a minimal number of the paths (Choo 2005, Scheiner and Holz-Rau 2007). Notably, the paths were limited to indicators within the same factor, in the sense that such correlations are conceptually more acceptable than correlating error terms across different factors (Hooper, Coughlan, and Mullen 2008). For descriptions and illustrations of the correlation paths, see “APPENDIX E”.

Table 19 Model Fit Indices: Overall Trips

Indices	Cut-offs	Model: trip frequencies by mode					Model: mode shares
		[Model A1] 2006 MHTS sample	[Model A2] 2006 MHTS	[Model A3] 2013 survey (A)	[Model A4] 2013 survey with utility (B)	Δ(B − A)	[Model A5] 2013 survey with utility
χ^2		172.872	264.260	256.595	356.063		251.440
d.f.		72	73	73	113		112
p	$p > 0.05$	0.000	0.000	0.000	0.000		0.000
Relative χ^2	≤ 2–5	2.401	3.620	3.515	3.151	−0.364	2.245
Hoelter's critical *N*	≥ 200 (α = 0.05)	893	10,429	378	402		565
RMSEA	≤ 0.08–0.10	0.029	0.009	0.049	0.046	−0.004	0.035
CFI	> 0.9	0.951	0.941	0.933	0.904	−0.029	0.954
SRMR	< 0.08	0.0761	0.0669	0.0662	0.0658	−0.0004	0.0624
GFI	≥ 0.9	0.934	0.949	0.925	0.924	−0.001	0.921
AGFI	≥ 0.9	0.904	0.927	0.892	0.897	0.005	0.892
AIC	The smaller, the better.	238.872	328.260	320.595	436.063	115.468	333.440
BIC	The smaller, the better.	417.632	593.430	478.651	633.633	154.982	535.949
Mardia's Ku	> 8–10	1.606	3.187	8.950	8.500		2.406
C.R.	< 1.96	1.548	12.895	6.792	5.372		1.521

Table 20 Model Fit Indices: Commuting Trips

Indices	**Cut-offs**	**Model: trip frequencies by mode**					**Model: mode shares**
		[Model C1] 2006 MHTS sample	**[Model C2] 2006 MHTS**	**[Model C3] 2013 survey (A)**	**[Model C4] 2013 survey with utility (B)**	**Δ(B − A)**	**[Model C5] 2013 survey with utility**
χ^2		175.015	226.152	220.460	272.118		228.105
d.f.		71	72	73	114		111
p	*p* > 0.05	0.000	0.000	0.000	0.000		0.000
Relative χ^2	≤ 2–5	2.465	3.141	3.020	2.387	−0.633	2.055
Hoelter's critical *N*	≥ 200 (α = 0.05)	872	12,039	440	531		618
RMSEA	≤ 0.08–0.10	0.030	0.009	0.044	0.037	−0.008	0.032
CFI	> 0.9	0.921	0.912	0.942	0.921	−0.021	0.943
SRMR	< 0.08	0.0653	0.0570	0.0589	0.0526	−0.0063	0.0500
GFI	≥ 0.9	0.931	0.945	0.943	0.954	0.011	0.927
AGFI	≥ 0.9	0.898	0.920	0.918	0.938	0.020	0.899
AIC	The smaller, the better.	243.015	292.152	284.460	350.118	65.658	312.105
BIC	The smaller, the better.	427.192	565.609	442.516	542.749	100.233	519.554
Mardia's Ku	> 8–10	3.860	8.822	3.097	8.558		8.811
C.R.	< 1.96	3.720	35.694	2.350	5.408		5.568

Table 21 Model Fit Indices: Shopping Trips

Indices	Cut-offs	Model: trip frequencies by mode					Model: mode shares
		[Model S1] 2006 MHTS sample	[Model S2] 2006 MHTS	[Model S3] 2013 survey (A)	[Model S4] 2013 survey with utility (B)	Δ(B − A)	[Model S5] 2013 survey with utility
χ^2		135.504	265.660	224.072	216.169		215.039
d.f.		72	74	74	113		113
p	*p* > 0.05	0.000	0.000	0.000	0.000		0.000
Relative χ^2	≤ 2–5	1.882	3.590	3.028	1.913	−1.115	1.903
Hoelter’s critical *N*	≥ 200 (α = 0.05)	1,140	10,500	438	663		666
RMSEA	≤ 0.08–0.10	0.023	0.009	0.044	0.030	−0.015	0.030
CFI	> 0.9	0.937	0.934	0.921	0.919	−0.002	0.933
SRMR	< 0.08	0.0533	0.0463	0.0574	0.0534	−0.0040	0.0581
GFI	≥ 0.9	0.952	0.965	0.932	0.943	0.011	0.941
AGFI	≥ 0.9	0.930	0.950	0.904	0.923	0.019	0.920
AIC	The smaller, the better.	201.504	327.660	286.072	296.169	10.097	295.039
BIC	The smaller, the better.	380.264	584.544	439.189	493.739	54.550	492.609
Mardia’s Ku	> 8–10	6.748	6.040	8.980	1.190		8.608
C.R.	< 1.96	6.503	24.438	6.815	0.752		5.440

Table 22 Model Fit Indices: Leisure Trips

Indices	**Cut-offs**	**Model: trip frequencies by mode**					**Model: mode shares**
		[Model L1] 2006 MHTS sample	**[Model L2] 2006 MHTS**	**[Model L3] 2013 survey (A)**	**[Model L4] 2013 survey with utility (B)**	**Δ(B − A)**	**[Model L5] 2013 survey with utility**
χ^2		133.848	255.152	217.042	255.300		241.029
d.f.		72	74	74	115		113
p	*p* > 0.05	0.000	0.000	0.000	0.000		0.000
Relative χ^2	≤ 2–5	1.859	3.448	2.933	2.220	−0.713	2.133
Hoelter's critical *N*	≥ 200 (α = 0.05)	1,154	10,932	452	570		594
RMSEA	≤ 0.08–0.10	0.023	0.009	0.043	0.034	−0.009	0.033
CFI	> 0.9	0.945	0.942	0.938	0.914	−0.024	0.920
SRMR	< 0.08	0.0525	0.0432	0.0562	0.0517	−0.0045	0.0583
GFI	≥ 0.9	0.955	0.969	0.934	0.943	0.009	0.918
AGFI	≥ 0.9	0.934	0.956	0.906	0.924	0.018	0.889
AIC	The smaller, the better.	199.848	317.152	279.042	331.300	52.258	321.029
BIC	The smaller, the better.	378.608	574.036	432.159	518.992	86.833	518.599
Mardia's Ku	> 8–10	7.794	3.850	4.035	6.293		7.263
C.R.	< 1.96	7.510	15.577	3.062	3.977		4.590

6.3.1 Covariance Fit

As in Tables 19–22, most fit indices indicate that all of the 20 individual models fit their data fairly well. However, according to χ^2, no models are acceptable: $p = 0.000$. (As a badness-of-fit index, χ^2 presents the magnitude of discrepancy between the sample and fitted covariance matrices, that is, between a model and its data; thus, the smaller χ^2, the better the model fit or the higher p, the better the model).

This contradictory result should be explained by the tendency that the χ^2 test almost always rejects models with large sample sizes, as many as 200 cases (Gim 2011b). Thus, this study referred to the relative χ^2 and Hoelter's critical N, both of which were developed to supplement the model χ^2 in an attempt to make it less dependent on sample size.

The relative χ^2, also called the normal or normed χ^2, is the ratio of the model χ^2 to its degrees of freedom. For its cut-off, although researchers on SEM fit indices did not reach a consensus, the value of 5 or less (Hoyle 2012, Wheaton et al. 1977) is considered to indicate "good fit."[35] According to this criterion, all of the 20 models are acceptable (relative χ^2 = 1.859–3.620).

As with the relative χ^2, Hoelter's critical N supplements the model χ^2. It shows sample size (N) above which the χ^2 test would become significant, that is, the largest N with which a model would have been accepted. For adequate fit, Hoelter's critical N is

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[35] The value of 3 or less (Kline 2011) and 2–3 or less (Carmines and McIver 1981) has also been recommended for "acceptable fit." More strictly, Tabachnick and Fidell (2000) suggested 2 or less as a cut-off for this index.

expected to be equal to or higher than 200: As mentioned above, with the sample size of more than 200, the model χ^2 is mostly significant, so models that would be rejected only with Hoelter's critical $N \geq 200$ are considered to have adequate fit.[36] As shown, all of the 20 models have higher values than this cut-off (Hoelter's critical N = 378–12,039).

RMSEA (Root Mean Square Error of Approximation) shows how well a model, with unknown but optimally chosen parameter estimates would fit the population covariance matrix. It is a standardized measure of error of approximation (i.e., lack of fit of a hypothesized model to the population). RMSEA is currently the most credited measure of model fit (Hooper, Coughlan, and Mullen 2008) because it considerably penalizes a lack of parsimony (Kenny and McCoach 2003)—its penalty for model complexity is χ^2 / *d.f.* for every parameter added to a model and it is higher than the penalty taken by CFI (= one for every parameter) to be shown below—and because it carries different meanings according to its ranges (Hooper, Coughlan, and Mullen 2008). (One of two major issues of model fit indices is that several indices falsely accept complex models; the other issue is that some tend to prefer large-sample models. They are discussed later.) Fit index researchers somewhat differently interpreted the ranges as follows.

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[36] In this sense, Hoelter's critical N should be used only when the sample size is over 200 (Thomas 2004); if the sample size is less than 200 and the model χ^2 is insignificant, it should not be reported. Meanwhile, Arbuckle (2012) was not convinced of Hoelter's judgment on the critical value of 200. Scholz (2009) also argued that this cut-off is overly conservative. Among studies particularly centered on Hoelter's critical N, Bollen and Liang (1988) highlighted its tendency to favor large-sample models and ambiguity as a fit index correcting for the model χ^2. Because these issues, Hoelter's critical N is not widely reported in the current SEM literature: Hu and Bentler (1999) recommended not using this index.

According to MacCallum et al. (1996), RMSEA of 0.00–0.01 is an indicator of "excellent fit", 0.01–0.05 of "good fit", and 0.05–0.08 of "mediocre fit". However, Arbuckle (2012) considered that RMSEA close to 0.00 shows "exact fit" while RMSEA of 0.00–0.05 stands for "close fit" and 0.05–0.08 for "fair fit". He assumed that RMSEA of 0.08–0.10 shows a reasonable error of approximation and as with Bollen and Scott (1993), a model was recommended to be discarded if RMSEA is higher than 0.10. Regarding these ranges, others provided different interpretations. Byrne (2010) considered that RMSEA of 0.08–0.10 is a sign for "mediocre fit" and if it is higher than 0.10, it shows "poor fit". Hu and Bentler (1999) argued that RMSEA equal to less than 0.06 should be a cut-off for "good fit" and Hooper et al. (2008) indicated that a cut-off of "acceptable fit" is 0.08 or as a more stringent limit, the value should be lower than 0.07. More recently, Hoyle (2012) recommended even stronger limit of 0.06. Table 23 summarizes different interpretations regarding RMSEA ranges.

Based on any of the interpretations on RMSEA ranges, all of the 20 models are strongly acceptable. Their range is 0.009–0.049, implying that they all have good fit according to MacCallum et al. (1996) and close fit according Arbuckle (2012).

Table 23 RMSEA Ranges and Model Fit

MacCallum et al. (1996)	0.00	excellent	0.01	good	0.05	mediocre	0.08			
Arbuckle (2012)	0.00 (exact)		close		0.05	fair	0.08	reasonable error*	0.10	> 0.10 (reject**)
Hu and Bentler (1999)					≤ 0.06 (good)					
Hooper et al. (2008)							≤ 0.07–0.08 (acceptable)			
Hoyle (2012)					≤ 0.06 (acceptable)					

* Byrne (2010) considered that this range (0.08–0.10) represents mediocre fit.

** It was also recommended by Bollen and Scott (1993); Byrne (2010) argued that this range is an indicator of poor fit.

Along with RMSEA, CFI (Comparative Fit Index), also called Bentler CFI, has been recommended for routine use because it performs well even for small sample sizes (Hooper, Coughlan, and Mullen 2008). With more variables (i.e., for complex models), it tends to decrease only slightly, compared to RMSEA (Kenny and McCoach 2003), in the sense that it modestly penalizes model complexity, particularly penalty of one for every parameter (or degree of freedom): CFI = [g(null model) − g(research model)] / g(null model), where g = $\chi^2 - d.f.$ and null model (also called baseline model) = the worst possible model, which is designed by making all variables in the research model have "zero covariances."[37]

CFI of higher than 0.9 indicates "good fit" and the value equal to or higher than 0.95 is interpreted as "very good fit" (Hooper, Coughlan, and Mullen 2008). The range of the 20 models is 0.904−0.954, which denotes that all of them achieved the marginal value of 0.9.

SRMR refers to standardized RMR (Root Mean square Residual). RMR is the square root of the difference between the residual of the sample covariance matrix and that of the hypothesized covariance matrix. (Thus, it is a badness-of-fit index as with χ^2, relative χ^2, and RMSEA.) Because RMR is calculated based on the scales of the variables, its value is less informative except the fact that the smaller, the better the model is (Gim

[37] As the formula shows, CFI compares χ^2 of the research model with that of the null model—accordingly, it is called an "relative" (or incremental) fit index—as opposed to other indices reported in this research (particularly, χ^2 and relative χ^2, RMSEA, GFI and AGFI, and SRMR) that directly test how well the research model fits the data (they are accordingly called "absolute" fit indices).

2011b). Instead, SRMR is more widely reported because through standardization, it resolves the issue of RMR as a scale-dependent indicator.

SRMR decreases as parameters increase or sample size increases, that is, it imposes no penalty for model complexity and tends to be unstable in relation to sample size. Despite these limitations, SRMR has been recommended by several SEM researchers (Hoyle 2012, Hu and Bentler 1999) because as an standardized index in a proportion fit metric, it is easy to interpret.

According to Hooper et al. (2008), SRMR lower than 0.08 indicates that a model is acceptable—this was seconded by Hoyle (2012)—and if it is smaller than 0.05, it is a sign of a well-fitting model. In contrast, Hu and Bentler (1999) suggested that SRMR lower than 0.08 is a cut-off for good fit and when used with another indicator as a set (they recommended CFI or RMSEA), it must be lower than 0.09. For the 20 models examined in this research, SRMR ranges from 0.043 to 0.076, which denotes that all of them are acceptable.

GFI (Goodness-of-Fit Index) represents the overall proportion of the covariance that was explained by the estimated population covariance of a model (i.e., the degree to which a model replicates the observed covariance matrix). Accordingly, it is roughly analogous to the multiple R^2 in multiple regression models. (Notably, in a later section, this research also shows the explained “variance” by each structural equation; GFI should be understood as the explained “covariance” in the data and “on the whole”.) GFI tends to produce a high value for complex models and large-sample models. AGFI (Adjusted GFI) was developed to adjust for model complexity, that is, to penalize small degrees of freedom (Hoyle 2012). However, both can be severely affected by sample size, and because of this issue, they became less popular. SEM researchers such as Sharma et al. (2005) suggested not to refer to these indices, but nevertheless, they are still frequently reported (Gim 2011b, 2013, Hooper, Coughlan, and Mullen 2008), given their historical importance (not because of their accuracy) (Hooper, Coughlan, and Mullen 2008).

For both GFI and AGFI, a value equal to or higher than 0.9 is considered to indicate good fit (Gim 2011b). All of the 20 models had acceptable values: GFI ranges from 0.918 to 0.969 and AGFI from 0.889 to 0.956. Notably, several models based on smaller samples (i.e., MHTS sample or survey) had AGFI lower than 0.9, whereas models using the entire MHTS had higher AGFI. This is because as stated above, AGFI produces higher values for large-sample models. Furthermore, similar to the relationship between adjusted R^2 and R^2 in regression analysis, AGFI runs lower than GFI. If rounded, the AGFI cut-off of 0.9 was met by all of the models. Thus, they all can be accepted as they stand.

AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) are both information criterion indices, that is, goodness-of-fit measures based on information theory. They do not have cut-offs—they are not normed to the 0–1 range—and the statistic itself does not show the model fit. Thus, they are not used for a single model, but only for the purpose of model comparison: The lower, the better the fit. This research refers to these indices to compare models with and without the utility factor.

Mardia's coefficient is not a model fit index, but a statistic that is used to test the assumption of multivariate normality. The significance test of Mardia's coefficient rejects most of the 20 models at the 95% confidence level (C.R. < 1.96), suggesting multivariate nonnormality. Accepted models include two overall trip models—(1) Model A1, the overall trip frequency model based on the 2006 MHTS sample (C.R. = 1.548) and (2) Model A5, the overall mode share model based on the 2013 survey (C.R. = 1.521)—and (3) Model S4, the shopping trip frequency model with the utility factor and based on the 2013 survey (C.R. = 0.752).

Meanwhile, this test is sensitive to sample size. While C.R. is Mardia's coefficient divided by its standard error, the standard error decreases with sample size because the formula of the standard error includes the square root of the sample size as the denominator. Accordingly, for a large sample size, C.R. is always large and rejects the multivariate normality assumption regardless of the coefficient. To circumvent this C.R. issue, Kline (2011) recommended using Mardia's coefficient of 8–10 as a cut-off for multivariate normality. For all models, the coefficient is within this tolerable range (1.190–8.980).

In summary, as evaluated by eight model fit indices, all of the 20 individual models had acceptable fit. Thus, one can be assured of the accuracy of the parameter estimates computed by the models.

In the next two sections, this research compares (1) models based on the sample of the MHTS with those using the entire MHTS (i.e., Models X1 with X2) to show how their difference in sample size affected model fit indices and (1) models without the utility factor and those with the factor (i.e., Models X3 with X4) to reveal which models have better fit.

6.3.2 Sensitivity of Covariance Fit Indices to Sample Size

Statistics of some indices differed between models based on the sample of the MHTS and the entire MHTS (i.e., Models X1 and X2). They have the same model structure and use the same measure of travel behavior, trip frequencies. The main difference is sample size: *N*(MHTS sample) = 1,664 and *N*(entire MHTS) = 29,336. In fact, not only does χ^2 increase with sample size, but also its supplements (i.e., relative χ^2 and Hoelter's critical *N*), GFI and its adjusted index (AGFI), and SRMR are affected by sample size. As sample size increases, Hoelter's critical *N*, GFI, and AGFI tend to increase and relative χ^2 and SRMR tend to decrease: All indicate a better fit for a large-sample model. Mardia's multivariate normality test is also strongly affected by sample size increase, and it always falsely rejects the normality assumption for a large-sample model.

These tendencies (sensitivity to sample size) are exactly present at all of the 8 models shown in Tables 19–22. Summarized in Table 24, differences in the values of the fit indices should be attributed to the difference in sample size, that is, one should not take them as a sign of better fit of one or the other.[38]

[38] While most researchers do not favor fit indices that are sensitive to sample size (Hoyle 2012), a few others (e.g., Cudeck and Henly 1991) argued that it is rather a fundamental trait of fit indices as found in any statistical inference; for them, it is similar to the tendency that the *p*-value decreases and a statistical test becomes significant when sample size increases.

Table 24 Sensitivity of Covariance Fit Indices to Sample Size

		Overall trips		Commuting trips	
		[Model A1] MHTS sample	**[Model A2] MHTS**	**[Model C1] MHTS sample**	**[Model C2] MHTS**
Badness-of-fit (the smaller, the better)	χ^2	172.872	264.260	175.015	226.152
	Relative χ^2	2.401	3.620	2.465	3.141
	SRMR	0.0761	0.0669	0.0653	0.0570
Goodness-of-fit (the higher, the better)	GFI	0.934	0.949	0.931	0.945
	AGFI	0.904	0.927	0.898	0.920
	Hoelter's critical *N*	893	10,429	872	12,039
	Mardia's Ku (C.R.)	1.548	12.895	3.720	35.694
		Shopping trips		**Leisure trips**	
		[Model S1] MHTS sample	**[Model S2] MHTS**	**[Model L1] MHTS sample**	**[Model L2] 2006 MHTS**
Badness-of-fit (the smaller, the better)	χ^2	135.504	265.660	133.848	255.152
	Relative χ^2	1.882	3.590	1.859	3.448
	SRMR	0.0533	0.0463	0.0525	0.0432
Goodness-of-fit (the higher, the better)	GFI	0.952	0.965	0.955	0.969
	AGFI	0.930	0.950	0.934	0.956
	Hoelter's critical *N*	1,140	10,500	1,154	10,932
	Mardia's Ku (C.R.)	6.503	24.438	7.510	15.577

6.3.3 Comparing Covariance Fit of Models with and without Consideration of Travel Utility

6.3.3.1 Statistical Comparison of Competing Models by Information Criteria Indices

The main purpose of this research is to compare competing models, one that considers travel utility and the other that does not (i.e., Models X3 and X4). For statistical comparison of competing models, the chi-square difference test (i.e., $\Delta\chi^2$ of the compared models and its significance test) has been used (Byrne 2012).[39] However, it correctly functions only for nested models, that is, when one of the models is obtained just by constraining—fixing or eliminating—regression or correlation paths from the other. For nonnested models (in this case, a model cannot be converted into the other by constraining parameters because they have different variables) as with those for this research, the most preferred index is AIC (Akaike's Information Criterion) (Byrne 2012) followed by BIC (Bayesian Information Criterion) (Schreiber et al. 2006), and thus, this research firstly referred to these statistics.[40]

As information criteria indices, AIC and BIC are used to check model parsimony (Mueller and Hancock 2008), that is, to select models with a smaller number of parameters—in the case of this research, models without the utility factor (i.e., Model X3)—given the same model fit. The penalty for model complexity taken by AIC is two (for every parameter), and BIC far more strongly penalizes model complexity (and thus,

[39] The $\Delta\chi^2$ test is unnecessarily stringent and has the same problem with the model χ^2 such as high sensitivity to sample size (Byrne 2012).

[40] The functionality of these information criteria indices has not yet been confirmed across different estimations.

it has a tendency to choose models with a small number of parameters): AIC = χ^2 + (2 * number of parameters) and BIC = χ^2 + [number of parameters * ln(sample size)].[41]

Regarding model parsimony, a model is favored if it explains more variation in the data, but at the same time, it is desirable to be parsimonious, that is, it should have a fewer number of variables for the explanation because the purpose of modeling is to summarize phenomena. In essence, a complex model is less theoretical, but because the estimation process is dependent on the sample data, it can paradoxically have better fit. In contrast, AIC and BIC, as parsimony indices, favor a complex model only if the model has better fit to the data “at the cost of model complexity”. That is, according to these indices, adding a new variable is justified only if it considerably increases the covariance fit.

Table 25 summarizes AIC and BIC in Tables 19–22. For both of AIC and BIC, the smaller the statistic, the better the fit is. As shown, models with the utility factor had higher AIC (by 10.097–115.468) and BIC (by 54.550–154.982). (The difference is larger according to BIC because as discussed above, BIC has a tendency to choose models with fewer parameters.) Thus, complex models with the utility factor cannot be justified for a significant improvement in the covariance fit. Notably, however, this does not necessarily mean that the complex models have lower explanatory power.

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[41] Because BIC uses sample size in its formula, it is recommended to use when the size is sufficiently large. For reliable outcome, both AIC and BIC should have equal to or more than 200 cases.

Table 25 Model Comparison with AIC and BIC

Overall trips		**[Model A3] Without utility (A)**	**[Model A4] With utility (B)**	**Δ(B − A)**
	AIC	320.595	436.063	115.468
	BIC	478.651	633.633	154.982
Commuting trips		**[Model C3] Without utility (A)**	**[Model C4] With utility (B)**	
	AIC	284.460	350.118	65.658
	BIC	442.516	542.749	100.233
Shopping trips		**[Model S3] Without utility (A)**	**[Model S4] With utility (B)**	
	AIC	286.072	296.169	10.097
	BIC	439.189	493.739	54.550
Leisure trips		**[Model L3] Without utility (A)**	**[Model L4] With utility (B)**	
	AIC	279.042	331.300	52.258
	BIC	432.159	518.992	86.833

6.3.3.2 Empirical Comparison of Competing Models

In addition to model comparison by AIC and BIC, which evaluate the covariance fit by considering both explanatory power and parsimony of alternative models, the models can be empirically compared (Bollen 1989). For the comparison, this research used indices that stay stable with parameter increases (relative χ^2 and AGFI), favors complex models (SRMR), and penalize the complexity (CFI and RMSEA).

First, relative χ^2, which is relatively stable with parameter increases—it is because this index is the model χ^2 divided by the degrees of freedom—consistently indicates that models with the utility factor (i.e., Models X4) have better fit: It was reduced by 0.364 in the overall trip model (Model A4) and up to 1.115 in the shopping trip model (Model S4). AGFI is also a parsimony-adjusted index because it was developed to correct the tendency that GFI increases for a model with more parameters.[42] AGFI also shows that models with the utility factor better fit the data: It increased by 0.005–0.020.

Another index that presents better fit for models with the utility factor (Models X4) is SRMR: Its value decreased by 0.0004–0.0063. However, it may not be strong evidence for the models because this index essentially favors complex models. Actually, CFI, a parsimony index—it tends to decrease with parameter increases—chose models "without" the factor (Models X3): By adding the utility factor, it decreased by 0.002–0.029. Indeed, CFI was the only index that favored Models X3.

RMSEA also impose penalty for model complexity (Mueller and Hancock 2008), that is, it increases if parameters are added to a model. Different from CFI, this parsimony index shows that models with the utility factor (Model X4) have better fit: RMSEA decreased by 0.004–0.015.

In summary, according to CFI, models without the utility factor (Models X3) are preferable, but this index in itself tends to reject complex models. All other indices indicated better fit for models with the factor (Models X4). This was the case not only of SRMR that favors complex models, but also of those adjusting for model complexity (i.e., relative χ^2 and AGFI). The strongest evidence came from RMSEA. It imposes penalty for model complexity, and even this parsimony index chose Models X4. Thus, one may consider that by including the utility factor, models could have better covariance fit.

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[42] There is an index named Parsimony-adjusted GFI (PGFI). It penalizes model complexity more strongly than AGFI. Compared to GFI and AGFI, however, no thresholds are available for PGFI, so it is not widely used in SEM studies.

Table 26 Model Comparison with Other Model Fit Indices

		Overall trips [Model A3] Without utility (A)	Overall trips [Model A4] With utility (B)	Overall trips Δ(B − A)	Commuting trips [Model C3] Without utility (A)	Commuting trips [Model C4] With utility (B)	Commuting trips Δ(B − A)
Badness-of-fit (the smaller, the better)	Relative χ^2	3.515	3.151	−0.364	3.020	2.387	−0.633
	SRMR	0.0662	0.0658	−0.0004	0.0589	0.0526	−0.0063
	RMSEA	0.049	0.046	−0.004	0.044	0.037	−0.008
Goodness-of-fit (the higher, the better)	AGFI	0.892	0.897	0.005	0.918	0.938	0.020
	CFI	0.933	0.904	−0.029	0.942	0.921	−0.021
		Shopping trips [Model S3] Without utility (A)	**Shopping trips [Model S4] With utility (B)**	**Shopping trips Δ(B − A)**	**Leisure trips [Model L3] Without utility (A)**	**Leisure trips [Model L4] With utility (B)**	**Leisure trips Δ(B − A)**
Badness-of-fit (the smaller, the better)	Relative χ^2	3.028	1.913	−1.115	2.933	2.220	−0.713
	SRMR	0.0574	0.0534	−0.0040	0.0562	0.0517	−0.0045
	RMSEA	0.044	0.030	−0.015	0.043	0.034	−0.009
Goodness-of-fit (the higher, the better)	AGFI	0.904	0.923	0.019	0.906	0.924	0.018
	CFI	0.921	0.919	−0.002	0.938	0.914	−0.024

Notably, the goal of this research is not to find a model that fits the given data "on the whole," but to examine whether the introduction of the utility factor better explains travel behavior "in particular". In the following section, this research compares competing models in terms of the level of the variance explained for travel behavior.

6.3.4 Variance Fit

Along with the model fit (i.e., covariance fit), this research is particularly concerned with the variance fit (i.e., explained variance), in the sense that the overall model fit says nothing about the variance explained for a variable (Fornell 1983). In the travel behavior literature, it is not uncommon that a model with high model fit poorly explains the variance for the travel behavior factor (Simma and Axhausen 2001). For most cases, the model fit is more important and the explained variance is just one consideration in assessing a model (Baumgartner and Homburg 1996, Gim 2011a), but this research focuses on the evaluation of "whether the introduction of travel utility better explains travel behavior," that is, between models with and without the utility factor (Models X3 and X4), which ones account for more variance in the travel behavior factor.

In SEM, the variance fit is evaluated by squared multiple correlation (SMC). It refers to the proportion of the variance explained by each structural equation and it is analogous to R^2 in regression analysis. Table 27 shows the difference in SMC between Models X3 and X4. By including the utility factor, the proportion of the variance explained for the travel behavior factor increased by 30.5%p (= 0.478 − 0.173) for commuting trips, 13.1%p (= 0.232 − 0.101) for shopping trips, and 11.6%p (= 0.242 − 0.126) for leisure trips although for overall trips, the improvement was just 0.3%p (= 0.146 – 0.143). These consistent results indicate that the effect of urban compactness on trip frequencies is better explained by the use of the utility as an intervening factor between the two, particularly when trip frequencies are separately measured by purpose.

Table 27 Variance Explained for Trip Frequencies

	Overall trips		**Commuting trips**		**Shopping trips**		**Leisure trips**	
Considering travel utility?	Model ID	SMC	Model ID	SMC	Model ID	SMC	Model ID	SMC
No	A3	0.143	C3	0.173	S3	0.101	L3	0.126
Yes	A4	0.146	C4	0.478	S4	0.232	L4	0.242

Note: Three other models (Models X1, X2, and X5) used different data (i.e., part or all of the MHTS) or different travel measure (i.e., mode shares).

Not only in a relative sense between models with and without the utility factor, but also compared to previous studies that reported lower R^2 ranges, as highlighted by Handy (1996) and Scheiner and Holz-Rau (2007), three purposes of trips were explained fairly well. In particular, the proposed model best accounted for commuting trips (47.4%). This may be because this purpose of trips is less individualized than shopping and leisure trips (Scheiner 2010). For overall trips, however, the explained variance was quite low (14.3%), and it was not bettered by considering the utility factor (14.6%). This implies that to explain travel behavior, studies should separately examine the behavior by travel purpose.

6.4 Configural Invariance in Urban Compactness

In addition to the sample survey, this research used the MHTS. The main purpose is to test whether the sample of the 24 neighborhoods well represent the population (i.e., all neighborhoods in Seoul). In “5.2 Sample Representativeness”, the representativeness concerning variables for the sociodemographic and trip frequency factors was confirmed, using nonparametric χ^2 goodness-of-fit test and one-sample *t*-test, each of which compared the distributions and means of the sample with those of the population.[43]

Regarding the representativeness of the sample in relation to the urban compactness factor, the sample and the population cannot be directly compared because the sample was constructed through nonproportional sampling (i.e., same number of neighborhoods from four neighborhood types into which different numbers of neighborhoods were classified), so overall urban compactness in the sample cannot be the same as that of the population (whether it is the distribution or the mean).

Nonetheless, the urban compactness factor should be tested if factor analysis (the measurement model in SEM) based on the sample can be replicated in the population. This is called configural invariance of the measurement model. If configural invariance is not confirmed, the meaning of the urban compactness factor is not the same between the sample and the population just because the factor name is the same. Configural invariance can be confirmed if the factor loadings of the indicator variables on the urban

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[43] Psychometric variables for the utility factor were not available from the MHTS, but only from the sample survey. Thus, this research alternately checked the construct validity of the psychometric measure through CFA and higher-order CFA.

compactness factor do not substantially differ between the sample and the population, insofar as the factor loadings contribute to the meaning of the factor (Byrne 2010).

Tables 28 shows factor loadings on the urban compactness factor (for detailed results, see “APPENDIX E”). (They are standardized path coefficients from the factor to its indicator variables; along with them, this research presents unstandardized coefficients, standard errors, and critical ratios later to discuss the effects of the indicator variables, that is, urban compactness components.) The loadings are consistent between the MHTS sample and the entire MHTS. Not only is the directionality (+/−) consistent, but also the relative magnitudes of the factor loadings are kept across eight different models [= 4 travel purposes (overall, commuting, shopping, and leisure) * 2 datasets (MHTS sample and entire MHTS)]: in descending order, road connectivity (c2) > transit availability (c3) > population density (c1) > land use balance (c4). This result confirms configural invariance. That is, the sampled neighborhoods can be deemed to sufficiently represent the entire city to the degree to which the effects of urban compactness components found in the neighborhoods can be generalized to all neighborhoods in Seoul.

Table 28 Factor Loadings on the Urban Compactness Factor

	Overall trips		Commuting trips		Shopping trips		Leisure trips	
	Loading	***p***	**Loading**	***p***	**Loading**	***p***	**Loading**	***p***
2006 MHTS sample								
Population density (c1)	0.599	0.004	0.598	0.004	0.613	0.016	0.593	0.003
Road connectivity (c2)	0.856	0.005	0.956	0.004	0.980	0.017	0.949	0.003
Transit availability (c3)	0.767	0.005	0.767	0.005	0.748	0.018	0.772	0.003
Land use mix (c4)	0.073		0.074		0.060		0.077	
2006 MHTS								
Population density (c1)	0.543	***	0.544	***	0.544	***	0.543	***
Road connectivity (c2)	0.870	***	0.968	***	0.969	***	0.970	***
Transit availability (c3)	0.609	***	0.610	***	0.609	***	0.608	***
Land use mix (c4)	0.109		0.109		0.109		0.109	

*** $p < 0.001$

Note: The *p*-values of land use mix are not shown because its factor loading was fixed to one as required in SEM.

In addition to the above way of confirming configural invariance (i.e., checking if the basic structure of the urban compactness factor is similar between the sample and the population), the invariance can be briefly tested by examining the model fit. Several simulation studies have tested model fit indices, including differences in CFI and SRMR (i.e., ΔCFI and ΔSRMR), and identified their cut-offs for configural invariance. Cheung and Rensvold (2002) conducted Monte Carlo simulations and suggested ΔCFI equal to less than 0.01 at the 99% confidence level; this level was proposed not to incorrectly regard configural invariance as variance. Similar cut-offs were recommended by Chen (2007). She argued that when sample size is greater than 300, ΔCFI should be equal to less than 0.010 (if $N \leq 300$, ΔCFI ≤ 0.005). She further recommended that ΔCFI be assisted by ΔSRMR because while each index has its own strengths and limitations, ΔSRMR tends to over-reject an invariant model when sample size is small. She suggested the following ΔSRMR cut-offs: ΔSRMR ≤ 0.030 if $N > 300$ and ΔSRMR ≤ 0.025 if $N \leq 300$.

Table 29 shows ΔCFI and ΔSRMR between models using the entire MHTS and those based on its sample. For the four travel purposes, the values of ΔCFI range from 0.003–0.010, that is, they are equal to or smaller than the cut-off of 0.010. The range of ΔSRMR is 0.007–0.009, which is also smaller than the cut-off of 0.030. These results show that the urban compactness factors extracted by the measurement model of SEM consistently measured the same concept whether the model used the entire MHTS or its sample.

In summary, based on (1) consistent factor loadings on the urban compactness factor and (2) negligible ΔCFI and ΔSRMR, one can consider that urban compactness measured with the 24 sampled 24 neighborhoods sufficiently reflects that of the entire neighborhoods in Seoul.

Table 29 Differences in Model Fit between the 2006 MHTS and MHTS Sample

	Cut-offs for configural invariance*	Overall trips	Commuting trips	Shopping trips	Leisure trips
ΔCFI	≤ 0.010	0.010	0.009	0.003	0.003
ΔSRMR	≤ 0.030	0.009	0.008	0.007	0.009

* According to Chen (2007), when sample size ≤ 300, ΔCFI ≤ 0.005 and ΔSRMR ≤ 0.025

6.5 Effects of Urban Compactness Components

Indeed, the relative magnitudes of the four urban compactness components turned out to be consistent not only between the sample data and the whole data of the MHTS (Models X1 and X2) for the four travel purposes (Models A, C, S, and L), but also across all of the 20 individual models (Models A1, A2, …, L4, and L5). That is, regardless of the data type (i.e., whether a model is estimated based on the MHTS, its sample, or the survey), model structure (i.e., whether a model includes the utility factor), and travel measure (i.e., whether travel behavior is defined by trip frequencies or mode shares) as well as of the travel purpose (i.e., overall travel, commuting, shopping, and leisure), urban compactness components in all of the 20 models were arranged as follows: in descending order of their relative magnitudes, road connectivity (c2), transit availability (c3), population density (c1), and land use mix (c4) as shown in the column "Standardized" of Tables 30–33.

Table 30 Path Coefficients: Overall Trips

	Unstandardized	S.E.	C.R.	*p*	Standardized
Model A1: 2006 MHTS sample					
Population density	5,293,206.386	1,842,870.151	2.872	0.004	0.599
Road connectivity	56,372.880	19,895.395	2.833	0.005	0.856
Transit availability	1,576.619	560.172	2.815	0.005	0.767
Land use mix	1.000				0.073
Model A2: 2006 MHTS					
Population density	1,766,060.394	98,550.614	17.920	***	0.543
Road connectivity	30,116.305	1,687.208	17.850	***	0.870
Transit availability	1,059.717	58.899	17.992	***	0.609
Land use mix	1.000				0.109
Model A3: 2013 survey without utility					
Population density	649,758.077	53,286.798	12.194	***	0.519
Road connectivity	2,666.575	229.228	11.633	***	0.869
Transit availability	335.603	27.427	12.236	***	0.575
Land use mix	1.000				0.428
Model A4: 2013 survey with utility					
Population density	658,776.191	53,373.669	12.343	***	0.518
Road connectivity	2,689.092	232.266	11.578	***	0.872
Transit availability	338.080	27.794	12.164	***	0.573
Land use mix	1.000				0.424
Model A5: 2013 survey with utility (mode shares)					
Population density	646,478.471	53,482.482	12.088	***	0.544
Road connectivity	2,873.064	252.926	11.359	***	0.839
Transit availability	358.475	30.261	11.846	***	0.598
Land use mix	1.000				0.417

*** $p < 0.001$

Table 31 Path Coefficients: Commuting Trips

	Unstandardized	S.E.	C.R.	*p*	Standardized
Model C1: 2006 MHTS sample					
Population density	5,254,894.677	1,816,390.977	2.893	0.004	0.598
Road connectivity	55,962.733	19,628.106	2.851	0.004	0.956
Transit availability	1,561.720	551.514	2.832	0.005	0.767
Land use mix	1.000				0.074
Model C2: 2006 MHTS					
Population density	1,769,020.774	98,842.597	17.897	***	0.544
Road connectivity	30,062.567	1,686.085	17.830	***	0.968
Transit availability	1,061.267	59.063	17.969	***	0.610
Land use mix	1.000				0.109
Model C3: 2013 survey without utility					
Population density	1,552,365.108	393,489.409	3.945	***	0.669
Road connectivity	10,440.859	2,847.358	3.667	***	0.763
Transit availability	1,265.694	344.821	3.671	***	0.715
Land use mix	1.000				0.141
Model C4: 2013 survey with utility					
Population density	1,999,058.842	650,260.680	3.074	0.002	0.653
Road connectivity	12,692.095	4,380.193	2.898	0.004	0.788
Transit availability	1,507.761	520.022	2.899	0.004	0.683
Land use mix	1.000				0.113
Model C5: 2013 survey with utility (mode shares)					
Population density	1,977,195.089	632,545.105	3.126	0.002	0.651
Road connectivity	12,489.996	4,241.560	2.945	0.003	0.790
Transit availability	1,491.456	506.111	2.947	0.003	0.684
Land use mix	1.000				0.115

*** $p < 0.001$

Table 32 Path Coefficients: Shopping Trips

	Unstandardized	S.E.	C.R.	*p*	Standardized
Model S1: 2006 MHTS sample					
Population density	6,269,413.961	2,596,877.633	2.414	0.016	0.613
Road connectivity	70,216.255	29,465.181	2.383	0.017	0.980
Transit availability	1,958.118	825.635	2.372	0.018	0.748
Land use mix	1.000				0.060
Model S2: 2006 MHTS					
Population density	1,768,191.949	98,761.454	17.904	***	0.544
Road connectivity	30,071.386	1,686.301	17.833	***	0.969
Transit availability	1,060.862	59.019	17.975	***	0.609
Land use mix	1.000				0.109
Model S3: 2013 survey without utility					
Population density	666,727.803	55,042.896	12.113	***	0.497
Road connectivity	2,547.840	217.576	11.710	***	0.897
Transit availability	323.585	26.087	12.404	***	0.556
Land use mix	1.000				0.430
Model S4: 2013 survey with utility					
Population density	1,470,789.374	350,607.117	4.195	***	0.656
Road connectivity	9,599.003	2,473.417	3.881	***	0.771
Transit availability	1,196.872	307.928	3.887	***	0.720
Land use mix	1.000				0.151
Model S5: 2013 survey with utility (mode shares)					
Population density	2,018,902.240	657,094.474	3.072	0.002	0.639
Road connectivity	12,426.337	4,290.248	2.896	0.004	0.796
Transit availability	1,512.178	521.539	2.899	0.004	0.685
Land use mix	1.000				0.113

*** $p < 0.001$

Table 33 Path Coefficients: Leisure Trips

	Unstandardized	S.E.	C.R.	*p*	Standardized
Model L1: 2006 MHTS sample					
Population density	5,066,577.299	1,685,528.847	3.006	0.003	0.593
Road connectivity	53,243.184	17,964.385	2.964	0.003	0.949
Transit availability	1,484.254	504.523	2.942	0.003	0.772
Land use mix	1.000				0.077
Model L2: 2006 MHTS					
Population density	1,762,777.623	98,190.425	17.953	***	0.543
Road connectivity	30,068.997	1,681.826	17.879	***	0.970
Transit availability	1,057.718	58.682	18.025	***	0.608
Land use mix	1.000				0.109
Model L3: 2013 survey without utility					
Population density	639,989.612	52,547.271	12.179	***	0.531
Road connectivity	2,733.967	236.199	11.575	***	0.852
Transit availability	342.935	28.253	12.138	***	0.586
Land use mix	1.000				0.428
Model L4: 2013 survey with utility					
Population density	668,580.597	65,030.176	10.281	***	0.627
Road connectivity	3,828.530	386.615	9.903	***	0.839
Transit availability	465.478	46.160	10.084	***	0.671
Land use mix	1.000				0.361
Model L5: 2013 survey with utility (mode shares)					
Population density	662,638.958	54,722.595	12.109	***	0.501
Road connectivity	2,569.805	219.672	11.698	***	0.891
Transit availability	325.887	26.331	12.377	***	0.560
Land use mix	1.000				0.430

*** $p < 0.001$

The result that road connectivity is the strongest urban compactness component echoes the finding of previous studies (Gim 2011a, Zhang 2004). As part of full-scale SEM, the measurement model produced this result, and it denotes that road connectivity best explains urban compactness and subsequently travel behavior. It further shows that the effect of road connectivity is the strongest not only on overall and commuting trips, the topics of earlier studies, but also on shopping trips (Models S1–S5) and leisure trips (Models L1–L5).

This research hypothesized that the effects of density on the utility and behavior of travel differ from those of three other urban compactness components; for example, when density reduces the utility for a particular travel purpose, the others increase it. In SEM settings, this hypothesis is confirmed if the direction (+/−) of the density variable is the opposite of that of the other three variables; this denotes that if density negatively affects the factors of travel utility and behavior, the other three variables positively affect them (and vice versa). However, as shown in all of the 20 models, the coefficients of the density variable have the same positive sign as those of the other variables. This suggests that hypotheses in relation to the density variable cannot be accepted (to be discussed later). Actually, the result is in line with the finding of a recent meta-analysis (Gim 2013) that synthesized 81 different tests from 39 studies and partially supports the argument that density functions as an intermediate (Ewing and Cervero 2010) for other urban compactness components (Cao, Mokhtarian, and Handy 2009), as discussed in "2.2.2.2 Effects of Congestion".

Then, which components of urban compactness are associated with density? Although few explicitly tested the mechanism of the association, there are plausible explanations. Stone et al. (2007) suspected that a plan to build transit facilities can be realized only if a neighborhood has a certain threshold of population (i.e., demand) so that public transit can be viable in the neighborhood (i.e., correlation between population density and transit availability). Indeed, this research conducted product-of-moment correlation analysis (see Table A.4 in "A.3.2 Checking Spatial Multicollinearity") and found that population density has significant correlation with transit availability (r = 0.478; p = 0.000) in Seoul.

In addition, Gordon (2008) regarded the effect of density as an increase in land use balance. That is, if population density increases, so does supportive industrial, commercial, and leisure infrastructure (Gim 2011b). As in the same Table A.4 in "A.3.2 Checking Spatial Multicollinearity", the density−land use mix correlation is also significant (r = 0.346; p = 000).

From this perspective, the effect of land use mix cannot be accepted as it stands even if land use mix turned out to be the weakest urban compactness component. Actually, studies that found a weak effect of land use mix considered that the weakness is because quantitative measures of land use mix cannot reflect in their values (1) particular land use classes that are more or less (Brown 2009, Christian 2011), (2) spatial configuration of a neighborhood (Cervero and Gorham 1995, Handy 1996, Kitamura, Mokhtarian, and Laidet 1997), (3) aesthetic attractiveness of land uses (Christian 2011), and variety within a single land use class (Gim 2011a). For example, if a single type of store (e.g., jewelry stores or car dealerships) is prevalent in a neighborhood, the neighborhood would be measured as having a high mix of commercial and residential land uses (Gim 2011a). If a strip shopping mall is newly built in the neighborhood, its land use mix measure will increase (Kitamura, Mokhtarian, and Laidet 1997). However, residents would not perceive it as a mixed-use neighborhood and the commercial land use would not appeal to their daily shopping travel. Thus, the result that land use mix was the weakest variable should be attributed in part to the methodological limitation of the measure. Indeed, in studies in which land use mix was evaluated in terms of perception (e.g., Gim 2011a, Kerr et al. 2006), it was found to be the strongest urban compactness component.

6.6 Effects on Travel Utility and Behavior

In the above section, this research discussed how urban compactness components constituted its factor, which subsequently determines their effects on travel utility and behavior. In this section, it examines how the urban compactness factor affected the utility and behavior as a whole, that is, at the factor level and then, at the variable level.

The total effect in SEM is a multiplication of standardized path coefficients. In the 20 individual models, almost all of the path coefficients for the relationships between factors and between a factor and its indicator variables were significant at the 90% confidence level. (For effective delivery, this research put detailed outcomes in "APPENDIX E".) Insignificant coefficients were found only for the relationships between the sociodemographic factor and some of its indicator variables as shown in Table 34. Specifically, three sociodemographic variables—number of children, age, and driver's license—were insignificant. In models using the entire MHTS, even these variables were significant possibly because they used a large sample.

For parameter estimation, these insignificant sociodemographic indicators were not excluded because this research attempted to control for the sociodemographic factor when estimating the urban compactness effect on travel utility and behavior. (If removed, the variables of number of children, age, and driver's license are no longer controlled for.) Insignificant path should be removed from a model only if the researcher determines that the path is now "theoretically" unsupported (Grace 2006). Instead, a desirable approach is to retain the variable and regards it as insignificant in the context of the particular research (i.e., it does not fit the current data) (Lamb, Shirtliffe, and May 2011).

Table 34 Insignificant Variables in SEM Models

(α = 0.1)	**2006 MHTS sample**	**2006 MHTS**	**2013 survey without utility**	**2013 survey with utility**	**2013 survey with utility (mode shares)**
Overall trips	Model A1	Model A2	Model A3	Model A4	Model A5
Household—children (s2)			✓	✓	✓
Individual—age (s6)			✓		
Commuting trips	Model C1	Model C2	Model C3	Model C4	Model C5
Household—children (s2)			✓	✓	✓
Individual—age (s6)	✓		✓		
Shopping trips	Model S1	Model S2	Model S3	Model S4	Model S5
Household—children (s2)			✓	✓	✓
Individual—age (s6)			✓	✓	
Individual—license (s7)	✓				
Leisure trips	Model L1	Model L2	Model L3	Model L4	Model L5
Household—children (s2)			✓	✓	✓
Individual—age (s6)			✓	✓	
Individual—license (s7)	✓				

Note: Except those in the above list (i.e., paths between the sociodemographic factor and the above variables), all paths between factors and between a factor and its variables were significant.

In the following sections, we shall examine the standardized total effects that urban compactness has on resultant factors (i.e., utility and travel behavior) and their indicator variables—that is, (1) effects on primary benefits, secondary benefits, and trip time and (2) subsequent effects on the frequencies and shares of automobile trips, transit trips, and nonmotorized trips—according to different travel purposes and on the whole. Notably, when the effects on variables have different signs (+/−), these opposite effects do not compromise those at the factor level. That is, the factor-level effect should be understood as a composite of the magnitudes of the variable-level effects. (The sign of the factor-level effect simply follows the variable-level effect for which unstandardized path coefficient was fixed to 1 for identification purposes: primary benefits in the utility factor and automobile trip frequency/mode share in the travel behavior factor.) For example, if two indicators have the effects of a and $-b$ and if the latter is for the fixed indicator, the factor-level effect is a combination of $|a|$ and $|-b|$ and its sign becomes negative (−).

6.6.1 Effects on the Utility and Behavior of Overall Trips

In essence, models based on the overall trips (i.e., Models A1–A5) tested the travel time budget theory, which assumes that people assign their travel time to different modes of travel.[44] As shown in Table 35, by adding the utility factor to Model A3, the

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[44] Model A's are based on overall trips regardless of travel purpose (A = overall trips; C = commuting trips; S = shopping trips; L = leisure trips). A1 and A2 use the 2006 MHTS data: A1 is based on the data of the neighborhoods sampled for the 2013 survey, whereas A2 uses the entire MHTS data. A3–A5 use the sample survey data: A3 has a model structure that is the same as that of A1 and A2, whereas A4 is a model that specifies travel utility. A5 is the same as A4 in all aspects except the fact that the model examines travel behavior using mode shares, not trip frequencies. (A1–A4 use trip frequency measures.)

urban compactness effect on the overall trip frequency (in Model A4) increased [Δ(|B| − |A|) = 0.008] and the sociodemographic effect decreased [Δ(|B| − |A|) = −0.004].

Regarding the explained variance (square multiple correlations), first, the model with the utility factor (Model A4) better explained the overall trip frequency than did the model without the factor (Model A3). However, the degree of the improvement in the explained variance was negligible: By adding the factor, the SMC increased from 0.143 to 0.146. With only the 0.3%p increase, one cannot tell at this stage whether the addition of the utility factor better explains travel behavior.

Second, the explained variances of the two models using the MHTS, the one based on its sample (Model A1) and the other on the entire MHTS (Model A2), were 16.6% and 17.0%, respectively. These proportions are higher than the proportion calculated based on the survey data (14.6% by Model A3). This is probably because the MHTS was defined by one weekday trips, whereas the survey measured trips for a week: It is more difficult to explain one-week trips insomuch as travel patterns differ on weekends and across different weekdays.

Particularly regarding the proposed model (Model A4), urban compactness increased travel utility: It increased primary benefits (standardized total effect = 0.104) and secondary benefits (0.148) and at the same time, it reduced trip time (0.050). As shown, primary and secondary benefits more strongly changed. This implies that urban compactness affects travel utility mainly by increasing travel benefits rather than by reducing trip time.

At the factor level, the urban compactness factor had a slightly smaller effect on the utility factor (0.584) than did the sociodemographic factor (|−0.620|). This difference was reflected in trip frequencies. That is, the urban compactness effect on the overall trip frequency (0.125) was less than the sociodemographic effect (|−0.132|). Notably, the difference between the two effects was smaller than that calculated from a model without the utility factor (Model A3); as shown in the column "Δ(|B| − |A|)" of Table 35, by considering the utility factor, the urban compactness effect changed by 0.008 and the sociodemographic effect by −0.004. Again, however, we cannot tell at this time which model is more reliable because Model A4 had only a slightly higher explanatory power (0.003 = 0.146 − 0.143).

A notable result is that the two models based on the one-week survey (Models A3 and A4) presented a stronger effect of urban compactness than those based on the one-day MHTS (Models A1 and A2): In Models A1 and A2, the urban compactness effect on the overall trip frequency was 0.012 and 0.027, respectively, but in Models A3 and A4, the estimated effect was 0.117 and 0.125. That is, the urban compactness effect was about six times stronger on one-week trips than on one-day trips. This may imply that studies based on large-scale one-day surveys could have undervalued the urban compactness effect.

At the variable level, urban compactness increased trip frequency regardless of travel mode. It increased automobile trips as well as those by its alternatives. However, the urban compactness effect on automobile trips was not comparable to that on alternative mode trips: The estimated effect in the proposed model (Model 4) was 0.005 on automobile trips, 0.067 on transit trips, and 0.086 on nonmotorized trips. This shows that urban compactness most strongly increased nonmotorized trips. (Meanwhile, by adding the utility factor, the estimated effect in Model A4 increased particularly on alternative mode trips—0.004 on transit trips and 0.005 on nonmotorized trips—compared to Model A3.)

Although automobile trips increased with increasing urban compactness, the change was at a modest level, and thus, one can assume that its mode share was reduced because in a relative sense, alternative mode trips more strongly increased. Indeed, as shown in the bottom part of Table 35, the shares of automobile, public transit, and nonmotorized changed by −0.126, 0.076, and 0.034, respectively.

Notably, although nonmotorized trips most strongly increased in number (i.e., on the absolute scale), regarding mode shares (i.e., on the relative scale), increases in public transit trips was the most prominent. This is probably because as shown in Table 12, the original share of transit trips (mean = 9.15 trips/week) was smaller than that of nonmotorized trips (mean = 10.91 trips/week). That is, because the transit share was previously smaller, it was more sensitively affected by the smaller number of trip increases.

Indeed, even between the models with the same structure, that is, those with the utility factor (Models A4 and A5), the estimated effect of urban compactness was stronger on mode shares (|−0.143| in Model A5) than on trip frequencies (0.125 in Model A4). This result is in line with the finding of Ewing and Cervero’s two meta-analyses (2001, 2010) that urban forms affect mode shares more strongly than trip frequencies. Moreover, as in Table 35, variations in travel behavior were better accounted for when it was defined by mode shares (SMC = 0.262) than by trip frequencies (SMC = 0.146). [Likewise, variations in travel utility were better explained by mode shares (SMC = 0.785) than by trip frequencies (SMC = 0.779).]

Table 35 Standardized Total Effects: Overall Trips

	[Model A1] MHTS sample		[Model A2] Entire MHTS		[Model A3] Survey without utility (A)		[Model A4] Survey with utility (B)		Δ(|B| − |A|)	
	SD	UC	SD	UC	SD	UC	SD	UC	SD	UC
Factor: overall trips by mode (FM)	**0.253**	**0.012**	**0.257**	**0.027**	**−0.136**	**0.117**	**−0.132**	**0.125**	**−0.004**	**0.008**
Automobile trips (yA)	0.129	0.006	0.128	0.014	−0.006	0.005	−0.006	0.005	0.000	0.000
Transit trips (yT)	0.098	0.005	0.098	0.011	−0.073	0.063	−0.071	0.067	−0.002	0.004
Nonmotorized trips (yN)	−0.163	−0.008	−0.157	−0.017	−0.095	0.081	−0.091	0.086	−0.004	0.005
Explained variance (SMC)	*0.166*		*0.170*		*0.143*		*0.146*		*0.003*	
Factor: utility (UT)							**−0.620**	**0.584**		
Primary benefits (mean) (u1)							−0.110	0.104		
Secondary benefits (mean) (u2)							−0.157	0.148		
−(Trip time) (total) (u3)							−0.053	0.050		
Explained variance (SMC)							*0.779*			

	[Model A5] Survey with utility	
	SD	UC
Factor: mode shares of overall trips (SM)	**0.383**	**−0.143**
Automobile trips (mA)	0.338	−0.126
Transit trips (mT)	−0.204	0.076
Nonmotorized trips (mN)	−0.091	0.034
Explained variance (SMC)	*0.262*	
Factor: utility (UT)	**−0.749**	**0.279**
Primary benefits (mean) (u1)	−0.144	0.054
Secondary benefits (mean) (u2)	−0.205	0.076
−(Trip time) (total) (u3)	−0.127	0.047
Explained variance (SMC)	*0.785*	

Note: SD = total effects of the sociodemographic factor; UC = total effects of the urban compactness factor; unit = standard deviation (i.e., in the –1-to-1 scale, the standardized effect refers to the change in the resultant variable/factor in its standard deviation unit for a standard deviation change in the urban compactness factor)

6.6.2 Effects on the Utility and Behavior of Commuting Trips

Although this research used a one-week survey, commuting trips typically occurs on weekdays. Thus, it expected the research models better explain the trips than trips for shopping and leisure because shopping and leisure trips are more individualized, and more difficult to predict (Scheiner 2010).

In fact, the proposed model with the utility factor (Model C4) explained a considerable proportion of the variance both in travel utility and trip frequencies.[45] As in Table 36, according to SMC, the variance in the utility was explained by 33.5% and the explained variance in commuting trips was as high as 47.8%. This proportion is remarkably higher than that previously reported, as found by Handy (1996) and Scheiner and Holz-Rau (2007); the researcher also confirmed in his previous study that the proportion is around 20–25% at most (Gim 2011a). Notably, by including the utility factor, the explanatory power in Model C4 increased by 30.5%p [see the column "Δ(|B| − |A|)"], from 17.3% explained in the model without the utility factor (Model C3). Meanwhile, the proposed model (Model C4) specified the path of urban compactness–utility–travel behavior. That is, according to its structure, urban compactness "directly" affects the utility factor. (Then, the utility factor affects travel behavior, that is, the urban compactness effect is transferred to the behavior). The explained variance in the utility

[45] Model C's are based on commuting trips (A = overall trips; C = commuting trips; S = shopping trips; L = leisure trips). C1 and C2 use the 2006 MHTS data: C1 is based on the data of the neighborhoods sampled for the 2013 survey, whereas C2 uses the entire MHTS data. C3–C5 use the sample survey data: C3 has a model structure that is the same as that of C1 and C2, whereas C4 is a model that specifies travel utility. C5 is the same as C4 in all aspects except the fact that the model examines travel behavior using mode shares, not trip frequencies. (C1–C4 use trip frequency measures.)

factor was 33.5%, which is also higher than the explained variance in Model C3 in which urban compactness was specified to "directly" affect commuting trips (17.3%).

The small proportion of the explained variance by Model C3 (17.3%) may be because the model used one-week data, not because it did not consider travel utility; indeed, based on the one-day MHTS, Models C1 and C2 explained the variance in commuting trips by 25.1% and 25.8%, the proportions similar to those reported in previous studies (Gim 2011a).

While the proposed model (Model C4) explained commuting trips quite well (47.8%), it accounted for even higher proportion of the variance when travel behavior was defined by mode shares (Model C5); this is consistent with the case of the overall trips. Specifically, by using commuting mode shares instead of commuting trip frequencies, the SMC for the utility increased from 0.335 (Model C4) to 0.775 (Model C5). Likewise, the SMC for travel behavior increased from 0.478 (Model C4) to 0.675 (Model C5).

Therefore, for commuting trips, one can safely consider that the model with the utility factor (Model C4) is better than that without the factor (Model C3). Then, this research can show how the urban compactness effect could be misestimated when it does not consider the utility. As shown in the "Δ(|B| − |A|)" column of Table 36, by considering the utility, the estimated urban compactness effect decreased by 0.019; a modest degree of misestimation.[46] (The sociodemographic effect also decreased, but the

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[46] Structural equation modeling (SEM) approaches are based on the standardized effect because SEM fixes one unstandardized coefficient per factor, for model identification purposes. As standardized, the standardized effect is the same as the standardized regression coefficient. That is, it shows how a one

difference was just 0.007.) This implies that if a study is based on a model without the utility factor, the urban compactness effect would be "overestimated." In particular, the degree of the overestimation may be the largest in automobile commuting (difference = −0.021), followed by nonmotorized commuting (−0.003), whereas transit commuting would stay unaffected (0.000). Thus, it implies that if studies do not consider the utility in their research models, they may overvalue the effect of urban compactness particularly on the frequency of automobile commuting.

Regarding the effects of urban compactness on utility components, in Model C4 (the trip frequency model with the utility factor), it increased primary benefits (standardized total effect = 0.063) and secondary benefits (0.199). However, its effect on the reduction of trip time was "negative" (−0.054); that is, in contrast to the positive effect on the reduction in trip time for the overall trip, urban compactness rather increased trip time particularly for commuting. In terms of relative magnitudes, urban compactness contributed to the trip time increase less strongly than to the benefit increases. The most notable effect of urban compactness in this model was an increase in secondary benefits (0.199 > 0.063 > |−0.054|).

According to the model structure of Model C4, changes in travel utility lead to changes in commuting trip frequencies. Urban compactness increased commuting trips by public transit (standardized total effect = 0.154) and by nonmotorized modes (0.154), but it "reduced" those by automobile (−0.045). In relation to the changes in utility

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standard deviation increase in urban compactness affects travel behavior in its standard deviation unit. An issue of the standard effect is shown in "7.1 Limitations".

components, this denotes that the trip time increase reduced automobile commuting and the benefit increases resulted in increases in transit and nonmotorized commuting. However, as with the smallest effect in the trip time increase, the urban compactness effect on the reduction in automobile commuting was less than a third of that on the increases in transit commuting and nonmotorized commuting ($\approx |-0.045| / |0.154|$ = effect on automobile commuting / effect on transit commuting or nonmotorized commuting). Furthermore, compared to Model C3 in which the utility factor was not specified—this is the model with less explanatory power—the estimated effect on automobile commuting in Model C4 was even smaller, as discussed above (i.e., if the utility is not considered, the effect would be the most strongly overestimated in relation to automobile commuting).

Urban compactness was found to affect commuting trip frequencies differently by travel mode, and this research expected that the difference is also reflected in the measure of mode shares. As shown in the bottom part of Table 36, changes of the travel behavior measure (from trip frequencies to mode shares) made decreases in automobile commuting highlighted: The standardized effect changed from −0.045 (decrease in trip frequency) to −0.191 (decrease in mode share). This difference can be explained by the result that only commuting trips decreased by automobile while those by its alternative modes consistently increased. Thus, even the small decrease in trip frequency caused a larger decrease in automobile mode share. In the same vein, although the same number of trips increased by public transit (standardized total effect = 0.154) and by nonmotorized modes (0.154), the share of nonmotorized modes (0.131) increased more rapidly than the transit share (0.103). This result is because as with the case of the overall trips, the original share of nonmotorized commuting (mean = 4.65 trips/week) was smaller than that of transit commuting (mean = 5.26 trips/week), so the same degree of the trip frequency increase more strongly affected the share of nonmotorized modes (see Table 12). In general, as with the case of the overall trips, the urban compactness effect was highlighted when travel behavior was defined by mode shares (in Model C5, standardized effect on the mode share factor = −0.517) rather than by trip frequencies (in Model C4, effect on the trip frequency factor = −0.337).

Lastly, in a relative sense, the effect of urban compactness was higher than that of sociodemographics. In Model C4, the urban compactness effect on trip frequencies was 2.6 times higher than the sociodemographic effect (2.612 = |−0.337| / |0.129|); this difference was consistent with the difference in their effects on travel utility (2.610 = |−0.488| / |0.187|). Notably, this result does not denote that by considering the utility factor, the urban compactness effect was "correctly" measured as higher, in the sense that even in the model without the utility factor (Model C3), the effect (−0.356) was higher than the sociodemographic effect (0.136) and the difference was kept as 2.6 times (2.618 = |−0.356| / |0.136|). Instead, the higher urban compactness effect may be because Models C3 and C4 both were fitted to the data of the one-week survey. In the two models based on the one-day MHTS (Models C1 and C2), the urban compactness effect (−0.078 in Model C1 and −0.026 in Model C2) was rather smaller than the sociodemographic effect (0.525 in Model C1 and 0.514 in Model C2). As discussed in "5.1.2.1 Differences in Measuring Trip Frequencies", the survey differed in that it considered nonmotorized links of motorized trips (e.g., walking from and to transit facilities). Thus, the higher urban compactness effect in Models C3 and C4 may imply that urban compactness affects commuting trips mainly by increasing nonmotorized link trips.[47]

[47] The other difference of the survey from the MHTS is that the survey considered weekend trips. However, assuming that commuting mostly occurs on weekdays, this research did not consider that this difference made the urban compactness effect be highlighted in the models based on the survey.

Table 36 Standardized Total Effects: Commuting Trips

	[Model C1] MHTS sample		[Model C2] Entire MHTS		[Model C3] Survey without utility (A)		[Model C4] Survey with utility (B)		Δ(|B| − |A|)	
	SD	UC	SD	UC	SD	UC	SD	UC	SD	UC
Factor: commuting trips (FC)	**0.525**	**−0.078**	**0.514**	**−0.026**	**0.136**	**−0.356**	**0.129**	**−0.337**	**−0.007**	**−0.019**
Automobile commuting (yAC)	0.500	−0.075	0.440	−0.022	0.025	−0.066	0.017	−0.045	−0.008	−0.021
Transit commuting (yTC)	−0.174	0.026	−0.207	0.011	−0.059	0.154	−0.059	0.154	0.000	0.000
Nonmotorized commuting (yNC)	−0.130	0.019	−0.131	0.007	−0.060	0.157	−0.059	0.154	−0.001	−0.003
Explained variance (SMC)	*0.251*		*0.258*		*0.173*		*0.478*		*0.305*	
Factor: utility (UT)							**−0.187**	**0.488**		
Primary benefits (commuting) (uC1)							−0.024	0.063		
Secondary benefits (commuting) (uC2)							−0.076	0.199		
−(Trip time) (commuting) (uC3)							0.021	−0.054		
Explained variance (SMC)							*0.335*			

	[Model C5] Survey with utility	
	SD	UC
Factor: commuting mode shares (SC)	**0.469**	**−0.517**
Automobile commuting share (mcA)	0.174	−0.191
Transit commuting share (mcT)	−0.093	0.103
Nonmotorized commuting share (mcN)	−0.119	0.131
Explained variance (SMC)	*0.675*	
Factor: utility (UT)	**−0.570**	**0.629**
Primary benefits (commuting) (uC1)	−0.067	0.074
Secondary benefits (commuting) (uC2)	−0.151	0.166
−(Trip time) (commuting) (uC3)	0.010	−0.011
Explained variance (SMC)	*0.775*	

Note: SD = total effects of the sociodemographic factor; UC = total effects of the urban compactness factor; unit = standard deviation (i.e., in the –1-to-1 scale, the standardized effect refers to the change in the resultant variable/factor in its standard deviation unit for a standard deviation change in the urban compactness factor)

6.6.3 Effects on the Utility and Behavior of Shopping Trips

In relation to shopping trip frequencies, a larger proportion of the variance was explained when a model included the utility factor (SMC by Model S4 = 0.232 and SMC by Model S3 = 0.101). As shown in the column "Δ(|B| − |A|)" of Table 37, the explained variance increased by 13.1%p when this research considered travel utility. Also, if defined by mode shares instead of trip frequencies, the explained variance became even larger (SMC by Model S5 = 0.285). [Likewise, the variance in the utility factor was better explained in the mode share model (SMC by Model S5 = 0.698) than in the trip frequency model (SMC = 0.656 by Model S4).]

Although the inclusion of the utility factor increased the explained variance to 23.2%, this proportion was smaller than that found in the above commuting model with the utility factor (47.8% by Model C4) because as discussed before, commuting is more structuralized and easier to predict. Nonetheless, the proportion of 23.2% is higher than that produced in the model based on the MHTS (16.7% by Model S1 and 16.2% by Model S2).[48] Considering that the model without the utility factor (Model S3) explained the variance of 10.1% in shopping trip frequencies because it fitted data from the one-week survey, one may find that the model with the utility factor (Model S4) has a quite good variance fit.

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[48] Model S's are based on shopping trips (A = overall trips; C = commuting trips; S = shopping trips; L = leisure trips). S1 and S2 use the 2006 MHTS data: S1 is based on the data of the neighborhoods sampled for the 2013 survey, whereas S2 uses the entire MHTS data. S3–S5 use the sample survey data: S3 has a model structure that is the same as that of S1 and S2, whereas S4 is a model that specifies travel utility. S5 is the same as S4 in all aspects except the fact that the model examines travel behavior using mode shares, not trip frequencies. (S1–S4 use trip frequency measures.)

By comparing Models S3 and S4, this research can show the degree to which the urban compactness effect changes if the utility is newly included in a model. The column "Δ(|B| − |A|)" of Table 37 shows that in the model with the utility factor (Model S4), the standardized effect on trip frequencies increased by 0.062: from |−0.019| by Model S3 to |−0.081| by Model S4. [The estimated effect was even larger if travel behavior was defined by mode shares (|−0.214| by Model S5).] In particular, as with the case of commuting trips, the difference was the largest in automobile shopping trips (0.061), 12.2 times larger than that in transit and nonmotorized trips (0.005 in both). That is, by considering the utility, one can find that urban compactness strongly reduces automobile shopping trips (−0.066) and otherwise, the urban compactness effect (−0.005 in Model S3) would be underestimated.

At the variable level, urban compactness affected the three utility components as follows: It increased primary travel benefits (standardized effect = 0.067), did not change secondary benefits (0.000), and reduced trip time (0.045). Regarding secondary travel benefits, urban compactness did not change them consistently when travel behavior was defined by mode shares: In Model S5, the standardized effect of urban compactness on secondary travel benefits equaled 0.000. Possibly because of this, although utility as a whole increased, trip frequencies were reduced by all modes of travel: Shopping trip changes in Model S4 were −0.066 by automobile, −0.013 by public transit, and −0.022 by nonmotorized modes. These values denote that urban compactness reduced shopping trips in descending order of automobile trips, nonmotorized trips, and transit trips. However, this order differed from that identified in the model without the utility factor (Model S3): In this model with "less explanatory power," the urban compactness effect was strong on nonmotorized trips (standardized effect = −0.017) and less so on transit trips (−0.008) and automobile trips (−0.005). Accordingly, if the utility is not considered, one may reach an incorrect conclusion that urban compactness reduces automobile trips only slightly while in fact, they are most strongly reduced (for shopping purposes).

Considering that trip frequencies were reduced in the order of automobile, nonmotorized, and transit trips in Model S4, this research expected that the most strongly affected mode (i.e., automobile) would have a reduced share. This was confirmed in the model based on mode shares (Model S5). The automobile share changed by −0.079. In contrast, the other modes assumed even greater shares (despite their decreases in trip frequency). Particularly, the urban compactness effect on the transit share (standardized effect = 0.176) was greater than that on the share of nonmotorized modes (0.060) because as shown above, transit trips were less strongly reduced.[49]

All in all, regarding the effects of urban compactness on shopping trips, while travel utility increased as a whole, particularly secondary benefits remained the same. This variation (and no variation) brought about overall decreases in shopping trip frequencies regardless of travel mode, but because trips by automobile were most strongly reduced, shares of its alternative modes rather increased. In this sense, utility increases in shopping trips can be expressed as increases in the “shares” of the alternative modes, especially the share of public transit.

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[49] The original share of public transit (mean = 2.17 trips/week) was smaller than that of nonmotorized modes (mean = 2.93 trips/week) and this difference may have canceled out part of the urban compactness effect on the shares of the two modes.

In a relative sense, urban compactness in the proposed model (Model S4) had a smaller effect on travel utility (standardized effect = |0.089|) than sociodemographics (|−0.197|). This was also the case regarding shopping trip frequencies: The urban compactness effect (|−0.081|) was smaller than the sociodemographic effect (|0.180|). Meanwhile, the difference in the effects that the two factors had on shopping trip frequencies, 0.099 (= |0.180| − |−0.081|), was "larger" than the difference estimated by Model S3, that is, by the model without the utility factor (0.004 = |0.023| − |−0.019|). Indeed, as shown in the column "Δ(|B| − |A|)" of Table 37, by considering the utility factor, the urban compactness effect did increase (0.062), but the sociodemographic effect more strongly increased (0.157). This means that if the utility is added to a model for higher explanatory power, the effect of urban compactness on shopping trip frequencies may be estimated to be higher than before, but its relative magnitude will be lower, compared to the newly estimated sociodemographic effect.

Table 37 Standardized Total Effects: Shopping Trips

	[Model S1] MHTS sample		[Model S2] Entire MHTS		[Model S3] Survey without utility (A)		[Model S4] Survey with utility (B)		Δ(|B| − |A|)	
	SD	UC	SD	UC	SD	UC	SD	UC	SD	UC
Factor: shopping trips (FS)	**0.728**	**0.061**	**0.828**	**0.139**	**0.023**	**−0.019**	**0.180**	**−0.081**	**0.157**	**0.062**
Automobile shopping (yAS)	0.097	0.008	0.101	0.017	0.006	−0.005	0.146	−0.066	0.140	0.061
Transit shopping (yTS)	−0.167	−0.014	−0.095	−0.016	0.010	−0.008	0.029	−0.013	0.019	0.005
Nonmotorized shopping (yNS)	−0.104	−0.009	−0.081	−0.013	0.021	−0.017	0.049	−0.022	0.028	0.005
Explained variance (SMC)	*0.167*		*0.162*		*0.101*		*0.232*		*0.131*	
Factor: utility (UT)							**−0.197**	**0.089**		
Primary benefits (shopping) (uS1)							−0.147	0.067		
Secondary benefits (shopping) (uS2)							−0.001	0.000		
−(Trip time) (shopping) (uS3)							−0.099	0.045		
Explained variance (SMC)							*0.656*			

	[Model S5] Survey with utility	
	SD	UC
Factor: shopping mode shares (SS)	**0.117**	**−0.214**
Automobile shopping share (msA)	0.043	−0.079
Transit shopping share (msT)	−0.097	0.176
Nonmotorized shopping share (msN)	−0.033	0.060
Explained variance (SMC)	*0.285*	
Factor: utility (UT)	**−0.404**	**0.736**
Primary benefits (shopping) (uS1)	−0.088	0.161
Secondary benefits (shopping) (uS2)	−0.121	0.000
−(Trip time) (shopping) (uS3)	−0.037	0.067
Explained variance (SMC)	*0.698*	

Note: SD = total effects of the sociodemographic factor; UC = total effects of the urban compactness factor; unit = standard deviation (i.e., in the –1-to-1 scale, the standardized effect refers to the change in the resultant variable/factor in its standard deviation unit for a standard deviation change in the urban compactness factor)

6.6.4 Effects on the Utility and Behavior of Leisure Trips

When it comes to the explained variance, Table 38 shows that the proposed model for leisure trips (Model L4, the model with the utility factor) has similar explanatory power (SMC = 0.242) to that of the proposed model for shopping trips (SMC by Model S4 = 0.232) although the proposed model for commuting has the highest variance fit (SMC by Model C4 = 0.478). By including the utility factor, Model L4 achieved higher fit than the model without the factor (Model L3): The difference in the fit was 0.116 (= 0.242 − 0.126).[50] The fit was also higher than that based on the one-day MHTS: The SMC was 0.165 in the model using the MHTS sample (Model L1) and 0.156 if the entire MHTS was used (Model L2). The SMC increased when travel behavior was defined by mode shares instead of trip frequencies (from 0.242 in Model L4 to 0.366 in Model L5). Likewise, the variance in the utility factor was better explained in the mode share model (SMC in Model L5 = 0.748) than in trip frequency model (SMC in Model L4 = 0.733). Along with the above-shown results, this one consistently presents that urban compactness better explains travel utility and behavior when the behavior is defined by mode shares than by trip frequencies, no matter which travel purpose is concerned, that is, for all of the four different purposes of travel (i.e., overall, commuting, shopping, and leisure).

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[50] Model L's are based on commuting trips (A = overall trips; C = commuting trips; S = shopping trips; L = leisure trips). L1 and L2 use the 2006 MHTS data: L1 is based on the data of the neighborhoods sampled for the 2013 survey, whereas L2 uses the entire MHTS data. L3–L5 use the sample survey data: L3 has a model structure that is the same as that of L1 and L2, whereas L4 is a model that specifies travel utility. L5 is the same as L4 in all aspects except the fact that the model examines travel behavior using mode shares, not trip frequencies. (L1–L4 use trip frequency measures.)

Also, when Models L4 and L5 are compared, one can note that urban compactness more strongly affected leisure mode shares (standardized effect = 0.545) than leisure trip frequencies (0.168). Thus, along with earlier results, this result suggests that without regard to travel purpose, the estimated effect of urban compactness is higher on the measure of mode shares than on trip frequencies, which accordingly supports Ewing and Cervero's argument based on two meta-analyses (2001, 2010). Furthermore, according to the findings of SEM, their argument is transferrable across different purposes of trips.

Regarding the way that urban compactness affects travel utility, it positively changed all of the three utility components, a result that is consistent with the cases of overall trips and shopping trips. (That is, only for commuting trips, urban compactness "negatively" affected the reduction of trip time, that is, it "increased" commuting trip time.) In particular, in the proposed model (Model L4), the degrees of the benefit increases—0.173 in primary benefits and 0.160 in secondary benefits—were far greater than the degree of the cost decrease (0.037). A consistent result was found when the urban compactness effect was estimated using the measure of mode shares: In Model L5, the standardized effect of urban compactness was 0.197 on primary benefit increases, 0.139 on secondary benefit increases, and 0.093 on trip time decrease. Based on these consistent results, one can consider that the urban compactness effect on leisure trips is best represented by benefit increases rather than by trip time decrease, that is, if the benefit side of travel utility is not analyzed, a study may overly underestimate the effect that urban compactness has on leisure trip frequencies and mode shares.

How changes in travel utility resulted in changes in leisure trips was in the same fashion as the overall trips. That is, leisure trips by automobile increased slightly (standardized effect in Model L4 = 0.028) and alternative mode trips more strongly increased (0.054 by public transit and 0.147 by nonmotorized modes). According to these relative magnitudes, urban compactness most strongly affected nonmotorized leisure trips: They increased 5.2 times more than automobile leisure trips.

Thus, although leisure trips increased by all of the three modes, as with the overall trips, the automobile share was rather reduced (standardized effect in Model L5 = −0.347) because automobile trips only modestly increased. Besides, according to trip frequencies, nonmotorized trips increased (0.147 in Model L4) more strongly than transit trips (0.054 in Model L4), but the increase in the share of nonmotorized modes (0.027 in Model L5) was far lower than that in the transit share (0.255 in Model L5). This result is because as shown in Table 12, transit trips (mean = 1.72 trips/week) was just a half of nonmotorized trips (mean = 3.33 trips/week), and the small increase in transit trips strongly increased the transit share.

Between urban compactness and sociodemographics, the urban compactness effect on travel utility was more than twice of the sociodemographic effect in the leisure trip frequency model (in Model L4, 2.458 = |0.816| / |−0.332|). This difference was kept in the mode share model (in Model L5, 2.273 = |0.900| / |−0.396|). This difference was exactly reflected in travel behavior. That is, the urban compactness effect was twice stronger than the sociodemographic effect in terms of trip frequencies (in Model L4, 2.471 = |0.168| / |−0.068|) and mode shares (in Model L5, 2.271 = |0.545| / |−0.240|). Thus, one can consider that on travel utility and behavior—whether it is defined by the absolute measure of trip frequencies or the relative measure of mode shares—the urban compactness effect is more than twice as large as the sociodemographic effect.

Compared to the model without the utility factor (Model L3), the model with the factor (Model L4) presented a lower sociodemographic effect (effect difference = −0.004) and a higher urban compactness effect (0.043), as shown in the column "$\Delta(|B| - |A|)$" of Table 38. Because the model without the utility factor turned out to have less explanatory power, one can estimate how the urban compactness effect may be misestimated if a model does not consider travel utility. The same column shows that the degree of the misestimation would be the highest for nonmotorized trips (effect difference = 0.039), followed by transit trips (0.014) and automobile trips (0.007).

Lastly, one can estimate how models based on the one-week survey would produce different results from those using a one-day survey. Despite the same structure (i.e., without the utility factor), the model based on the 2013 survey (Model L3) showed that the urban compactness effect was larger than the sociodemographic effect ($|0.125| > |-0.072|$). However, if the effects were estimated based on the MHTS, the relative magnitude was the opposite: The urban compactness effect was "smaller" than the sociodemographic effect whether the effects were estimated using the MHTS sample (in Model L1, $|0.107| < |0.704|$) or the entire MHTS (in Model L2, $|0.169| < |0.750|$). This implies that the effect of urban compactness on leisure trips may be highlighted if a study (1) investigates trips conducted for a whole week and (2) considers link trips made by supportive travel modes such as walk and bike.

Table 38 Standardized Total Effects: Leisure Trips

	[Model L1] MHTS sample		[Model L2] Entire MHTS		[Model L3] Survey without utility (A)		[Model L4] Survey with utility (B)		Δ(|B| − |A|)	
	SD	UC	SD	UC	SD	UC	SD	UC	SD	UC
Factor: leisure trips (FL)	**0.704**	**0.107**	**0.750**	**0.169**	**−0.072**	**0.125**	**−0.068**	**0.168**	**−0.004**	**0.043**
Automobile leisure (yAL)	0.072	0.011	0.107	0.024	−0.012	0.021	−0.011	0.028	−0.001	0.007
Transit leisure (yTL)	−0.085	−0.013	−0.048	−0.011	−0.023	0.040	−0.022	0.054	−0.001	0.014
Nonmotorized leisure (yNL)	−0.072	−0.011	−0.045	−0.010	−0.062	0.108	−0.060	0.147	−0.002	0.039
Explained variance (SMC)	*0.165*		*0.156*		*0.126*		*0.242*		*0.116*	
Factor: utility (UT)							**−0.332**	**0.816**		
Primary benefits (leisure) (uL1)							−0.071	0.173		
Secondary benefits (leisure) (uL2)							−0.065	0.160		
−(Trip time) (leisure) (uL3)							−0.015	0.037		
Explained variance (SMC)							*0.733*			

	[Model L5] Survey with utility	
	SD	UC
Factor: leisure mode shares (SL)	**−0.240**	**0.545**
Automobile leisure share (mlA)	0.153	−0.347
Transit leisure share (mlT)	−0.112	0.255
Nonmotorized leisure share (mlN)	−0.012	0.027
Explained variance (SMC)	*0.366*	
Factor: utility (UT)	**−0.396**	**0.900**
Primary benefits (leisure) (uL1)	−0.041	0.197
Secondary benefits (leisure) (uL2)	−0.061	0.139
−(Trip time) (leisure) (uL3)	−0.087	0.093
Explained variance (SMC)	*0.748*	

Note: SD = total effects of the sociodemographic factor; UC = total effects of the urban compactness factor; unit = standard deviation (i.e., in the –1-to-1 scale, the standardized effect refers to the change in the resultant variable/factor in its standard deviation unit for a standard deviation change in the urban compactness factor)

6.7 Testing Hypotheses

Tables 39–40 present the standardized total effects of urban compactness on travel utility, trip frequencies, and mode shares. This research extracted the effects from above Tables 35–38 (particularly, from the sections Models X4 and X5) so that it can explicitly test research hypotheses. Meanwhile, it should be noted that in all models, the coefficients of the urban compactness components consistently had positive (+) signs (see Tables 30–33). This means that the directions of the standardized effects in Tables 39–40 are retained. [Otherwise, that is, if a certain component had a negative (−) sign, for that component, the direction of the effects would accordingly change (i.e., from + to − and vice versa).]

Table 39 Standardized Urban Compactness Effects on Travel Utility and Trip Frequencies

Trip frequencies	Automobile	Transit	Nonmotorized	Combined (factor)*	Explained variance
Commuting	−0.045	0.154	0.154	|−0.337|	0.478
Shopping	−0.066	−0.013	−0.022	|−0.081|	0.232
Leisure	0.028	0.054	0.147	|0.168|	0.242
Overall	0.005	0.067	0.086	|0.125|	0.146
Utility	Trip time	Primary benefits	Secondary benefits	Combined (factor)*	Explained variance
Commuting	−0.054	0.063	0.199	|0.488|	0.335
Shopping	0.045	0.067	0.000	|0.089|	0.656
Leisure	0.037	0.173	0.160	|0.816|	0.733
Overall	0.050	0.104	0.148	|0.584|	0.779

* The sign of the effect on a factor (+/−) follows that on an indicator variable whose unstandardized path coefficient is fixed to 1 (automobile trips for the trip frequency factor and primary benefits for the utility factor).

Table 40 Standardized Urban Compactness Effects on Travel Utility and Mode Shares

Mode shares	Automobile	Transit	Nonmotorized	Combined (factor)*	Explained variance
Commuting	−0.191	0.103	0.131	|−0.517|	0.675
Shopping	−0.079	0.176	0.060	|−0.214|	0.285
Leisure	−0.347	0.255	0.027	|0.545|	0.366
Overall	−0.126	0.076	0.034	|−0.143|	0.262
Utility	Trip time	Primary benefits	Secondary benefits	Combined (factor)*	Explained variance
Commuting	−0.011	0.074	0.166	|0.629|	0.775
Shopping	0.067	0.161	0.000	|0.736|	0.698
Leisure	0.093	0.197	0.139	|0.900|	0.748
Overall	0.047	0.054	0.076	|0.279|	0.785

* The sign of the effect on a factor (+/−) follows that on an indicator variable whose unstandardized path coefficient is fixed to 1 (automobile trips for the mode share factor and primary benefits for the utility factor).

The first hypothesis is: "(Assuming that compact urban form reduces trip length) urban compactness (H1a) reduces trip time particularly by alternative modes and therefore (H1b) increases alternative mode travel." As in the bottom of Table 39 (intersection of "Trip time" and "Overall"), urban compactness positively affected trip time reduction (0.050) and subsequently increased transit trips (0.067) and nonmotorized trips (0.086). Thus, evaluated by the measure of trip frequencies, this hypothesis is accepted. The hypothesis is also accepted in terms of mode shares: Urban compactness contributed to trip time savings (0.047) and then, it increased the transit share (0.076) and the nonmotorized mode share (0.034). Although transit trips increased less strongly than nonmotorized trips (0.067 < 0.086), the urban compactness effect was larger in increasing the transit share (0.076 > 0.034) because the original share of public transit was smaller (and thus, the transit share more sensitively increased by the smaller increase in transit trips).

The second hypothesis is: "(Assuming that compact urban form reduces trip speed) urban compactness (H2a) increases trip time particularly by automobile and therefore (H2b) decreases automobile travel." As mentioned above, urban compactness positively affected trip time reduction, that is, it actually "reduced" trip time (0.050). Accordingly, automobile trips "increased" by 0.005. Thus, in terms of the absolute measure of trip frequency, this hypothesis is rejected. However, because the increase in automobile trips (0.005) was far smaller than increases in transit and nonmotorized trips (0.067 and 0.086, respectively), the automobile share was rather reduced, that is, urban compactness did negatively affected (i.e., decreased) the automobile share (−0.126). Combined together, urban compactness did not increase trip time of automobile travel, but actually reduced it; then, the absolute number of automobile trips slightly increased, but the automobile share was reduced because trips by other modes more strongly increased. Thus, this hypothesis is rejected when it is tested based on trip frequency and partially supported if tested by mode share.

The third hypothesis details H1 because it is concerned not only with travel modes, but also with travel purposes: "Urban compactness (H3a) reduces alternative mode trip time *particularly for shopping and leisure* and accordingly (H3b) increases alternative mode travel for these purposes." As in Table 39, urban compactness reduces trip time for shopping (0.045) and for leisure (0.037) in a model that uses the measure of trip frequencies. Subsequently, leisure trips increased by alternative modes—by public transit (0.054) and by nonmotorized modes (0.147)—as hypothesized. For shopping trips, although urban compactness reduced trip time, it rather reduced both of transit trips (−0.013) and nonmotorized trips (−0.022). However, because shopping trips by automobile were more strongly reduced (−0.066), the shares of public transit and nonmotorized modes increased. That is, when travel behavior was defined by mode shares, SEM results on shopping trips became consistent with the case of leisure trips: Urban compactness reduced trip time of shopping travel (0.067) and leisure travel (0.093), and the shares of public transit and nonmotorized modes increased both for shopping (0.176 and 0.060) and leisure (0.255 and 0.027). Thus, this hypothesis is partially accepted based on the measure of trip frequencies—because transit and nonmotorized shopping trips were rather reduced although trip time did decrease, as hypothesized—whereas it is completely accepted according to the measure of mode shares.

The fourth hypothesis details H2 (urban compactness --> increase in automobile trip time --> decrease in automobile travel) because it additionally considers travel purposes: "Urban compactness (H4a) increases automobile trip time *particularly for commuting purposes* and accordingly (H4b) reduces automobile *commuting travel*." As in the first row of the bottom "Utility" part of Table 39 (intersection of "Trip Time" and "Commuting"), urban compactness negatively affected trip time reduction for commuting (−0.054) and subsequently reduced commuting trips by automobile (−0.045). The same result was produced according to the measure of mode share. In Table 40, urban compactness increased trip time for automobile commuting (−0.011) and reduced its share (−0.191). Thus, this hypothesis is accepted.

Notably, not only did population density reduce trip time, frequency, and share of automobile commuting, but also the reduction resulted from the significant effects of land use mix, road connectivity, and transit availability (They were all significant and had the "same" positive signs). Then, how would these non-density urban compactness components increase trip time of automobile commuting in the first place? This may be partially caused by density-centered spatial multicollinearity: Neighborhoods with high land use mix, road connectivity, and transit availability are typically those with high population density, and they are more congested (i.e., low trip speed and extended trip time). In "6.5 Effects of Urban Compactness Components", this research highlighted that population density makes transit facilities economically viable (increases transit availability) (Stone et al. 2007) and induces supportive land uses (increases land use mix) (Gordon 2008). However, as shown in SEM, the three urban compactness components may have their own effects as follows.

First, regarding road connectivity, as opposed to automobile-centered road networks that are equipped with wide roads, large blocks, and many cul-de-sacs, pedestrian-friendly road networks are characterized by narrow roads and small blocks (Ewing and Cervero 2001, 2010), both of which increase the density of road intersections. Thus, in case of high road connectivity, automobiles should reduce trip speed on these narrow roads and stop more frequently on the intersections. Consequently, the outcome of road connectivity is the same (i.e., speed decrease) as that of population density; a difference is that the density reduces the speed through congestion.

Second, in relation to transit availability, the catchment area of a transit station has a high pedestrian volume that negatively affects automobile travel (Richter et al. 2006). Particularly in Seoul, areas near transit facilities put a priority on pedestrian travel: In addition to well-connected roads, they have more one-way streets, road crossings, traffic signals, and stop signs (Seoul Metropolitan Government 2010). These all reduce automobile trip speed.

Third, with regard to land use mix, mixed use areas in Seoul have small blocks to contain various activities in a walkable distance and these blocks typically do without parking facilities. Thus, parking is difficult and requires quite an amount of walking from and to distant parking facilities (Gim 2011a).

In summary, trip time of automobile commuting may increase not only because of population density (more congestion), but also because of pedestrian-friendly road connectivity and transit availability (reduced automobile trip speed) and land use mix (nonmotorized link trips).[51]

The fifth hypothesis involves changes in primary travel benefits: "Urban compactness (H5a) increases primary benefits of *alternative mode travel for shopping and leisure* and accordingly (H5b) increases the particular travel." Tables 39–40 present that by urban compactness, primary travel benefits increased for shopping and leisure whether travel was measured by trip frequencies (0.067 for shopping and 0.173 for leisure) or mode shares (0.161 for shopping and 0.197 for leisure); the benefit increases were larger than those for commuting (0.063 in relation to trip frequencies and 0.074 to mode shares). However, the behavioral response differed: Transit and nonmotorized trips "decreased" for shopping (−0.013 and −0.022) and increased for leisure (0.054 and 0.147), whereas transit and nonmotorized mode shares consistently increased both for

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[51] All of the four variables were significantly loaded onto the urban compactness factor in the commuting model and they had the same positive (+) sign. How automobile trip time would be reduced by each of the urban compactness components is discussed in the above paragraphs.

shopping (0.176 and 0.060) and leisure (0.255 and 0.027). Thus, this hypothesis is partially supported when travel behavior is defined by trip frequencies—because urban compactness increased primary travel benefits as hypothesized, but the benefit increases resulted in more leisure trips only, not in more shopping trips—and entirely accepted when it is defined by mode shares. While land use mix was significant, the other three urban compactness components also increased primary travel benefits. This appears to be partially attributed to spatial multicollinearity. This research found that land use mix most weakly contributed to the urban compactness factor, but the factor as a whole sufficiently increased primary benefits. This supports an argument made by Schimek (1996) and Zhang (2004): Although one urban compactness component would have a modest effect, the effect combined with those of other components may be considerable.

Last, the sixth hypothesis is related to changes in secondary travel benefits: "Urban compactness (H6a) increases secondary benefits of *alternative mode travel for shopping and leisure* and accordingly (H6b) increases the particular travel." Tables 39–40 show that for leisure travel, urban compactness increased secondary benefits (0.160 in relation to the trip frequency measure and 0.139 in relation to the mode share measure), but for shopping, it did not make any difference (0.000 according to both of the measures). Then, people actually reduced the absolute number of shopping trips by public transit and nonmotorized modes (−0.013 and −0.022) and increased leisure trips by the two modes (0.054 and 0.147). If measured by mode shares, however, both transit and nonmotorized trips consistently increased both for shopping (0.176 and 0.060) and leisure (0.255 and 0.027). Thus, the increase in secondary travel benefits was limited to leisure trips, and leisure trips increased regardless of the measure of travel behavior (i.e., trip frequencies and mode shares). By comparison, while the benefits did not change for shopping trips, these trips were reduced in number, but because a greater number of automobile trips were reduced, the shares of public transit and nonmotorized modes rather increased. Hence, this hypothesis is partially supported.

Table 41 shows the original hypotheses, the degrees to which they are accepted or rejected (according to the measures of travel behavior, either trip frequencies or mode shares), and research findings, whereby the hypotheses are updated. The updates are italicized. As such, the column "[Corrected according to the tests (in italic)]" shows why and where the original hypotheses were accepted, partially accepted, or rejected.

Table 41 Testing Research Hypotheses: Effects of Increases in Urban Compactness on Travel Utility and Behavior

ID	**[Hypotheses]**		**[Tests]**		**[Corrected according to the tests (in italic)]**	
	Effects on travel utility (Ha)	Subsequent effects on travel behavior (Hb)	By trip frequencies	By mode shares	Effects on travel utility (Ha)	Subsequent effects on travel behavior (Hb)
H1 (costs)	The costs of alternative mode travel decrease.	Alternative mode travel increases.	Accepted	Accepted		
H2 (costs)	The costs of automobile travel increase.	Automobile travel decreases.	Rejected	Partial	The costs of automobile travel* *decrease*.	Automobile *trip frequency increase and mode share* decreases.
H3 (H1 detailed)	The costs of alternative mode shopping and leisure travel decrease.	Alternative mode shopping and leisure travel increases.	Partial	Accepted		Alternative mode shopping *trip frequency decreases and mode share* increases. Alternative mode leisure travel* increases.
H4 (H2 detailed)	The costs of automobile commuting increase.	Automobile commuting decreases.	Accepted	Accepted		
H5 (primary benefits)	Primary benefits of alternative mode shopping and leisure travel increase.	Alternative mode shopping and leisure travel increases.	Partial	Accepted		Alternative mode shopping *trip frequency decreases and mode share* increases. Alternative mode leisure travel* increases.
H6 (second-ary benefits)	Secondary benefits of alternative mode shopping and leisure travel increase.	Alternative mode shopping and leisure travel increases.	Partial	Partial	Secondary benefits of alternative mode shopping travel* *do not change*. Secondary benefits of alternative mode leisure travel* increase.	Alternative mode shopping *trip frequency decreases and mode share* increases. Alternative mode leisure travel* increases.

* Travel = consistent whether the hypothesis was tested by the measure of trip frequencies or that of mode shares

6.8 Summary of Research Findings

While research hypotheses were either accepted or rejected by the measure of travel behavior, consistent results were found regardless of the measure. First, secondary travel benefits most strongly increased for commuting trips—0.199 (0.166) for commuting trips, 0.000 (0.000) for shopping trips, and 0.160 (0.139) for leisure trips (effects by the mode share measure are in parentheses)—and accordingly, commuting trips by public transit and nonmotorized modes consistently increased both in the absolute measure of trip frequencies and the relative mode share measure. Regarding primary travel benefits, this research hypothesized that increases in primary benefits are not meaningful for commuting (i.e., job increases in density, variety, quality, and uniqueness) because jobs (commuting destinations) are less spatially flexible. Indeed, this research found that primary benefits least strongly increased for commuting—0.063 (0.074) for commuting trips, 0.067 (0.161) for shopping trips, and 0.173 (0.197) for leisure trips—that is, urban compactness only modestly increases commuting primary benefits.

In fact, for commuting, secondary travel benefits were more sensitively increased than trip time and primary benefits: trip time reduction by −0.054 (−0.011), primary benefit increases by 0.063 (0.074), and secondary benefit increases by 0.199 (0.166) (effects by the mode share measure are in parentheses). That is, by urban compactness, (1) secondary benefits most easily increase for commuting (among different purposes of travel) and (2) commuting is most strongly affected by increases in secondary travel benefits (among utility components). They consistently denote that *increases in transit and nonmotorized trips for commuting are primarily determined by increases in* *secondary travel benefits*. Actually, except for three types of secondary benefits that would be strongly expected for non-commuting travel—as discussed in “3.3 Hypotheses”, exploring an unfamiliar route, feeling amenities (e.g., enjoying scenic beauty on a particular route), and experiencing the outdoors—most secondary benefits are also expected (or even more so) during commuting. They include anti-activity (relaxation, taking a rest/nap, and clearing the head), external activities while traveling (reading books/newspapers/magazines, listening to music/radio, and watching television/videos) and at stopovers (running errands at stores and leaving/collecting children at school), buffer (transition from home to office), status expression (showing off a luxury car), curiosity (idly exploring other passengers and gathering information), and conquest (breaking away from introversion and inertia).

In contrast to the case of secondary travel benefits, primary benefits most strongly increased for leisure trips—0.063 (0.074) for commuting trips, 0.067 (0.161) for shopping trips, and 0.173 (0.197) for leisure trips (effects by the mode share measure are in parentheses)—and thus, leisure trips by transit and nonmotorized modes consistently increased both in trip frequency and in mode share. Furthermore, for leisure, primary travel benefits were more sensitively changed than trip time and secondary benefits: trip time reduction by 0.037 (0.093), primary benefit increases by 0.173 (0.197), and secondary benefit increases by 0.160 (0.139). This shows that by urban compactness, (1) primary benefits most easily increase for leisure (among different purposes of travel) and (2) leisure trips are most strongly affected by increases in primary benefits (among utility components). Thus, *increases in transit and nonmotorized trips for leisure hinge mainly on increases in primary travel benefits*.

Regarding the other utility component, trip time was reduced for shopping and leisure—0.045 (0.067) for shopping trips and 0.037 (0.093) for leisure trips (effects by the mode share measure are in parentheses)—but trip time reduction was less effective than benefit increases, especially primary benefit increases: for shopping trips, 0.045 (0.067) < 0.067 (0.161) and for leisure trips, 0.037 (0.093) < 0.173 (0.197). Furthermore, trip time reduction was only weakly related to changes in transit and nonmotorized trips, and notably, despite trip time reduction, shopping trips decreased. In fact, the trip time effect was consistently represented by its "increase" for commuting: −0.054 (−0.011) for commuting (i.e., negative effect of urban compactness on trip time reduction). That is, because urban compactness increases trip time, automobile commuting trips were consistently reduced both in frequency and share. Accordingly, *decreases in automobile trips for commuting depend on increases in trip time*.

In relation to the other purpose of travel, shopping, although primary travel benefits increased by 0.067 (0.161) and trip time was reduced by 0.045 (0.067), secondary benefits did not change—0.000 (0.000)—by urban compactness (effects by the mode share measure are in parentheses). Then, shopping trips were reduced without regard to travel mode (−0.066 by automobile, −0.013 by public transit, and −0.022 by nonmotorized modes) and stronger decreases in automobile trips led to increases in the shares of public transit and nonmotorized modes (automobile share by −0.079, transit share by 0.176, and nonmotorized mode share by 0.060). Combined together, these findings denote that *without increases in secondary travel benefits, people would not make additional shopping trips and because of primary benefit increases and trip time reduction, they can reduce shopping trips by automobile*. Indeed, people would not make additional shopping trips by expecting higher secondary benefits, insomuch as daily shopping destinations may not differ significantly.

In summary, this research adds to approaches to positive utility of travel by considering the effects of urban compactness and by separately examining the effects according to travel purposes:

- Primary benefits and leisure trips: By urban compactness, primary travel benefits most easily increase for leisure trips; this purpose of trips is also most strongly affected by primary benefits (i.e., density, variety, quality, and uniqueness of leisure facilities). Then, transit and nonmotorized leisure trips increase in frequency and mode share.
- Secondary benefits and commuting trips: By urban compactness, secondary travel benefits most easily increase for commuting trips; this purpose of trips is also most strongly affected by secondary benefits (e.g., taking a rest/nap, clearing the head, and listening to music/radio during commuting, dropping off children at school, feeling transition from home to office, showing off a luxury car, idly exploring other passengers in a bus/subway, and breaking away from introversion/inertia). Then, transit and nonmotorized commuting trips increase in frequency and mode share.
- Trip time and commuting trips: Trip time "reduction" by urban compactness is less strong than benefit increases for shopping and leisure. For commuting, trip time "increases," and accordingly, automobile commuting trips are reduced in frequency and mode share.

- Utility and shopping trips: Without secondary benefit increases, primary benefit increases and trip time reduction result in less shopping trips, primarily by automobile.

Urban compactness components were hypothesized to have “differing” effects on the utility. According to the original hypotheses, density should increase trip time for automobile commuting, and the other components should reduce that for alternative mode shopping and leisure travel. However, all of the components had the “same” direction of the effects on trip time changes (see Tables 30–33).

First, density reduces the speed of automobile commuting (and increases its trip time) because it increases congestion. However, speed is reduced by the other components as well. Land use mix leads to small and fragmented land uses with limited access to parking facilities. Accordingly, parking near offices becomes more difficult, which in turn brings about additional link trips from distant parking facilities to the final destination, offices. Road connectivity makes roads narrower and blocks smaller, which accordingly increases road intersections. For these reasons, automobiles reduce trip speed and stop more frequently. Regarding transit availability, the catchment area of a transit facility is accompanied by those characteristics that function as traffic calming measures: one-way streets, road crossings, traffic signals, and stop signs as well as well-connected roads for pedestrian travel (i.e., road connectivity). All in all, not only density, but also the other urban compactness components directly increase trip time.

Second, density by itself does not reduce trip time for non-automobile travel. Instead, it indirectly affects the time by increasing land use mix (Gordon 2008) and transit availability (Stone et al. 2007). If population density increases, shopping and leisure infrastructure is built to support the population (Gim 2011b), which increase land use mix. Transit facilities are constructed only if they can be economically viable, that is, only if the density is more than a certain level. Notably, this argument explicitly assumes that density has a causal effect on land use mix and transit availability, as opposed to the term “spatial multicollinearity” in which no specific direction is in mind.

Third, in line with the second point, benefit increases are also concerned with density. (This research originally hypothesized that primary benefits are affected primarily by land use mix and secondary benefits by land use mix and road connectivity.) However, density raises supportive working, shopping, and leisure infrastructure and transit facilities. Thus, it increases land use mix and transit availability, whereby road connectivity increases. Thus, all of the urban compactness components may contribute to increases in primary and secondary travel benefits.

In conclusion, this research refines the activity-based utility theory of derived travel demand by clarifying the effects of urban compactness as follows.

- The effect of congestion (trip speed reduction and trip time increase, followed by decreases in automobile trips) is present only for commuting. The effect is directly brought about by all of the urban compactness components.
- The effect of the reduction in physical distance between trip origin and destination (trip length reduction and trip time decrease, followed by increases in non-automobile trips) is particularly highlighted for shopping and leisure travel. Urban compactness components other than density directly contribute to the distance reduction, whereas density is in effect by improving the other urban compactness components.

CHAPTER 7.

CONCLUSIONS

In an attempt to better explain the effects that urban form has on travel behavior, this dissertation research reintroduced the concept of travel utility and refined it using two recent utility-based theories: activity-based utility theory of derived travel demand and approaches to positive utility of travel. Based on the theories, it developed a conceptual model in which the utility was specified as an intermediary between urban compactness and travel behavior. The model was then verified through a mixed methods approach that consisted of 24 semi-structured interviews and subsequent exploratory factor analysis. The interviews also functioned as a pre-test, that is, based on the outcomes of the interviews, this research modified the questionnaire of a survey, the main test. The survey was conducted in 24 neighborhoods in Seoul, Korea, using a hand-delivered survey method that was supported by financial incentives and reminder calls. Accordingly, it achieved a very high response rate (86.9%). Based on a total of 1,032 responses from the survey and GIS datasets, this research tested the conceptual model according to three purposes of trips (commuting, shopping, and leisure) and for overall trips. It conducted thorough statistical tests to confirm the representativeness of the sample (χ^2 goodness-of-fit tests and one-sample *t*-tests), construct validity of the psychometric survey (confirmatory factor analysis), and configural invariance of urban compactness measures, and finally identified a total of 20 SEM models that had good model fit (or covariance fit) to the degree to which their results are generally reliable—

models considering the utility were more reliable—and transferrable to the entire population (i.e., all neighborhoods in Seoul).

The most important finding of the models was that by considering travel utility, trip frequencies were better explained (i.e., better variance fit). Although the degree of the increase in explanatory power was modest when travel purposes were not considered (14.6% by 0.3 percentage point increase), when this research separately modeled trip frequencies, the explained variance increased remarkably: by 30.5 percentage points for commuting trips (from 17.3% to 47.8% of the variance in commuting trip frequency), by 13.1 percentage points for shopping trips (from 10.1% to 23.2% of the variance), and by 11.6 percentage points for leisure trips (from 12.6% to 24.2% of the variance). Thus, the argument of this research, travel behavior is better explained by considering the utility, was strongly supported.

In general, compared to the measure of trip frequencies, individual models were better explained by the measure of mode shares. It is because the shares present the current frequency of trips by a certain mode relative to the previous frequency and to the frequencies of other modes, that is, because this measure well reflects the magnitude of the urban compactness effect on "underused" mode travel.

In contrast to the earlier explanation based on the utility theory of derived travel demand (i.e., "urban compactness changes travel behavior by reducing trip time"), this research found that urban compactness changes the behavior mainly by increasing travel benefits and when it is concerned with trip time, its effect is at work by "increasing" (not reducing) the time and limited to automobile commuting. Thus, for higher gains from urban compactness strategies, efforts for increasing travel benefits would function better than those for reducing trip time.

7.1 Limitations

While this research tested and confirmed the representativeness of its sample of neighborhoods for entire Seoul, it did not check whether Seoul is representative of other major cities. As such, its findings may in part be attributed to the unique settings of the study area. In Seoul, various shopping and leisure needs are easily fulfilled within residential neighborhoods in comparison to U.S. cities in which shopping and leisure destinations are often beyond the walking distance (Gim In press). Also, public transit systems in Seoul are highly convenient relative to those in the U.S. These imply that in many U.S. cities, the three modes of travel examined in this research (i.e., automobile, public transit, and nonmotorized modes) may not be equally available. If so, travel utility or psychological impulses of a traveler would be less important than spatial, temporal, and institutional constraints in explaining travel behavior. Moreover, as for commuting, relatively high job stability in Seoul possibly affected the magnitude of the effect that urban compactness has on congestion and trip time. Hence, the findings of this research are particular to Seoul, and further research is needed to examine their geographical transferability to other cities in indifferent settings.

As with urban form characteristics around residences, those in and along the route to the destination of a trip may affect how it occurs. In this sense, a methodological limitation of this research is that it measured urban compactness in respondents' neighborhoods although congestion usually takes place (or it is worse) at trip destinations (considering that jobs are often agglomerated) and many people commute to their offices that are located outside the neighborhoods. If so, particularly for commuting, travel patterns could have a different relationship with urban form according to whether it was measured at trip origins or destinations. Hence, it is recommended that future studies examine the magnitudes of the relationship based on urban compactness measured at the destinations and how differences in the measurement of urban compactness alter its effects on travel utility (not only trip time, but also travel benefits) and behavior.

People often schedule multiple trips together, and urban form would affect trip-chaining behavior. Particularly with regard to shopping, Asian cities have its venues often within the neighborhood, and by walking to the venues, they are able to fulfill secondary purposes along with the main one (i.e., shopping). This research suspected trip-chaining behavior particularly for shopping travel (i.e., because of higher primary benefits, people can conduct various activities once they begin traveling from home). However, with its intrinsic limitations, purpose-based surveys cannot measure such a secondary purpose. To evaluate secondary purposes of travel, activity-based surveys and time-use surveys may function better than purpose-based trip surveys (Handy 2005b).

This research aimed at identifying an overall trend in the relationship between urban compactness and travel behavior. By doing so, it did not evaluate how differences between neighborhoods in varying settings bring about different travel patterns. They can be duly examined when urban form is evaluated at the micro level. Meanwhile, this research deliberately sampled neighborhoods so that their settings differ from each other. Thus, in addition to its macro-level components, the researcher plans to examine the micro-level characteristics of urban form, including urban design elements, between several neighborhoods in the final sample. Presumably, the micro-level characteristics may be particularly meaningful for pedestrians and bikers, and accordingly for public health researchers.

Structural equation modeling (SEM) approaches are based on standardized effects because SEM fixes unstandardized coefficients (one per factor) for model identification purposes. [SEM reports unstandardized coefficients (see “APPENDIX E”), but they are relative to those variables whose unstandardized coefficients are fixed to 1.] Standardized effects are in the –1-to-1 scale, like correlation coefficients, and thus, they can be compared across different models. However, unless measured in an absolute unit, the effects cannot present whether their magnitudes are enough to justify public expenditures in cases in which planners consider urban compactness strategies. A very recent report of the U.S. Environmental Protection Agency, *Our Built and Natural Environments: A Technical Review of the Interactions among Land Use, Transportation, and Environmental Quality*, had a particular interest in quantifying the absolute magnitudes of the urban compactness effects (Office of Sustainable Communities 2013). This research makes little contribution to the practical purpose.

7.2 Additions to Theory

The contributions of this dissertation research can be presented in theoretical and practical aspects. For theory, this research combined two revisions of the utility theory of derived travel demand—activity-based utility theory of derived travel demand and approaches to positive utility of travel—considering that albeit beneficial, they are only partially sufficient in explaining how people respond to urban form variations.

Conceptualized in the mid-2000s, the activity-based utility theory has not been empirically tested, and this research analyzed the applicability of the theory. This theory separately explains the “two sides of a coin” in relation to the effects that urban compactness has on travel behavior. The one side is decreases in trip length (and subsequent decreases in trip time) and the other is decreases in trip speed (and increases in the time), which is made by congestion. That is, combined together, they have differing effects on trip time. In practice, the double-edged effects are in place not separately, but together. Then, a legitimate suspicion is that the effects would be offset to some degree by choices made by travelers, such as time of travel. Through empirical analysis, this research found that the degree differs by travel purpose.

Overall, the effect of reduced trip length is more substantial than that of congestion, and even in a highly congested city like Seoul, urban compactness as a whole reduces trip time. Also, this research found that when trip time is reduced, its effect on travel behavior (as assumed in the theory) is better reflected in the measure of mode shares than in trip frequencies: The shares of non-automobile modes increase and the automobile share is reduced for travel overall.

For all trips (i.e., when travel purposes are not considered), trip time is reduced, but when limited to commuting, it increases, that is, the congestion effect is stronger than the effect of trip length reduction, and consequently, commuting trip time does increase. As such, this research clarifies that the impact of congestion is significant for commuting travel and in practice, congestion particularly affects “automobile” commuting and consequently, only automobile commuting trips are reduced. At the same time, non-automobile commuting increases in number, which suggests modal shift. This is because most people go to the office anyhow, that is, commuting trips are temporally and spatially inflexible. On the other hand, for shopping and leisure purposes of trips, the congestion effect is weaker (than the effect of trip length reduction), so trip time does not increase, but is reduced. Leisure trips increase by all modes, accordingly. At the same time, the frequency of shopping trips are reduced, without regard to travel mode, and this discrepancy cannot be explained by the activity-based utility theory by itself, in the sense that this theory does not take into account the “benefit” side of travel utility.

In short, while activity-based utility theory focuses on people’s overall behavioral response to urban compactness (i.e., to decrease travel, increase travel, or shift modes), this research identified how the response would differ by travel purpose and explains why.

- For commuting, people’s response to urban compactness is *modal shift*.
- For shopping, people *reduce trip frequency*.
- For leisure, they *increase trip frequency*.

In contrast to the activity-based utility theory, this research considered that urban compactness would increase “benefits” of travel for its own sake and by auxiliary activities (anti-activity and external activities) on the way to the travel destination. By incorporating the positive utility approaches into the activity-based utility theory, this research was capable of explaining why shopping trips do not increase despite cost (trip time) reduction. People in a compact neighborhood do not make additional shopping trips because secondary travel benefits do not increase for daily shopping travel (e.g., traveling to explore unfamiliar routes/destinations, to enjoy scenic beauty, or just to be alone); besides, because primary benefits (density, variety, quality, and uniqueness of local shopping options) increase (in addition to trip time reduction), they can save shopping trips, that is, their shopping needs can be satisfied by a smaller number of trips.

Regarding approaches to positive utility of travel, previous studies do not show how travel benefits would differ by travel mode and purpose. Although recent studies began to estimate the benefits from transit travel—for example, Johansson et al. (2006) investigated car, train, and bus as means for commuting, and regardless of travel purpose, Van Exel et al. (2011) considered car and public transit mutual alternatives—few analyzed the benefits from nonmotorized travel, so the studies as a whole could not analyze interactions across the three modes of road transportation: automobile, public transit, and nonmotorized modes. If travel modes are not comprehensively examined, one may suspect that urban compactness allows shifts between transit modes or from nonmotorized modes to public transit, but former car users stick to the automobile (Scheiner and Holz-Rau 2007). This research investigated the interactions by testing the potential for modal shift from the automobile to its alternative modes according to their competitive and substitutive relationship. In addition, this research aimed to contribute to the positive utility approaches by examining how the benefits differ according to travel purposes and urban form variations. [To this aim, this research added a unique feature to its survey: It evaluated the benefits "separately by travel purpose" considering that the benefits would differ by travel purpose. Actually, only for the feasibility of empirical analysis, the benefits can be measured together (for a generic purpose of travel), and analyzed in models that are separated by travel purpose; previous studies employed this approach.] As such, this research can elaborate the positive utility approaches by showing that the benefits are affected by urban compactness and its interaction with travel purposes. Furthermore, because the approaches are concerned with "increases" in travel benefits, they cannot explain why a certain mode of travel is "reduced." Based on the activity-based utility theory, which discusses the costs (disutility) of travel, this research can supplement the approaches.

This research found that urban compactness increases travel benefits for non-automobile trips rather than for automobile trips. Specifically, urban compactness increases secondary travel benefits most strongly for non-automobile “commuting” trips, and these trips are mainly determined by secondary benefits. Instead, decreases in automobile commuting result largely from trip time increase. (In this sense, for automobile commuting, the positive utility approaches are not useful relative to the activity-based utility theory because the approaches do not consider trip time per se.) This implies that modal shift occurs particularly for commuting trips: Automobile commuting is reduced mainly by trip time reduction while non-automobile commuting increases owing to increases in secondary travel benefits.

Regarding leisure trips, their increases by transit and nonmotorized modes depend on primary travel benefits. Urban compactness increases primary benefits for leisure trips and subsequently increases leisure trips by non-automobile modes (although those by automobile also slightly increase). This suggests that people in a compact neighborhood would make additional trips for leisure because this purpose of trips is spatially and temporally flexible.

In contrast, because shopping trips are less fluctuating—people do not make extra trips for daily shopping just because shopping venues became more attractive (primary benefit increases) and closer (trip time reduction)—shopping trips do not significantly increase.[52] Thus, people's behavioral response to urban compactness is a net decrease in shopping trips, especially automobile shopping trips (owing to trip time reduction: When trip time is reduced, non-automobile trips tend to increase and in this particular case, "non-automobile trips are less strongly reduced."). Consequently, to understand how urban compactness affects shopping trips, one need to examine the two sides of travel utility together, that is, travel benefits (positive utility approaches) and costs (activity-based utility theory).

All in all, travel behavior can be duly explained when it is examined by travel mode and purpose and only if the costs and benefits of travel are both evaluated. Given that previous studies mostly focused on travel costs, it should be highlighted that according to urban compactness, variations in travel benefits are far greater than those in travel costs, and without consideration of travel benefits, the effects of urban compactness would be underestimated.

7.3 Recommendations for Practice

In addition to its contributions to theory, this dissertation research found implication for practice. First of all, no recommendations shown in this section should be taken for granted; they can be employed only if planners attempt to reduce motorized trips and increase nonmotorized trips. Also, descriptive models of this research presented the effects of urban compactness based only on a psychological measure, travel utility,

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[52] People may sometimes like to window-shop, but they are more likely to use the time savings for leisure trips. Also, while shopping trips are in various ranges of trip time, trips for nonregular shopping (e.g., jewelry, furniture, clothing, and automobiles)—these are usually attractive to window-shoppers—are more distant because the stores have much wider service ranges.

that is, it did not capture various dimensions of the trip-making behavior (at best, the models explained less than half of the variance in trip frequencies). This implies that recommendations given below might not be effective. Nonetheless, for planning practitioners who consider intervening in urban forms to alter people's travel patterns (from driving to its alternatives, that is, walking, biking, and walking to transit facilities for transit ridership), this research can provide more confidence, as opposed to the elusive picture of the modest effect of urban form on reducing automobile commuting, highlighted in previous studies.

Higher congestion associated with urban compactness increases trip time more than shorter trip length decreases trip time for automobile commuting and accordingly, urban compactness reduces automobile commuting trips. (Congestion does not increase automobile trip time for other purposes of travel that are more flexible and can be made when congestion does not occur; trip time for shopping and leisure is reduced because decreases in trip length exceed decreases in trip speed due to congestion.) However, its effect on automobile trip time ($|-0.054|$) is lower than the effect on primary travel benefits ($|0.063|$) and 3.7 times lower than the effect on secondary benefits ($\approx 0.199 / |-0.054|$). The subsequent effect on decreases in automobile commuting trips (−0.045) becomes marginal—accordingly, this result is consistent with the finding of previous studies that urban compactness has a modest effect on automobile commuting—but because of the benefit increases, transit commuting trips (0.154) and nonmotorized commuting trips (0.154) increase. As shown, the major effect of urban compactness lies in increases in benefits. If focused only on travel costs (trip time), planning studies would reach a rather discouraging conclusion (marginal reduction in automobile commuting), but when travel benefits are considered together, urban compactness strategies deserve to be employed, insofar as they would increase non-automobile commuting trips.

Actually, commuting trip frequencies do not significantly change because most regular workers go to the office for a fixed number of times a week independent of trip length and congestion.[53] Although trip time and travel benefits increase, commuters will not add to commuting by going elsewhere or commuting more often. Thus, instead of saving commuting trips, their behavioral response to urban compactness is modal shift from the automobile to its alternative modes. They are likely to take public transit to the same office (especially if it is located beyond a walkable distance). Notably, people increase non-automobile commuting not because they can save commuting trip time, but mainly because they can gain higher travel benefits, particularly secondary travel benefits. Thus, planners who seek to shift commuting from automobiles to alternative modes can best do so by increasing the secondary benefits of alternative travel modes. However, among different types of secondary travel benefits, planners can alter only instrumental benefits, that is, mechanical characteristics of travel modes. Thus, the following can be effective in increasing transit commuting: improving convenience, comfort, and safety of public transit (e.g., at night), making transit travel more manageable and controllable as desired by commuters (e.g., schedule and service time), and using soft policies that highlight the environmental friendliness of non-automobile travel.

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[53] Flexible work arrangements (e.g., compressed work weeks, flextime, telecommuting, and satellite offices) are not widespread in Seoul.

This research found that leisure trips are highly sensitive to urban form. In compact neighborhoods, people walk more to leisure facilities that meet their needs locally, whereas those living in sprawled neighborhoods have no choice but to drive elsewhere. Accordingly, an effective strategy for public health planners who seek to encourage walking and biking trips is to locate more, diverse, quality, and unique venues for leisure within neighborhoods.

Locating leisure venues in a neighborhood may alter travel mode choice more effectively than building venues for work in neighborhoods, namely jobs–housing balance, proposed by Cervero (1989) and supported by some of the later studies (Cervero and Duncan 2006, Levine 1998, Wang and Chai 2009, Weitz 2003). This concept is based on the expectation that commuting behavior can be managed by locating job opportunities within localized areas or building residences close to employment centers. People were expected to work and live in the same neighborhood (i.e. self-containment), meaning that to reduce commute travel, people would select jobs in their neighborhood. This research found that in compact neighborhoods, commuting trip time does not decrease, but increases because of congestion. This implies that most people commute to the same office, that is, they do not change to local jobs or move to be close to their jobs.[54] As such, this research can explain why "other factors must be more important … than commuting cost, and that policies aimed at changing the jobs–housing balance would have only a minor effect on commuting" (Giuliano and Small 1993, p. 1485).

[54] In fact, according to 2001 American Housing Survey, how close to their jobs are was a main consideration in selecting residential neighborhoods only for 12% of U.S. households with home ownership (Cox 2004).

According to the findings of this research, increases in jobs–housing balance, that is, building workplaces in residential neighborhoods are relatively ineffective at reducing travel demand, and commuting cost affects commuting patterns only weakly. More important factors are commuting benefits, especially secondary travel benefits of commuting. That is, because urban compactness makes it easier to conduct external activities and to expect intrinsic benefits, people are willing to walk to transit facilities and take public transit to travel to their workplace.

Because of urban compactness, leisure trips increase and the increase is mostly accounted for by nonmotorized trips. Planners who seek to promote alternative modes of travel and in particular seek to increase walking and biking as forms of mobility (to promote public health) can do so by locating more leisure venues in a neighborhood. In contrast to leisure trips, urban compactness leads to a reduction in the frequency of shopping trips. People do not shop more often just because shopping venues became closer (trip time decrease). Also, urban compactness does not change secondary travel benefits (e.g., variety-seeking and curiosity) inasmuch shopping venues would not starkly differ day to day. Thus, increasing secondary benefits such as improving amenities and beautifying the streetscape would not be highly effective in altering shopping trips. Primary travel benefits, however, can be increased considerably. That is, by situating more, diverse, quality, and unique shopping venues in residential neighborhoods (increasing primary benefits), transportation planners can make people lessen shopping trips. (Possibly, by doing so, planners can encourage trip chaining, that is, let people consider buying different goods and services in a single trip.)

In summary, by revealing the ways that urban form affects travel utility and behavior, this research draws implications for planning practice as follows.

- Planners who seek to reduce travel demand can link urban compactness strategies to specific interventions designed to enhance the benefits of travel, especially for shopping and leisure activities, as opposed to the more ambiguous strategies to achieve modest effects on reducing automobile commuting, as highlighted in previous studies. Urban compactness increases non-automobile commuting mainly by strengthening travel benefits. Also, instead of commuting trips, planning strategies for reducing travel demand work better when they are aimed at shopping and leisure trips, since these are more responsive to urban compactness.
- Planners who seek to reduce travel demand need to more effectively identify specific strategies aimed at particular trip purposes. Urban compactness alters travel patterns by (1) shifting modes of travel for commuting, (2) decreasing the number of shopping trips (especially by automobile), and (3) increasing the number of leisure trips (largely by nonmotorized modes). The first two are meaningful to transportation planners and the last to public health planners. Meanwhile, (1) planners can best promote modal shift for commuting by altering the mechanical characteristics of transit travel: Workable plans include improving its convenience, comfort, safety, and control (e.g., extended service time and customized running schedule) and publicizing its environmental friendliness. (2–3) Unlike commuting, shopping and leisure trips change mainly because of shifts in primary travel benefits (rather than by trip time and secondary travel benefits). Hence, increasing shops and leisure venues—in number, diversity, quality, and

uniqueness—in line with housing is more effective than jobs–housing balance approaches in altering travel demand. Then, people would reduce automobile shopping trips and increase non-automobile leisure trips.

7.3.1 Planning and Policy Considerations

This section lists specific planning and policy options for planners who attempt to manage travel behavior. The options are neither comprehensive nor argued to be the most effective in changing the behavior. In fact, compared to the relationship between land use and travel behavior, previous studies have not duly investigated how land use "policies" affect the behavior (Knaap and Song 2004). Thus, the following options need to be taken with caution.

7.3.1.1 Increasing Connectivity

This research found that road connectivity is the most important in defining urban compactness and it subsequently has the strongest effect on travel utility and behavior. While urban compactness components are generally correlated with each other, density-centered spatial multicollinearity is not present in a few neighborhoods in Seoul (see "A.3.2 Checking Spatial Multicollinearity" and "A.3.3 Neighborhood Stratification: Calculating *Z* Scores"). Thus, plans that are clearly oriented to road connectivity can be useful in increasing public transit and nonmotorized travel.

Through an empirical study in 13 U.S. cities, Handy, Paterson, and Butler (2003) recommended several options that are effective in increasing pedestrian-friendly road connectivity. Among others, the following can be introduced to subdivision ordinances or street design standards.

- Reducing the number of dead-end streets and their lengths
- Creating nonmotorized travel links to dead-end streets
- Reducing block length and area

Song and Knaap (2004) found in Portland that subdivisions regulations are effective in increasing road connectivity at the neighborhood level. However, the above options may not be effective for immediate effects because noticeable changes in urban form components, including road connectivity, require a significant amount of time (Hall 2001, Jenks and Burgess 2000, Boone-Heinonen et al. 2011, Transportation Research Board 1995, 2009). Also, increases in road connectivity may infringe privacy of nearby residents and bring about conflicts with those who do not favor high pedestrian volumes around their houses (Hall 2001).

7.3.1.2 Increasing Density

Population density turned out to reduce automobile commuting and increase leisure travel by public transit and nonmotorized modes. If these changes are sought, planners may work on development policies (and with developers) for the following practices.

- Changing building requirements or making them flexible to promote high density developments: for example, alleviating requirements on building setback, floor area ratio, and minimum lot size and lowering minimum parking requirements (or establishing maximums)
- Facilitating approval process for building expansion (e.g., adding rooms or floors), infill development, and redevelopment

Zoning/building codes have often been set to impede or limit high density residential development (Knaap et al. 2007, Knaap and Song 2004). Thus, planners can first consider revising those on minimum and maximum building heights and densities. Reducing minimum lot size in these codes or subdivision ordinances can increase not only density, but also road connectivity and land use mix.

Also, local governments can consider granting density bonuses as an incentive zoning technique. This tool allows developments whose density is higher than that provided by zoning codes. In return for higher density development and higher profits, developers are required to offer additional amenities (e.g., plazas, public places, retail space, and parks) as well as affordable housing. Thus, this option can also help increase density and diversity of commercial and leisure venues.

Possible barriers to these actions include an opposition from existing residents who favor low residential density (Hall 2001) and a significant amount of time and effort that is required for density increases (Gordon 2008).

7.3.1.3 Reducing Automobile Traffic Speed

Urban compactness was found to reduce automobile commuting and cause shifts of commuting modes by increasing trip time. Also, as discussed in “3.3 Hypotheses”, speed reduction increases secondary benefits of nonmotorized travel by increasing road safety and thus, it can also increase nonmotorized leisure travel, which is mainly affected by secondary travel benefits. Hence, the following actions can be considered in local transportation ordinances to reduce automobile traffic speed.

- Lowering speed limits: It needs be accompanied by strict enforcement (e.g., well-arranged speed camera systems).

- Narrowing streets (Ewing and Cervero 2001, 2010) and installing speed humps/bumps
- Improving signage (speed limit and stop signs and "current speed" displays)

Reducing minimum street widths in zoning codes or development policies also allows above-discussed high density development. Furthermore, it discourages on-street parking and accordingly has a similar effect with imposing maximum parking requirements (Guo et al. 2012), which is shown next.

Possible obstacles to speed reduction programs include motorists' resistance and financial and technical difficulties that hinder strong law enforcement. Secondly, traffic speed reduction affects not only automobiles, but also bus transit. On almost all of its arterials, Seoul maintains bus-only lanes, an aggressive form of high occupancy vehicle (HOV) lanes, and public buses are relatively free from congestion.

Meanwhile, fuel prices have been reported to have negative association with traffic speed (Congressional Budget Office 2008). Thus, fuel taxes (in terms to road user fees and carbon taxes) can also be considered with caution.

7.3.1.4 Introducing Parking Caps

This research found that urban compactness increases leisure trips mostly by alternative modes, but at the same time, it slightly encourages automobile leisure trips. Thus, planners who plan to control automobile leisure trips could consider additional parking measures.

In addition to parking management tools that are in place (e.g., priced parking), parking caps can be an option. It limits the maximum amount of parking spaces, and it is the opposite of the traditional minimum parking standards. Several studies (Mildner, Strathman, and Bianco 1997, Morrall and Dan 1996) reported that reducing parking capacity helps shift automobile travel to alternative mode travel and to create compact land use patterns. Also, as stated above, it is effective in increasing density. In contrast, according to Manville and Shoup (2005), minimum parking requirements reduce the effect of density that makes automobile travel less attractive. They accordingly suggested to establish the maximum parking requirement and to eliminate the minimum.

A barrier to this option is a concern that establishing the maximum parking requirement may bring about spillover parking (i.e., parking that overflows into neighboring areas) (Millard-Ball 2002). Thus, this option is often supported by other measures such as parking time limit and metering. Also, the possibility of spillover parking is why cities that employed the maximum requirement still have the minimum standard. Nonetheless, minimum parking spaces need to be calculated based on the needs of the neighborhood so that it does not have excessive parking capacity. People in compact neighborhoods have alternative travel options, and they may not need as many parking lots as those living in low compact neighborhoods.

APPENDIX A:

DATASET PROCESSING

A.1 Processing Urban Form Datasets

A.1.1 Population Density

As a residential density measure, this research used gross population density in the neighborhood. Notably, studies on the urban form–travel relationship are categorized into two groups: The first group of studies compares home-origin trips from different "residential neighborhoods" and the second examines trips to non-home destinations in different "activity centers" (Ewing and Cervero 2010). Falling into the first group, this dissertation research focused on how to capture trips within residential neighborhoods, different from the second group that aims at how to increase accessibility to the centers. In this vein, it did not consider employment density. Actually, for studies that evaluate employment density (e.g., Boarnet and Crane 2001, Frank, Stone, and Bachman 2000), it is rather a proxy for land use mix (or jobs–housing balance) (Boarnet and Crane 2001, Forsyth et al. 2007, Frank, Stone, and Bachman 2000, Gim 2012). Moreover, this is an appropriate proxy for those that consider only commuting travel, but this research examined different purposes of travel together. As such, employment density could not substitute for land use mix for this research. To measure land use mix, it used Shannon entropy, a more precise measure than employment density (to be discussed below).

A.1.2 Buffers to Neighborhoods

In Seoul, neighborhood boundaries are defined along major roads. Also, transit facilities are often located close to the roads. Thus, if the boundaries are used in their original form, this research may not precisely calculate the numbers of road intersections and transit facilities that serve each neighborhood. Besides, most studies in the literature (to be shown below) used buffers to consider the walkable distance. Thus, this research applied buffers to the neighborhood in computing the degrees of urban compactness by all of its components except population density.

In general, this research used a 0.5-mile buffer in evaluating urban compactness components, but particularly for calculating the number of bus stops, it employed a 0.25-mile buffer. Considering the walkable distance, a group of studies applied a 0.5-mile buffer (e.g., Coogan et al. 2009, Vargo, Stone, and Glanz 2012) or that of 1 kilometer (≈ 0.62 mile) (e.g., Frank, Kerr, et al. 2007) without regard to which components are concerned, for consistency and convenience. However, those that were focused on public transit applied a 0.25-mile buffer around bus stops in contrast to a 0.5-mile buffer for the measurement of other urban form variables (Zhao et al. 2003). This split buffering is notable in studies in which buses and subways were evaluated together, not separately: They used a 0.25-mile buffer for bus stops and a 0.5-mile buffer for subway stations (e.g., El-Geneidy, Tétreault, and Surprenant-Legault 2010). Such a difference is based on different walkable distances, that is, places from which a majority of transit users walk to respective facilities. Studies conducted in Korea also used these distances due to different walkability to bus stops and subway stations (e.g., Kim et al. 2005) or identified a shorter service range by bus stops than that by subway stations; the estimated ranges were around

0.25 mile and 0.5 mile, respectively (e.g., Kim, Lee, and Chun 2010).[55] Lastly, Transportation Research Board (2003) recommended in its Transit Capacity and Quality of Service Manual to use the buffer distance of 0.25 mile for bus stops and of 0.5 mile for subway stations. Consequently, this research used these split buffer distances: 0.25 mile for counting bus stops and 0.5 mile for evaluating other urban compactness characteristics, including the number of subway stations. The buffers were used to standardize urban compactness components with the neighborhood area.

Below, this research presents detailed procedures used for data processing. Despite easier ways to achieve the same output, this research used the particular procedures to circumvent mechanical limitations it faced: the basic level of ArcGIS software (i.e., the ArcView version) with few licensed extensions and the low capacity of the workstation that was available to the researcher.

A.1.3 Processing Land Use Mix Dataset

Planning studies have assessed land use mix with the jobs–housing ratio (Messenger and Ewing 1996, Miller and Ibrahim 1998, Schwanen, Dieleman, and Dijst 2004), entropy (Cervero 2002, Sun, Wilmot, and Kasturi 1998, Vance and Hedel 2007, Zhang 2004), and dissimilarity (Cervero and Kockelman 1997, Kockelman 1997). The entropy refers to the areal similarity of different land uses in a specific spatial unit, and the dissimilarity the diversity of land uses between a certain GIS grid cell and the ones

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[55] When the consistent buffer was applied, that is, when this research used a 0.5-mile buffer to calculate the number of bus stops, the transit availability variable turned out to be insignificant in most SEM models. It may imply that at least in Seoul, the walkable distance to bus stops may be shorter than that to subway stations. In an area similar to that of the City of Chicago, Seoul has a far larger number of bus stops (= 25,943) than typical U.S. cities (i.e., higher density of bus stops).

surrounding it. Among the measures of land use mix, this research used Shannon entropy: $-\sum k\ [(p_j) * \ln(p_j)] / \ln(k)$ (where p_j = share of the land use j and k = total number of land uses).[56] According to this equation, the more the areas of land uses are balanced, the higher the entropy measure is. To evaluate the entropy, the Land Characteristics Map was employed. This dataset identified 18 land uses in Seoul, and this research reclassified them into five categories: residential, business, commercial, leisure, and mixed. Then, the five categories were used for calculating Shannon entropy.

For data processing, first, this research used a VB (Visual Basic) script (particularly, the IF statement) in ArcGIS Field Calculator to combine land uses in the Land Characteristics Map (total = 1,018,271 polygons in 2012 and 1,044,765 polygons in 2007) into five classes (residential, business, commercial, leisure, and mixed) while excluding uninhabitable terrains (i.e., roads, reservoirs, streams, and rivers).[57] Accordingly, the classes agree with three purposes of travel that it analyzes (commuting, shopping, and leisure).

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[56] For methodological issues concerning this land use mix measure, see “6.5 Effects of Urban Compactness Components”.

[57] A total of 18 land uses were classified as follows: (1) residential = single-family + multi-family + row housing + condominium + housing—others + housing—open space; (2) business = business use + industrial use + industrial—others + industrial—open space; (3) commercial = commercial use + commercial—others + commercial—open space; (4) leisure = parks and others + leisure facilities and others; and (5) mixed = mixed use + mixed—others + mixed—open space.

Table A.1 Visual Basic Script: Reclassifying Land Uses

```
dim x
if [landuse] = "single-family" then
x = "residential"
elseif [landuse] = "multi-family" then
x = "residential"
elseif [landuse] = "row housing" then
x = "residential"
elseif [landuse] = "condominium" then
x = "residential"
elseif [landuse] = "housing--others" then
x = "residential"
elseif [landuse] = "housing--open space" then
x = "residential"
elseif [landuse] = "business use" then
x = "business"
elseif [landuse] = "industrial use" then
x = "business"
elseif [landuse] = "industrial--others" then
x = "business"
elseif [landuse] = "industrial--open space" then
x = "business"
elseif [landuse] = "commercial use" then
x = "commercial"
elseif [landuse] = "commercial--others" then
x = "commercial"
elseif [landuse] = "commercial--open space" then
x = "commercial"
elseif [landuse] = "parks and others" then
x = "leisure"
elseif [landuse] = "leisure facilities and others" then
x = "leisure"
elseif [landuse] = "mixed use" then
x = "mixed"
elseif [landuse] = "mixed--others" then
x = "mixed"
elseif [landuse] = "mixed--open space" then
x = "mixed"
else
x = "error"
end if
```

Then, through the ArcGIS Dissolve operation, the five classes were identified as five polygons.

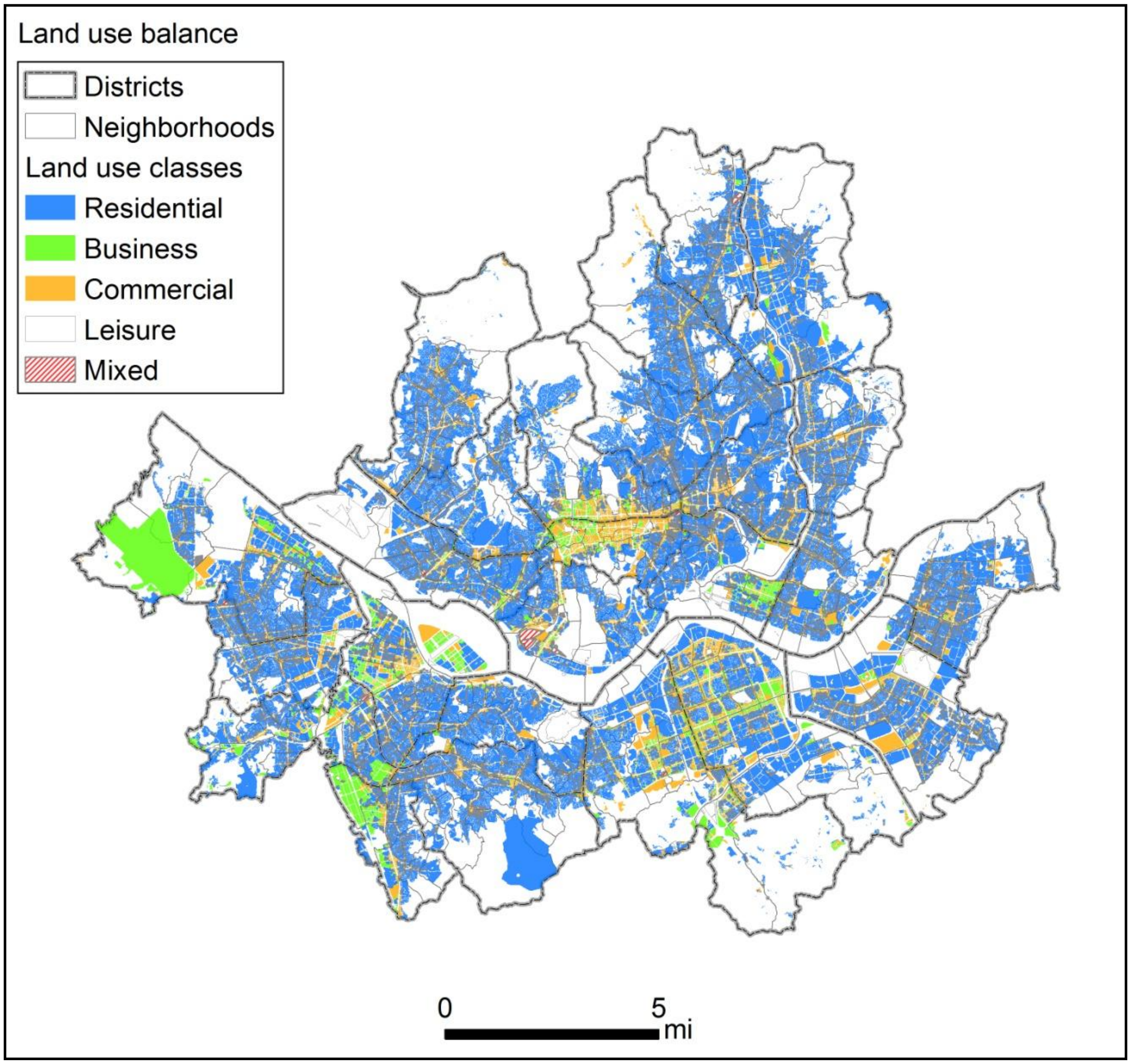

Figure A.1 Land Use Mix: Reclassification

In their equation of Shannon entropy, Frank et al. (2005) included three land uses: residential, office, and commercial uses. Thus, in addition to the three classes, this research considered land use for leisure activities as the fourth land use class since it attempted to analyze travel for leisure purposes as well. The fifth class used in this research was the mixed use. The term “mixed” refers to mixed use developments that have residential, business, and commercial functions together (Jeong and Lee 2010). They became popular in the 1990s in which the central government of Korea began to address the issues of jobs–housing mismatch (to revitalize urban centers) and long distance commuting (to alleviate traffic congestion). Housing is typically affected by the Housing Act and allowed only in the Residential Zone and Quasi-Residential Zone. However, mixed use buildings are under the control of the Architecture Act, denoting that they can be built in the Commercial Zone. They are relatively free from regulations on neighborhood living facilities, and they can be located close to offices, shops, and leisure facilities.

After the ArcGIS Dissolve operation that identified five polygons in line with five land use classes, this research used the Intersect operation. In particular, it geometrically intersected the polygons with the administrative unit dataset (i.e., the 0.5-mile buffered neighborhood dataset that were processed from the Administrative Unit Boundaries for Census dataset) in order to assign them to the neighborhood in which they are located. Accordingly, if an original land use polygon was not entirely within the neighborhood, this research could consider only its portion (total = 157,708 polygons in 2012 and 160,458 in 2007). The intersected dataset had attributes not only from the Land Characteristics Map, but also from the Administrative Unit Boundaries for Census, including an attribute field with the name of the administrative unit, and thus, each case (intersected polygon) had its land use class and the name of the administrative neighborhood in which the case was present.[58]

Then, this research calculated the area of each polygon. It simply exported the intersected dataset to a personal geodatabase because (1) it automatically calculate the area of each polygon and (2) in the process of the exportation, this research could remove all unnecessary fields and reduce the file size to speed up the following operations.

In the geodatabase dataset, this research made an ID field that consisted of the neighborhood name and land use class, for example, "Gangnam Gaepo1 & Business", where Gangnam is a district name; it also used the district name field in order for a neighborhood to have a unique ID, that is, because different neighborhoods sometimes had the same name.

Lastly, using the ArcGIS Summarize function, this research summarized the ID field according to "Shape_Area" (the name is automatically given in the geodatabase) to produce descriptive statistics of the area field (e.g., sum, mean, variance, minimum, and maximum). This function created a DBF file in which each case presented the area (i.e., sum) of each land use class in a particular neighborhood. This summed area was used for calculating the entropy measure.

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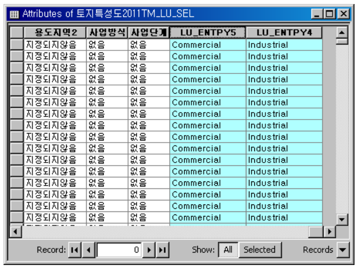
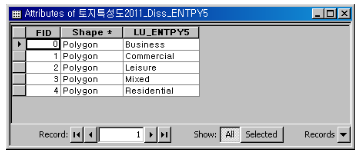
[58] Compared to similar operations such as Clip and Split for which one should assign the clipping and splitting features separately from the input feature, Intersect does not define the intersecting feature, that is, all features function as input features and they intersect each other; accordingly, the output feature contains attributes from all of the features used for the operation. (Clip and Split produce a dataset whose feature table has attributes only from the input feature.)

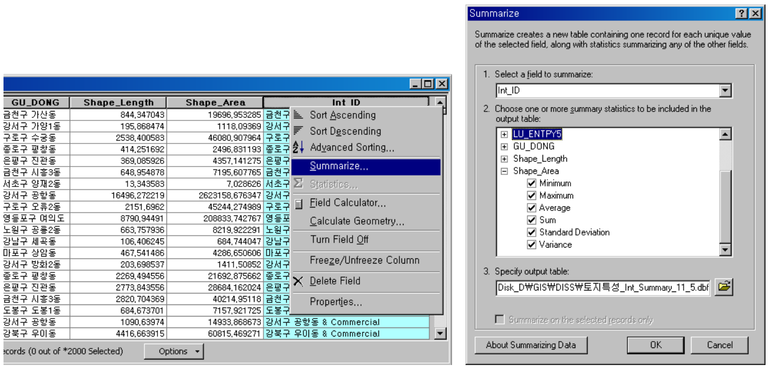


(1) Reclassify operation

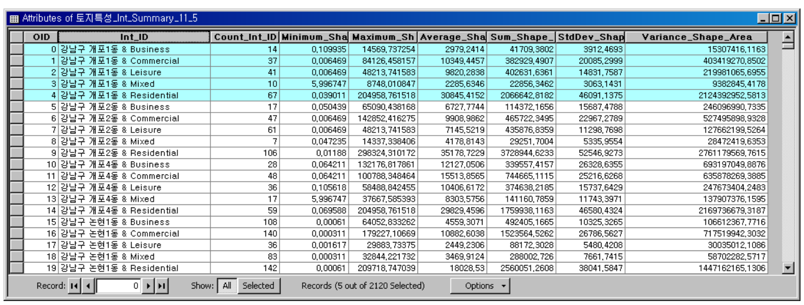


(2) Dissolve operation

(3) Intersect operation



(4) ID assignment and Summarize operation



Summarized output

Figure A.2 Data Processing: Land Use Mix

Because the classification system of the land use dataset contained a class representing mixed land use, this research calculated Shannon entropy as a weighted mean: It firstly calculated the entropy using four land use classes except the mixed use class and then, it averaged the calculated entropy and the mixed use class by their shares in area.

First, Shannon entropy was evaluated with four classes of land uses as follows.

$$e_4 = -\sum k\ [(p_j) * \ln(p_j)] / \ln(k)$$ **Equation A1**

where

e_4 = entropy based on four land uses (i.e., residential, business, commercial, and leisure)

p_j = share of the land use j

k = total number of land uses (= 4)

or

$$e_4 = (-1) * [(u_{residential} / v) * \ln(u_{residential} / v) + (u_{business} / v) * \ln(u_{business} / v)$$
$$+ (u_{commercial} / v) * \ln(u_{commercial} / v)$$
$$+ (u_{leisure} / v) * \ln(u_{leisure} / v)] / \ln(k)$$ **Equation A2**

where

u_j = area of the land use j (where, j = residential, business, commercial, and leisure)

v = total area of the four land uses

Then, this research calculated the area-weighted mean of Shannon entropy by treating the entropy value of the mixed land use as one.

$$e_5 = [(e_4 * v) + (1 * w)] / (v + w) \qquad \textbf{Equation A3}$$

where

e_5 = entropy based on five land uses in which the mixed use is considered (i.e., residential, business, commercial, leisure, and "mixed")

e_4 = entropy based on four land uses (i.e., residential, business, commercial, and leisure)

v = total area of the four land uses

w = area of the mixed land use

A.1.4 Processing Road Connectivity and Transit Availability Datasets

In descending order of measurement precision and ascending order of data availability, road connectivity has been evaluated with three types of variables, including the density of intersections or cul-de-sacs (Boarnet and Crane 2001, Cervero and Kockelman 1997, Frank et al. 2008, Rajamani et al. 2003, Zhang 2004, 2006), indirect measures such as average block area or density, based on an assumption that smaller blocks result from an increase in road networks (Frank, Stone, and Bachman 2000, Krizek 2003), and road connectivity judgment with street maps or through site visits, as expressed with dummy variables of grid or discontinuous street patterns (Boarnet and Crane 2001, Crane and Crepeau 1998). This research defined road connectivity as the density of intersections of the roads within buffered neighborhood. For evaluation of transit availability, that is, to calculate the density of transit facilities in a neighborhood, this research obtained two types of datasets: Bus Stops from Bus Management System and Subway Lines from Korean New Address System. Datasets on road connectivity and transit availability were processed as follows.

First, to calculate the number of road intersections (for the road connectivity component) and the numbers of the bus stops and subway stations (for the transit availability component), this research used a freeware, Hawth's Analysis Tools for ArcGIS (http://www.spatialecology.com/htools/), particularly its Count Points In Polygons tool. Using this tool, it counted points in a polygon (road intersections and subway stations in a 0.5-mile buffered neighborhood and bus stops in a 0.25-mile buffered neighborhood).[59] That is, this research created points that stand for the locations of road intersections and transit facilities; because the formats of the datasets on road networks, subway stations, and bus stops differed from each other, and it processed each dataset as follows.

The Bus Stops dataset of December 2012 was numeric GPS data that consisted of XY coordinates without a shapefile. Thus, based on the data, this research created a GIS point dataset. The Subway Lines dataset comprised two layers, Subway Lines and Subway Stations, where subway stations were expressed as polygons. Accordingly, through the ArcGIS Feature To Point operation, the polygons were transformed to points. Then, this research counted the numbers of bus stops and subway stations falling within

---

[59] Alternately, one can use the ArcGIS Joins operation to attach the attribute data of a point dataset to those of a polygon dataset. In this process, the number of points can optionally be summed up in the resultant polygon dataset.

0.25-mile and 0.5-mile buffered neighborhoods, respectively, using Hawth's Analysis Tools for ArcGIS.

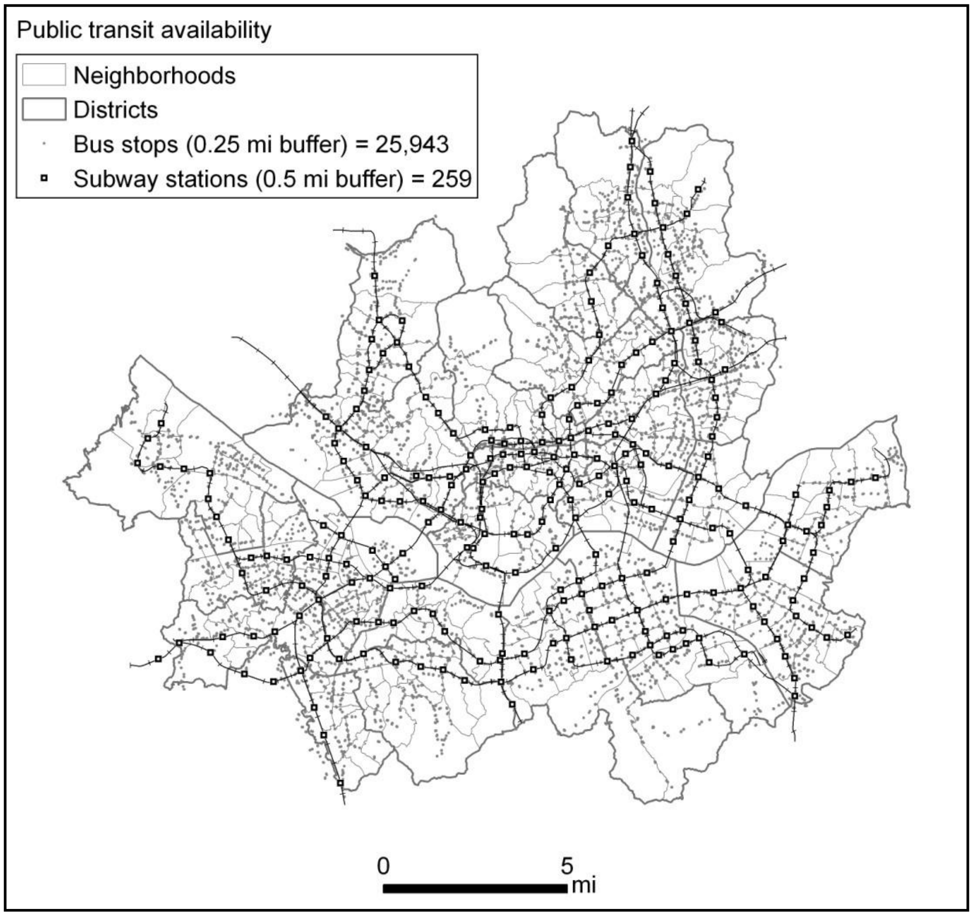


Figure A.3 Transit Availability: Point Locations of Bus Stops and Subway Stations

To identify point locations of road intersections from the polyline features of the Street Centerlines dataset, the easiest way was probably to use the Network Analyst extension in ArcGIS. However, without the license of the extension in the workstation at

The Seoul Institute, the researcher has taken three steps to reach the same output: (1) Intersect, (2) Add XY Coordinates, and (3) Dissolve.

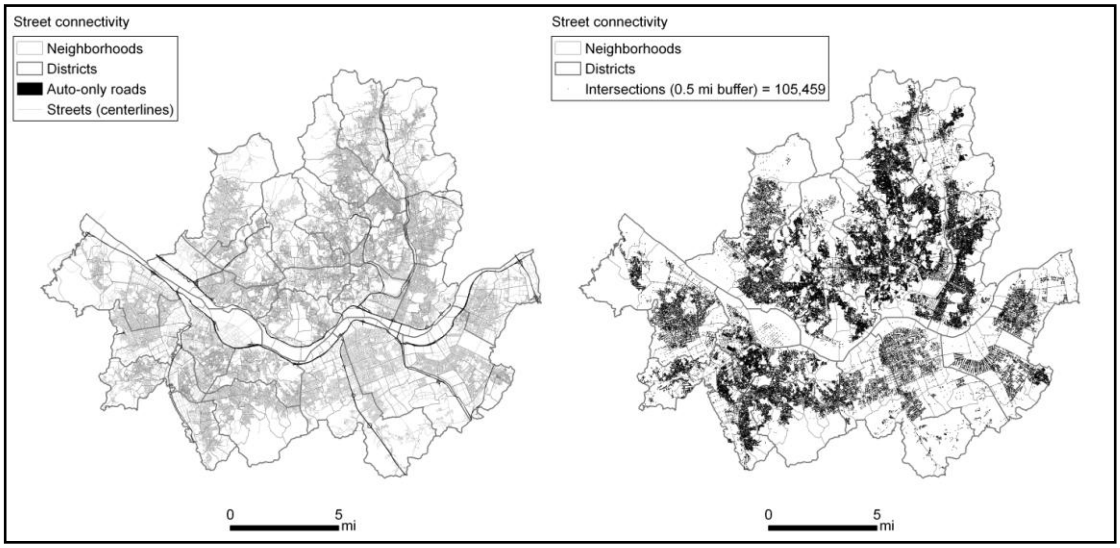


Figure A.4 Road Connectivity
Note: polyline raw data (left) and point locations of road intersections (right)

For the Intersect operation, this research added the polyline feature of the Street Centerlines dataset as an input feature and changed the output type to “POINT”. This operation created two multipoints at one location, so they were needed to be combined into one. Accordingly, this research used the Add XY Coordinates operation to build a unique ID, that is, the XY coordinate was used to indicate one unique location. Then, based on the coordinates (i.e., POINT_X and POINT_Y), this research conducted the Dissolve operation to combine the duplicated features. This resulted in only one multipoint for each intersection, as shown in Figure A.5. (Additionally, to calculate the number of points using Hawth's Analysis Tools, this research updated the multipoints to points using the Feature To Point tool available in Hawth's Analysis Tools.)

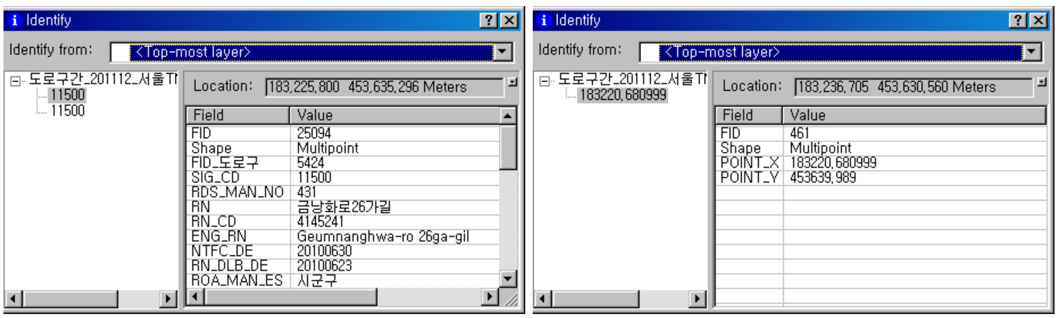


Figure A.5 Data Processing: Road Intersection Points

A.2 Processing Metropolitan Household Travel Survey Data

A.2.1 Data Screening

The database of the 2006 MHTS consisted of three tables according to three sections of the survey: Each of them were named Household, Person (referring to household member), and Trip. The Household table carried answers given by household heads and the Person and Trip tables by all household members except those under the school age. In total, the database had information of 159,643 persons from all neighborhoods in Seoul. Firstly, this research selected (1) adults (those who are equal to or more than 18 years of age as of 2006) in the Person table (i.e., [birth year] <= 1988) and (2) trips made by them in the Trip table using the personal ID. Then, in the Trip table, trips whose origin was home were extracted (i.e., [trip origin] = 1). Lastly, the three tables were joined, using the personal ID as a key for the joining: Household data were attached to personal data, and subsequently, the combined personal data were attached to trip data.[60] (Because the Person table did not have a field for the household ID, it was manually created by splitting the personal ID: Its first 6 digits referred to the neighborhood.)

In the joined table as a combination of the Household, Person, and Trip tables, this research created three new fields in which automobile ownership, travel purposes, and travel modes were reclassified. The first field was made to sum the number of sedans and that of vans because the MHTS asked the number of automobiles by specific type. In the second field, travel purposes were reclassified into commuting, shopping, and leisure, using an IF statement in Microsoft Excel: commuting = “to go to work” + “to go to school”, shopping = “to buy something (shopping)”, and leisure = “leisure/recreation/social”. By the statement, the following purposes of travel were filtered out: “for pick-up or drop-off” and “others”. (The MHTS actually had two other purpose categories, “work-related (business)” and “to return to work or home”, but they were excluded when this research selected home-origin trips.) In the last field, travel modes were reclassified as follows: automobile = “sedan/van”, public transit = “commuter/school bus” + “city bus” + “intercity bus” + “minibus” + “express bus” + “other buses (shuttle bus, tour bus, etc.)” + “subway” + “rail” + “high-speed rail (KTX)”, and nonmotorized modes = “walk” + “bike”. Accordingly, the following modes of travel

[60] In the Trip table, the personal ID field had 1,051 missing values (i.e., unidentified travelers). These cases could not be joined with the other two tables anyway and thus, this research excluded them from the analysis.

were not used for the analysis: “taxi”, “motorbike”, and “others (airplane, boat, truck, special vehicle, etc.)”.

Regarding nonmotorized modes, Table A.2 shows that Seoul has considerably low biking share (= 1.55%) as with other Korean cities. In contrast, walking occupies even larger share (= 27.63%) than the automobile and any of the public transit modes. Thus, one can regard walking as the representative of nonmotorized travel.

Table A.2 Mode Shares in Seoul

Automobile	**Public transit**			**Nonmotorized modes**		**Others***
	Bus	**Subway**	**Rail**	**Walking**	**Biking**	
4,093,865	4,560,756	3,865,767	22,104	5,084,760	284,415	488,322
22.25%	24.79%	21.01%	0.12%	27.63%	1.55%	2.65%
	Sum = 45.92%			Sum = 29.18%		

* Taxi, motorbike, truck, and others (airplane, boat, truck, special vehicle, etc.)
Note: Values were calculated, using the Seoul survey of the 2006 MHTS.

As a result, the processing of the MHTS returned the data of 35,283 home-origin trips made by 29,336 adult members in automobiles, public transit, and nonmotorized modes for commuting, shopping, and leisure purposes. (Meanwhile, the same procedure was done for the 24 neighborhoods that this research sampled for the structured survey so that it can examine how analytical results differ when only the sampled neighborhoods are used. For the sampled neighborhoods, 1,943 trips made by 1,664 adults were selected.)

A.2.2 Data Transformation and Trip Frequency Calculation

The data of the three tables had one-to-many relationships: One household could have multiple members and one member could make multiple trips. In the combined table, each case represented a trip, not a household member. Thus, this research programmed a VB script in Microsoft Excel to transform the data at the trip level into the level of the individual, the unit for SEM. Also, because different cases (i.e., trips) in the combined table had the same ID if they were made by the same individual, this research computed trip frequencies by counting the occurrences of the same personal ID.

Before running the following VB program, this research confirmed that the data were arranged by the personal ID (unique for every respondent). Then, it made a total of 15 sheets in which the programmed outcome would be inserted: nine sheets according to three purposes and three modes of travel (1_1 = commuting_automobile, 1_2 = commuting_public transit, …, 3_3 = leisure_nonmotorized modes), three sheets for three travel purposes (Purp1 = commuting, Purp2 = shopping, and Purp3 = leisure), and three sheets for three travel modes (Mode1 = automobile, Mode2 = public transit, and Mode3 = nonmotorized modes). In an additional sheet labeled as “Overall”, this research calculated trip frequencies and other descriptive statistics.

Table A.3 Visual Basic Script: Changing the Level of the MHTS Data

```
Dim Wrb As Workbook
Dim Dsht As Worksheet
Dim Rsht As Worksheet
Dim Rsht1(1 To 9) As Worksheet
Dim Rsht2(1 To 3) As Worksheet
Dim Rsht3(1 To 3) As Worksheet

Dim Person_Num, Person_Num2, Purp_Mode As String
Dim Purp, Mode As Long
Dim Row_cnt As Long
Dim Cnt1(1 To 9) As Long
Dim Cnt2(1 To 3) As Long
Dim Cnt3(1 To 3) As Long
Dim Dura, Sum, Freq, Mean As Double

Sub Tommy()

Set Wrb = ThisWorkbook

Set Dsht = Wrb.Sheets("Trimmed&Arranged")

Set Rsht = Wrb.Sheets("Overall")

Set Rsht1(1) = Wrb.Sheets("1_1")
Set Rsht1(2) = Wrb.Sheets("1_2")
Set Rsht1(3) = Wrb.Sheets("1_3")
Set Rsht1(4) = Wrb.Sheets("2_1")
Set Rsht1(5) = Wrb.Sheets("2_2")
Set Rsht1(6) = Wrb.Sheets("2_3")
Set Rsht1(7) = Wrb.Sheets("3_1")
Set Rsht1(8) = Wrb.Sheets("3_2")
Set Rsht1(9) = Wrb.Sheets("3_3")

Set Rsht2(1) = Wrb.Sheets("Purp1")
Set Rsht2(2) = Wrb.Sheets("Purp2")
Set Rsht2(3) = Wrb.Sheets("Purp3")

Set Rsht3(1) = Wrb.Sheets("Mode1")
Set Rsht3(2) = Wrb.Sheets("Mode2")
Set Rsht3(3) = Wrb.Sheets("Mode3")

        Rsht.Select
        Rsht.Cells.ClearContents
```

Table A.3 (continued)

```
        Rsht.Cells(1, 1) = "Personal ID"
        Rsht.Cells(1, 2) = "Frequency"
        Rsht.Cells(1, 3) = "Mean"
        Rsht.Cells(1, 4) = "Sum"
        For ii = 6 To 29 Step 1
                Rsht.Cells(1, ii - 1) = Dsht.Cells(2, ii)
        Next ii

For i = 1 To 9 Step 1
        Rsht1(i).Select
        Rsht1(i).Cells.ClearContents
        For ii = 1 To 29 Step 1
                Rsht1(i).Cells(1, ii) = Dsht.Cells(2, ii)
        Next ii
Next i

For i = 1 To 3 Step 1
        Rsht2(i).Select
        Rsht2(i).Cells.ClearContents
        For ii = 1 To 29 Step 1
                Rsht2(i).Cells(1, ii) = Dsht.Cells(2, ii)
        Next ii
Next i

For i = 1 To 3 Step 1
        Rsht3(i).Select
        Rsht3(i).Cells.ClearContents
        For ii = 1 To 29 Step 1
                Rsht3(i).Cells(1, ii) = Dsht.Cells(2, ii)
        Next ii
Next i

For i = 3 To 10000000 Step 1
        If Dsht.Cells(i, 1) = "" Then Exit For
        Person_Num = Dsht.Cells(i, 1)
        Person_Num2 = Dsht.Cells(i + 1, 1)
        Purp = Dsht.Cells(i, 2)
        Mode = Dsht.Cells(i, 3)
        Purp_Mode = Purp & "_" & Mode

        Select Case Purp_Mode
        Case "1_1": sht_str = 1: Cnt1(sht_str) = Cnt1(sht_str) + 1
        Case "1_2": sht_str = 2: Cnt1(sht_str) = Cnt1(sht_str) + 1
        Case "1_3": sht_str = 3: Cnt1(sht_str) = Cnt1(sht_str) + 1
```

Table A.3 (continued)

```
Case "2_1": sht_str = 4: Cnt1(sht_str) = Cnt1(sht_str) + 1
Case "2_2": sht_str = 5: Cnt1(sht_str) = Cnt1(sht_str) + 1
Case "2_3": sht_str = 6: Cnt1(sht_str) = Cnt1(sht_str) + 1
Case "3_1": sht_str = 7: Cnt1(sht_str) = Cnt1(sht_str) + 1
Case "3_2": sht_str = 8: Cnt1(sht_str) = Cnt1(sht_str) + 1
Case "3_3": sht_str = 9: Cnt1(sht_str) = Cnt1(sht_str) + 1
End Select
Rsht1(sht_str).Cells(Cnt1(sht_str) + 1, 1) = "'" & Person_Num
Rsht1(sht_str).Cells(Cnt1(sht_str) + 1, 2) = Purp
Rsht1(sht_str).Cells(Cnt1(sht_str) + 1, 3) = Mode
Rsht1(sht_str).Cells(Cnt1(sht_str) + 1, 4) = Purp_Mode

For ii = 5 To 29 Step 1
        Rsht1(sht_str).Cells(Cnt1(sht_str) + 1, ii) = Dsht.Cells(i, ii)
Next ii
Cnt2(Purp) = Cnt2(Purp) + 1
Rsht2(Purp).Cells(Cnt2(Purp) + 1, 1) = "'" & Person_Num
Rsht2(Purp).Cells(Cnt2(Purp) + 1, 2) = Purp
Rsht2(Purp).Cells(Cnt2(Purp) + 1, 3) = Mode
Rsht2(Purp).Cells(Cnt2(Purp) + 1, 4) = Purp_Mode

For ii = 5 To 29 Step 1
        Rsht2(Purp).Cells(Cnt2(Purp) + 1, ii) = Dsht.Cells(i, ii)
Next ii
Cnt3(Mode) = Cnt3(Mode) + 1
Rsht3(Mode).Cells(Cnt3(Mode) + 1, 1) = "'" & Person_Num
Rsht3(Mode).Cells(Cnt3(Mode) + 1, 2) = Purp
Rsht3(Mode).Cells(Cnt3(Mode) + 1, 3) = Mode
Rsht3(Mode).Cells(Cnt3(Mode) + 1, 4) = Purp_Mode

For ii = 5 To 29 Step 1
        Rsht3(Mode).Cells(Cnt3(Mode) + 1, ii) = Dsht.Cells(i, ii)
Next ii
Dura = Dsht.Cells(i, 5)
Freq = Freq + 1
Sum = Sum + Dura

If Person_Num <> Person_Num2 Then
        Row_cnt = Row_cnt + 1
        Mean = Sum / Freq
        Rsht.Cells(Row_cnt + 1, 1) = "'" & Person_Num
        Rsht.Cells(Row_cnt + 1, 2) = Freq
        Rsht.Cells(Row_cnt + 1, 3) = Mean
        Rsht.Cells(Row_cnt + 1, 4) = Sum
```

Table A.3 (continued)

```
                For ii = 6 To 29 Step 1
                        Rsht.Cells(Row_cnt + 1, ii - 1) = Dsht.Cells(i, ii)
                Next ii

                Dura = 0
                Freq = 0
                Sum = 0
        End If

Next i
End Sub
```

A.3 Process of Sampling, Interviews, and Survey

A.3.1 Sampling Strategies

How to make interviews fruitful and surveys representative hinges in part on the sampling method. In regard to a sample survey, the representativeness is secured according to the level to which the sampling is random (Shadish, Cook, and Campbell 2002, Babbie 2004). Among other random sampling methods (e.g., simple random sampling, systematic sampling, and cluster sampling), this research employed stratified sampling because by minimizing sampling error, it is known to construct the most unbiased sample (Babbie 2004). Particularly, this research used a multilevel stratified sampling strategy: stratified sampling for categorizing neighborhood types, judgmental sampling for selecting neighborhoods and blocks, and cluster sampling for selecting households.

A.3.1.1 Stratifying Neighborhoods

Sampling error decreases if a population is homogeneous in relation to variables under consideration. Thus, for the best result, the stratification variable—a variable that separates a population into homogenous groups or strata—should be a research variable; then, sampling error on the stratification variable is reduced to zero (Babbie 2004, Fotheringham, Brunsdon, and Charlton 2000, Rogerson 2001) and to the extent to which cases in a stratum are homogeneous, they become homogenous on other variables (Babbie 2004, Rogerson 2001). In this sense, an explanatory variable is often chosen as the stratification variable since it is hypothesized to systematically affect outcome variables. Thus, among research variables for this research (urban compactness, utility, and travel behavior), it used urban compactness to stratify neighborhoods and to make a sample. (Furthermore, in a practical sense, population values were known only for urban compactness, that is, other research variables could not be used to make a sampling frame and selecting neighborhoods from the entire neighborhoods.) Then, neighborhoods in each stratum would show similar utility and travel patterns if research hypotheses are supported.

To utilize urban compactness for stratification, this research considered that urban compactness components were hypothesized to have differing effects on the utility and behavior of travel: Population density discourages automobile commuting and the other three (i.e., land use mix, road connectivity, and transit availability) encourage alternative mode shopping and leisure travel. This research used these two dimensions for neighborhood stratification.[61]

In a typical neighborhood of high (and low) urban compactness, population density is associated with the other three components due to density-centered spatial multicollinearity. In a few extreme cases, however, population density is high, but it is not accompanied by land use mix, road connectivity, and transit availability. They (henceforth, "unplanned growth") were mostly built before an economic boom in the early 1970s and experienced haphazard growth since. In contrast, "new towns" that began

[61] An alternative sampling method would be consonant–dissonant matching (e.g., Frank, Saelens, et al. 2007, Schwanen and Mokhtarian 2005b, a). For the sampling, this method uses not only urban compactness, but also people's intrinsic desire, that is, whether urban form of their neighborhood is consonant with their travel desire. However, as one of the researchers acknowledged in her later methodological study (Mokhtarian and Cao 2008), this method is defective for several reasons. One that is relevant to this research is that because a 2-by-2 matrix is developed by two variables (i.e., urban compactness and intrinsic desire), neither can be represented as more than a dichotomous variable, that is, for urban compactness, dense or not (Schwanen and Mokhtarian 2005b, a) or walkable or not (Frank, Saelens, et al. 2007). As stated, this research considered two different urban compactness effects, one by population density and the other by the other three urban compactness components. This suggests that urban compactness itself should be expressed by a 2-by-2 matrix.

to emerge in the early 2000s are equipped with a good deal of land use mix, road connectivity, and transit availability, but they do not have a comparable number of inhabitants. Figure A.6 shows travel patterns expected in each quadrant at its extremes.

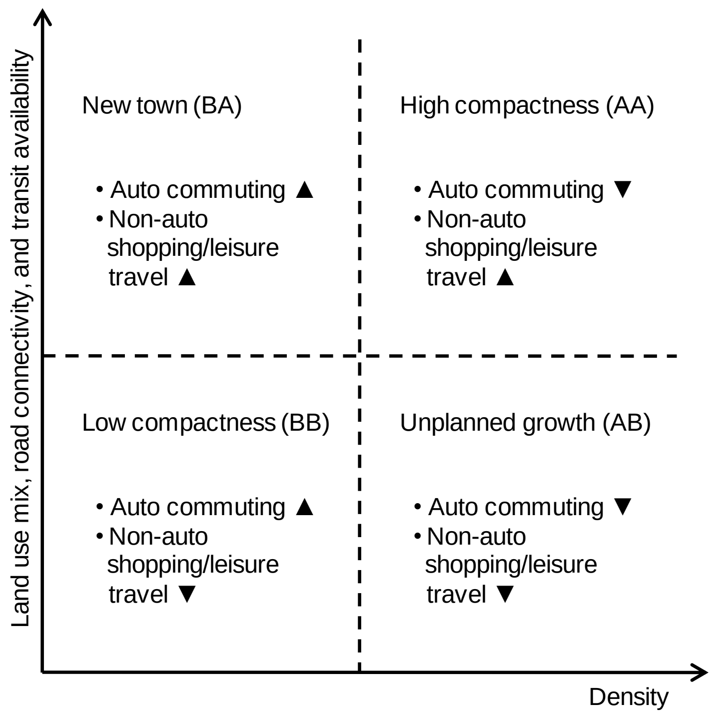


Figure A.6 Neighborhood Types by Urban Compactness

After stratifying neighborhoods, this research sampled six neighborhoods from each quadrant while considering their distances to the urban center; as such, it could prevent the sample from being geographically biased. Interviews and a survey were conducted in the 24 sampled neighborhoods (= 6 neighborhoods * 4 neighborhood types).

A.3.1.2 Sampling Interviewees

To collect diverse voices from interviews, this research constructed a sample of interviewees with a broad range of sociodemographics. Particularly, it made comparable the ratios of the following sociodemographic classes, in the sense that they have been reported to differentiate travel behavior: (1) gender, (2) marital status, (3) age group, (4) household size, (5) household income—planning studies (Cao, Mokhtarian, and Handy 2007, Næss and Jensen 2004, Schwanen, Dieleman, and Dijst 2004) argued that those who are male, married, older, and in a large and high-income household are more likely to travel by automobile—and (6) automobile ownership (Ewing, DeAnna, and Li 1996, Loutzenheiser 1997, Messenger and Ewing 1996). While these sociodemographics are suspected to be significant on the whole (Schwanen, Dieleman, and Dijst 2004), automobile ownership (Pucher and Renne 2003) and income (Cao, Mokhtarian, and Handy 2007, Zegras 2004), which is also a strong determinant of automobile ownership (Messenger and Ewing 1996, Pucher and Renne 2003), are expected to be more strongly associated with the utility and behavior of travel. Therefore, this research sampled the first set of interviewees to maximize variations in automobile ownership and income classes (5–6) and examined the values of the other four sociodemographic variables (1–4). Then, the second set of the interviewees was made different from the first set in the four variables. This research continuously checked the overall sociodemographics of the current sample as a guide for the selection of the next set (e.g., if people in their fifties were underrepresented in the current sample, they became the target for the next set). Such a nonproportional sampling method is similar to that of the Puget Sound Transportation Panel (PSTP) Survey: It deliberately oversampled households utilizing uncommon travel modes. [Studies using PSTP data include Frank and Pivo (1994), Frank et al. (2000), and Krizek (2003).] Likewise, Holden and Norland (2005) sampled study areas to maximize the variation in urban forms in the Greater Oslo Region.

Following Næss's strategy (2005, 2009), this research recruited one household from each of the 24 sampled neighborhoods—it firstly selected one residential block in the center of each neighborhood—and interviewed with one adult member (equal to more than 18 years of age, the minimum age for obtaining a driver's license) per household, taking into account the sociodemographic composition of the final sample (total 24 interviews = 1 resident * 24 neighborhoods). The number of the interviewees appeared to suffice. Gardner and Abraham (2007) contacted 19 automobile commuters in central Brighton and Hove, the U.K. Næss and Jenson (2004) sampled 11 adults in Frederikshavn, Denmark. In later studies, Næss (2005, 2009) interviewed with 17 people in Copenhagen, Denmark.

A.3.1.3 Sampling Survey Respondents

In each of the 24 sampled blocks, this research benefited by its head who considerably streamlined the survey.[62] The head was asked to allot survey questionnaires to all household representatives who participated at a monthly block meeting (March 2013) or all households in the block. The questionnaires were then handed out to all adult household members. Through this process, this research distributed a total of 1,200

[62] The block head is elected among those living the block and serves for three years, as provided by the Resident Registration Act and the Framework Act on Civil Defense. Main responsibilities include promoting public relations between the Administrative Neighborhood Office and block residents, training the residents for emergency preparedness, and conducting administrative tasks such as taking the census and distributing emergency resources and notices.

questionnaires (500 copies per block). One month later, the block head began to retrieve responses from each household. After initial check, the head mailed them back to the research institution. This distribution and collection process was the same as that of the 2006 MHTS, except the fact that this research sampled blocks instead of block groups to make sure that all respondents in a neighborhood were exposed to the same urban forms.

Figure A.7 presents the sampling process and sample sizes for the interviews and survey.

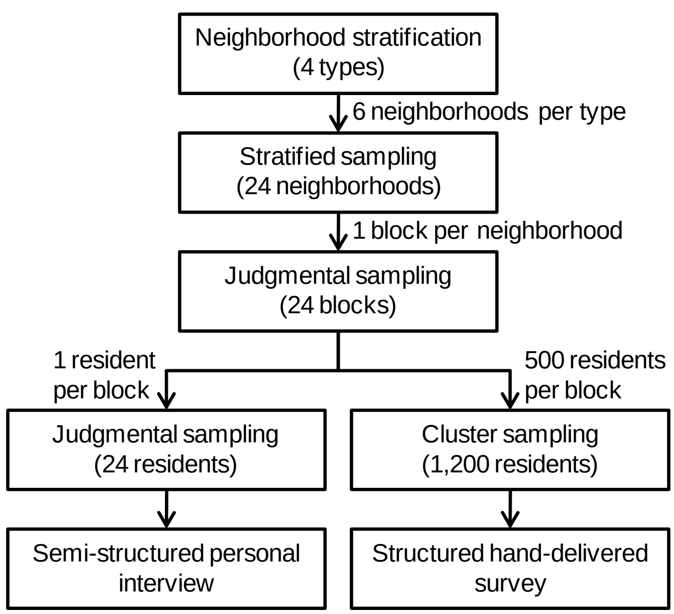


Figure A.7 Data Collection Process: Interviews and Survey

For the representativeness of survey responses, this research considered not only the process of sampling, but also that of response collection. Fundamentally, it followed the response collection process of the 2006 MHTS. Considering the sociodemographic composition and transportation settings in Seoul, the MHTS identified a hand-delivered survey as suitable for collecting unbiased responses. Empirical studies conducted in other areas (e.g., Webster 1997, Dunning and Cahalan 1973, Steele et al. 2001, Stover and Stone 1974, Yu and Cooper 1983) also reported that this way of response collection improves the response rate and at the same time, it increases the quality of the responses (i.e., considered responses and filled-out responses) and reduces the chance of non-sampling error (e.g., measurement error) as well as sampling error (i.e., selection bias); compared to the mail survey, it can control the survey process through personal visits and relative to the telephone survey, it provides sufficient time for considered responses.

A.3.2 Checking Spatial Multicollinearity

Before the actual stratification of the neighborhoods for the sampling, this research analyzed if spatial multicollinearity is indeed significant and centered on density, using the processed datasets of urban compactness. Then, it becomes justifiable to categorize the neighborhoods according to two dimensions: population density and the other urban compactness components.

Table A.4 shows that population density has significant correlations with all other urban compactness components. Although transit availability is also correlated with the others, but the coefficients are not as high as those identified based on the density.

Table A.4 Pearson's Correlations between Urban Compactness Components

	Land use mix	Road connectivity	Transit availability
Population density	0.346***	0.423***	0.478***
Land use mix		−0.013	0.155***
Road connectivity			0.326***

*** $p < 0.01$

A.3.3 Neighborhood Stratification: Calculating *Z* Scores

For the two dimensions of urban compactness, this research calculated *Z* scores for population density and for the other three components (i.e., land use mix, road connectivity, and transit availability). Then, it can classify all neighborhoods into four types; from each type, this research attempts to sample six neighborhoods while considering their distances to the urban center. Particularly, the three components were expressed as a composite *Z* score as follows (Ley 2007).[63]

$$Z_c = \frac{\sum Z}{\sqrt{\sum S + \sum r \times 2}}$$

Equation A4

where

Z_C = *Z* score as a composite of *Z*-land use mix, *Z*-road connectivity, and *Z*-transit availability

[63] Another option for a composite measure would be a factor score that is computed through factor analysis. However, the factor analysis approach by itself gives weights to the three urban compactness components according to factor loadings. This is not desirable, in the sense that this research aims to provide the "same" weight to them in the process of the neighborhood sampling.

Z = Z score of an urban compactness component (i.e., land use mix, road connectivity, and transit availability)

S = variance of a Z score

r = Pearson's product-of-moment correlation

According to Equation A4, Z_C is the sum of the three Z scores divided by the composite standard deviation. Of the two elements of the rooted denominator, the sum of the variances (i.e., ΣS) equals the number of urban compactness components (= 3) since the variance of a single Z score is always one due to normalization (i.e., for all Z scores, mean = 0 and variance = 1).

Meanwhile, one may consider the simple summation of the three Z scores—Z-land use mix, Z-road connectivity, and Z-transit availability—(e.g., FitzGerald 1999, Ackerman and Cianciolo 2000) instead of dividing the sum by the composite standard deviation. However, for the stability of the composite measure and its variance, and accordingly "to make it comparable with Z-density," this research calculated the composite Z score. Figure A.8 shows the distribution of all neighborhoods in Seoul according to the two dimensions of urban compactness (i.e., Z-density and the composite Z score).

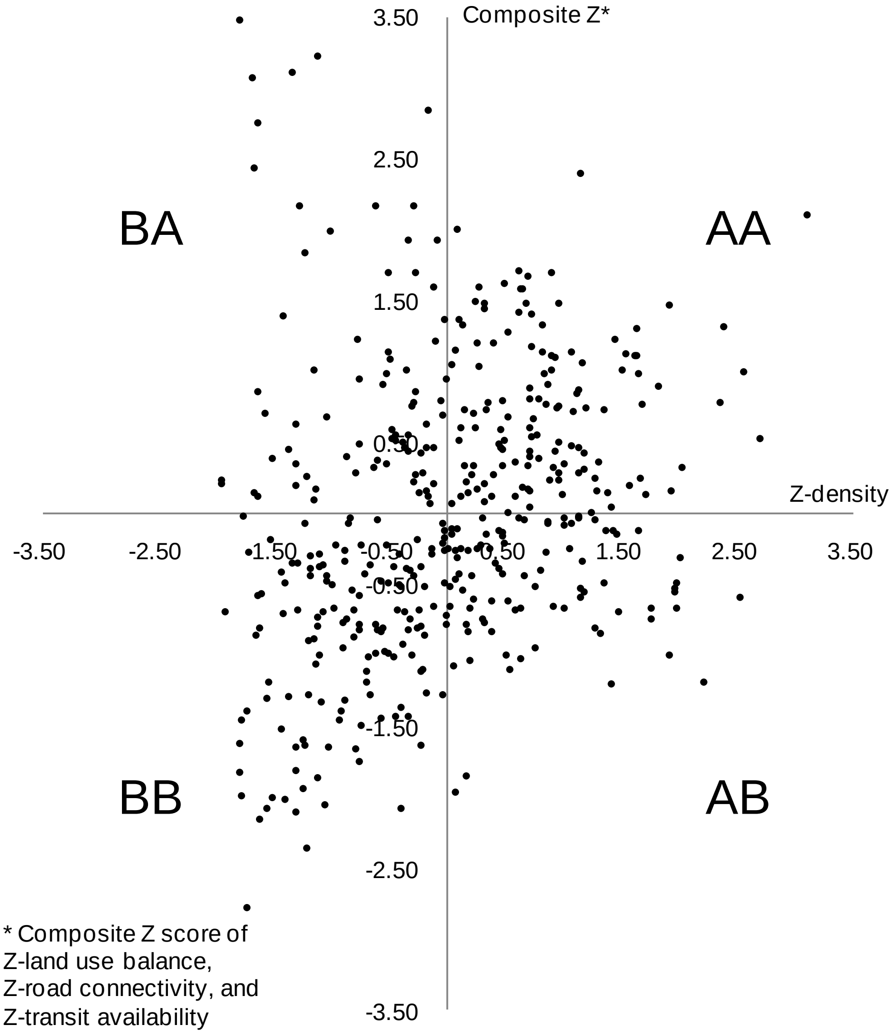


Figure A.8 Urban Compactness by *Z*-Density and Composite *Z* Score

In Figure A.8, each neighborhood type contains a different number of neighborhoods—*f*(AA) = 126, *f*(AB) = 84, *f*(BA) = 75, and *f*(BB) = 139—but this research samples the same number from the type (= 6) since it focuses on sampling neighborhoods whose urban compactness components have reasonable variations for inferential statistics rather than on making the sample perfectly represent the population (for descriptive statistics); the rationale for this nonproportional sampling was discussed in “4.2.3 Data Validation Strategy”.

Notably, although this research named each of the four neighborhood types high compactness (AA), unplanned growth (AB), new town (BA), and low compactness (BB), these names present no more than the relative degrees of urban compactness, insomuch as they were identified by the means of the two *Z* scores (origin of the graph). Thus, although a neighborhood was classified into the low compactness type, its compactness level could be much higher than the levels of those often found in the U.S. In Table A.5, even unplanned growth (AB) and low compactness (BB) neighborhoods have a considerable number of transit facilities, an average of 61 and 41 facilities/mile^2, respectively. In this sense, this research does not insist that neighborhoods outside the AA type (high compactness) have undesirable urban forms.

Table A.5 Descriptive Statistics of Neighborhood Types

		Population density (persons/mi^2)	Z-density	Land use mix (entropy)	Z-land use mix	Road connectivity (inter-sections/mi^2)	Z-road con-nectivity	Transit availability (facilities/mi^2)	Z-transit availability	Composite Z score
High compact-ness (AA)	μ	94,031.095	0.855	0.631	0.118	910.180	0.794	94.301	0.648	0.749
	σ	19,954.759	0.601	0.131	0.845	325.463	0.922	24.291	0.669	0.520
	Min	66,262.580	0.019	0.347	−1.711	239.918	−1.106	29.160	−1.146	0.001
	Max	168,845.302	3.107	0.862	1.608	1,637.532	2.855	176.329	2.907	2.386
Unplanned growth (AB)	μ	91,331.759	0.774	0.540	−0.470	525.041	−0.298	60.753	−0.276	−0.502
	σ	21,044.179	0.633	0.112	0.723	216.308	0.613	24.318	0.670	0.387
	Min	65,785.015	0.005	0.317	−1.902	112.643	−1.466	6.697	−1.765	−1.966
	Max	149,390.644	2.522	0.879	1.712	1,231.613	1.705	116.931	1.271	−0.022
New town (BA)	μ	42,676.805	−0.708	0.748	0.869	774.787	0.410	97.171	0.727	0.964
	σ	18,621.116	0.576	0.150	0.964	298.327	0.845	41.981	1.156	0.863
	Min	5,000.388	−1.975	0.336	−1.780	167.543	−1.311	25.235	−1.254	0.063
	Max	89,171.814	0.709	0.986	2.401	1,362.499	2.076	244.150	4.775	3.472
Low compact-ness (BB)	μ	37,008.782	−0.861	0.567	−0.291	361.461	−0.761	41.251	−0.813	−0.897
	σ	17,166.700	0.517	0.152	0.981	217.736	0.617	19.581	0.539	0.588
	Min	1,200.703	−1.939	0.161	−2.906	27.481	−1.708	4.970	−1.812	−2.778
	Max	65,394.466	−0.007	0.956	2.212	1,006.342	1.066	98.853	0.773	−0.015

Note: *Z*-density and the composite *Z* score, which was defined by the three other *Z* scores, were used to define four neighborhood types.

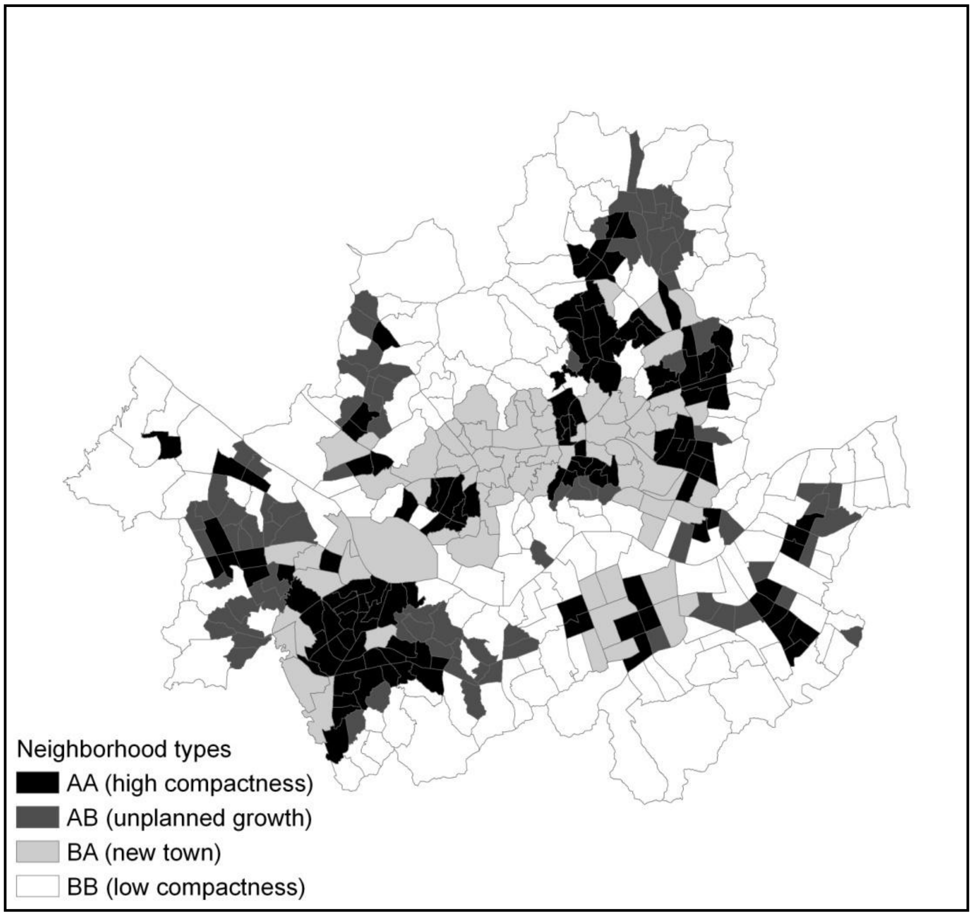


Figure A.9 Neighborhood Distribution by Urban Compactness Type

A.3.4 Strategies for Spatially Even Sampling: Distances to Urban Center

To prevent a sample of neighborhoods from being spatially biased, this research considered the distance from the urban center. The urban center of Seoul comprises ten neighborhoods, three in the District of Jongno (Jongno 1st–4th Street, Jongno 5th–6th Street, and Sajik) and seven in the District of Jung (Euljiro, Gwanghui, Hoehyeon, Myeong, Pil, Sindang 1, and Sogong) (Kim 2005). In the centroid of the urban center, this research created a total of 6 buffer zones so that the last zone contains or touches all neighborhoods: Accordingly, the unit distance of the multiple ring buffers became 1.7 miles and the radius of the last ring was 10.2 miles (see Figure A.10).

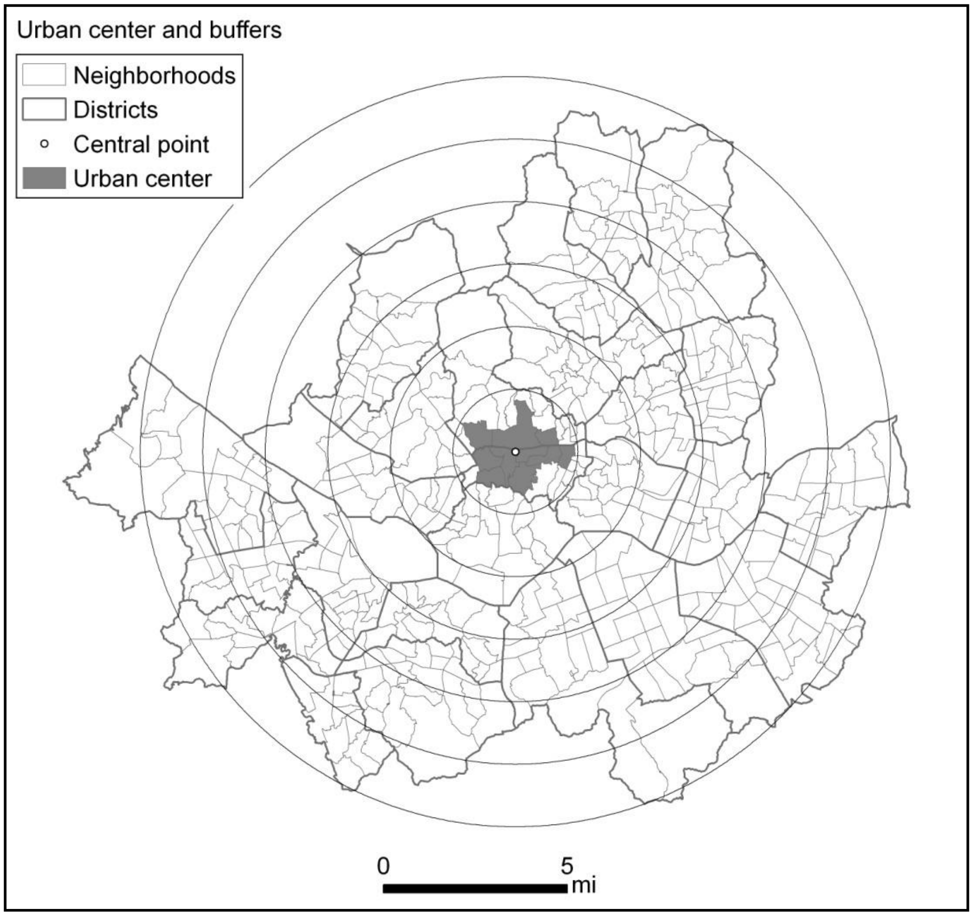


Figure A.10 Urban Center and Multiple Ring Buffers

From the urban center outward, this research went through a total of six rounds (according to the six buffer zones) to identify six neighborhoods for each of the four neighborhood types. The aim was to choose neighborhoods so that in each type, they can be dispersed across Seoul. To this aim, this research has taken the following into account.

The first law of geography is that a geographical phenomenon is spatially concentrated, that is, the nearer, the more possible a particular phenomenon is found. Thus, if neighborhoods in the same type were clustered together, this research selected the most representative one. Second, otherwise, that is, if neighborhoods in different types were close to each other, both were chosen (e.g., islands as surrounded by different types of neighborhoods). Third, to evenly sample neighborhoods throughout Seoul, the next neighborhood (in an outer buffer ring) was selected to be the most detached from the currently sampled neighborhoods (i.e., those sampled in inner rings).

- Sampling from the urban center outward according to six buffer rings
- Sampling the next neighborhood that is the most distant from the currently sampled ones
- Sampling one representative neighborhood in a spatial cluster (i.e., a group of neighborhoods classified into the sample type)
- Sampling all neighborhoods if they share boundaries and fall into different types

Notably, the neighborhood sampling was based mainly on the categorical (not continuous) level of urban compactness—that is, four neighborhood types—and a possibility was that in a continuum, urban compactness variation in the sample is not wide enough for statistical analysis. Thus, the next step was checking the sampling bias in terms of the variation: In cases in which the sampled neighborhoods had similar values in urban compactness, this research checked how each was selected, that is, whether it was sampled because it was the most distant from those already selected in smaller buffers, because it represented a cluster, or because it was an island surrounded by different types of neighborhoods. Then, this research went back to the same buffer ring and selected an alternative neighborhood that had the same characteristic but a different degree of urban compactness. Finally, it confirmed the relevance of the sampled neighborhoods through group meetings with experts at The Seoul Institute.

Figures A11–A12 show neighborhoods that were included in the final sample by neighborhood type and on the whole.

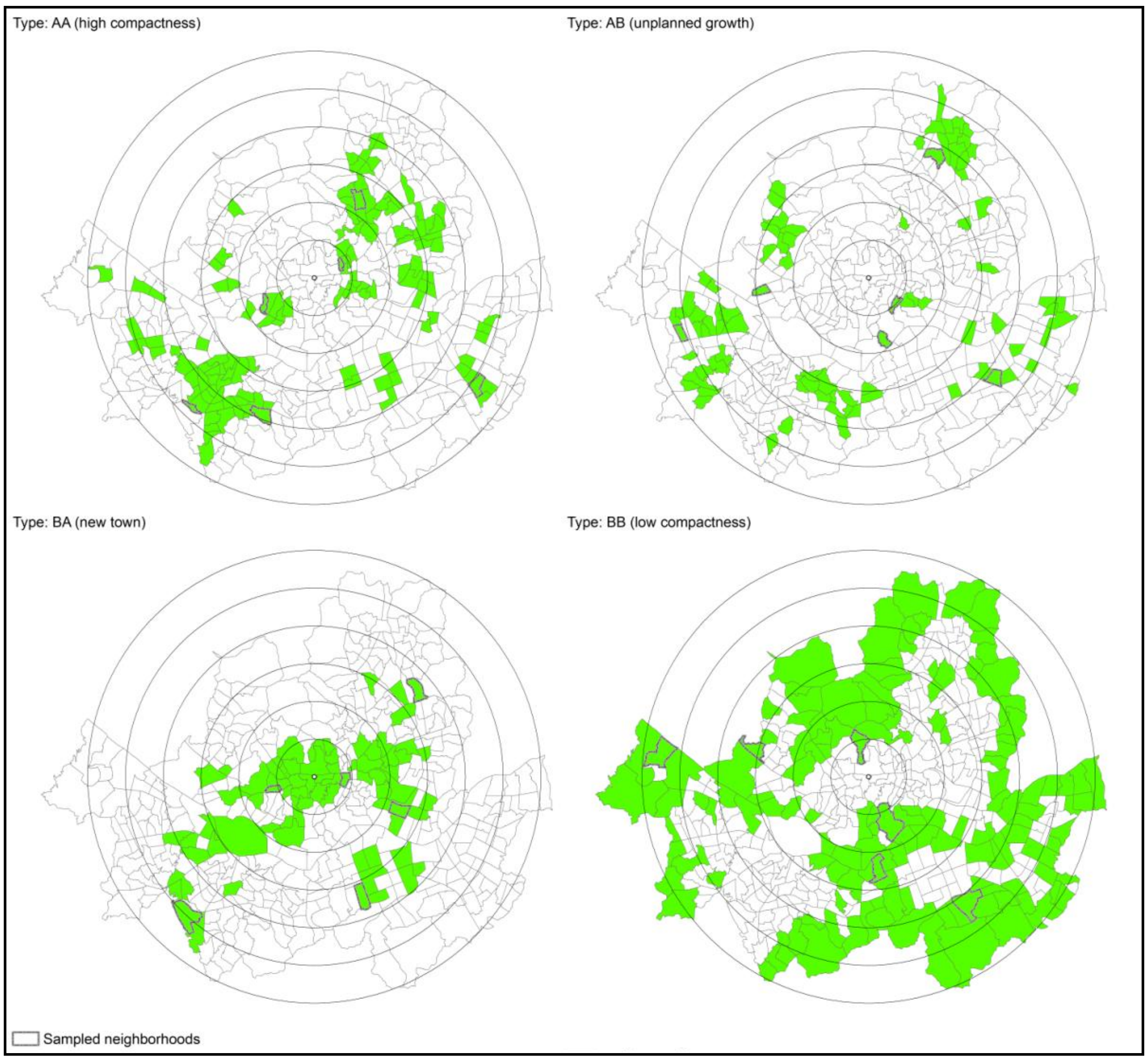


Figure A.11 Sampling Neighborhoods by Neighborhood Type

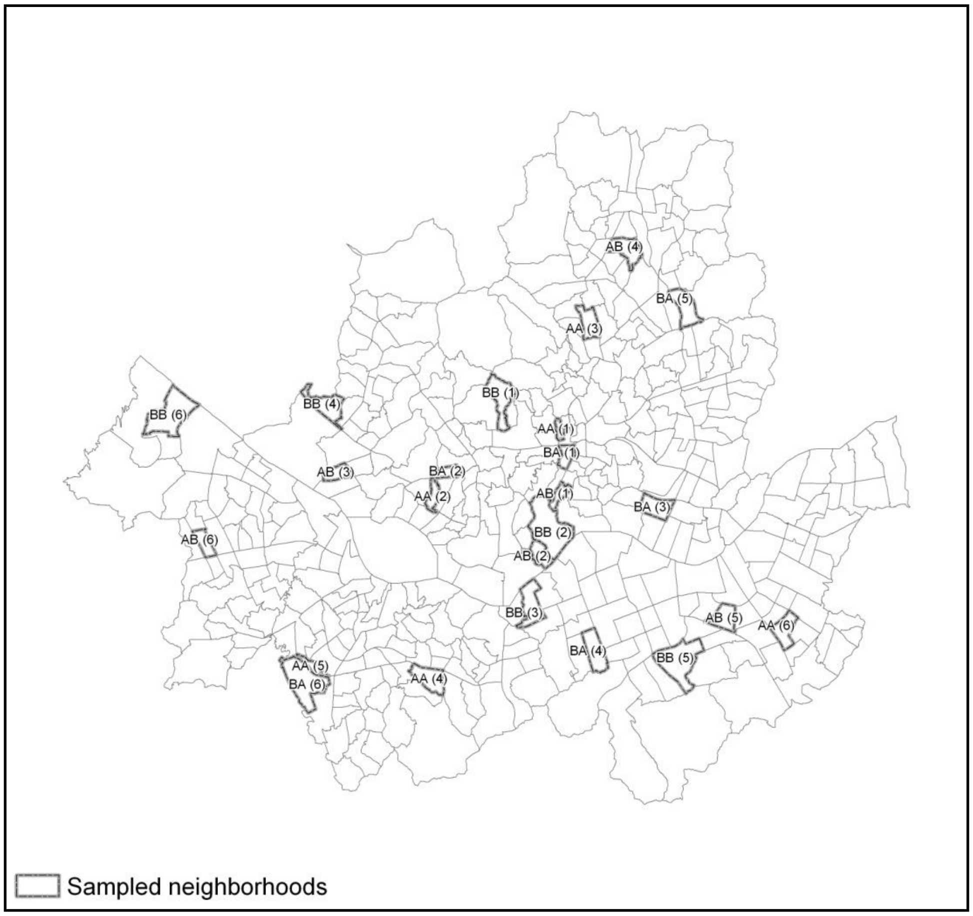


Figure A.12 Final Sample of the Neighborhoods

As shown in Figure A.13, the sampled neighborhoods have sufficient urban compactness variations to the degree to which they can make inferential statistics feasible.

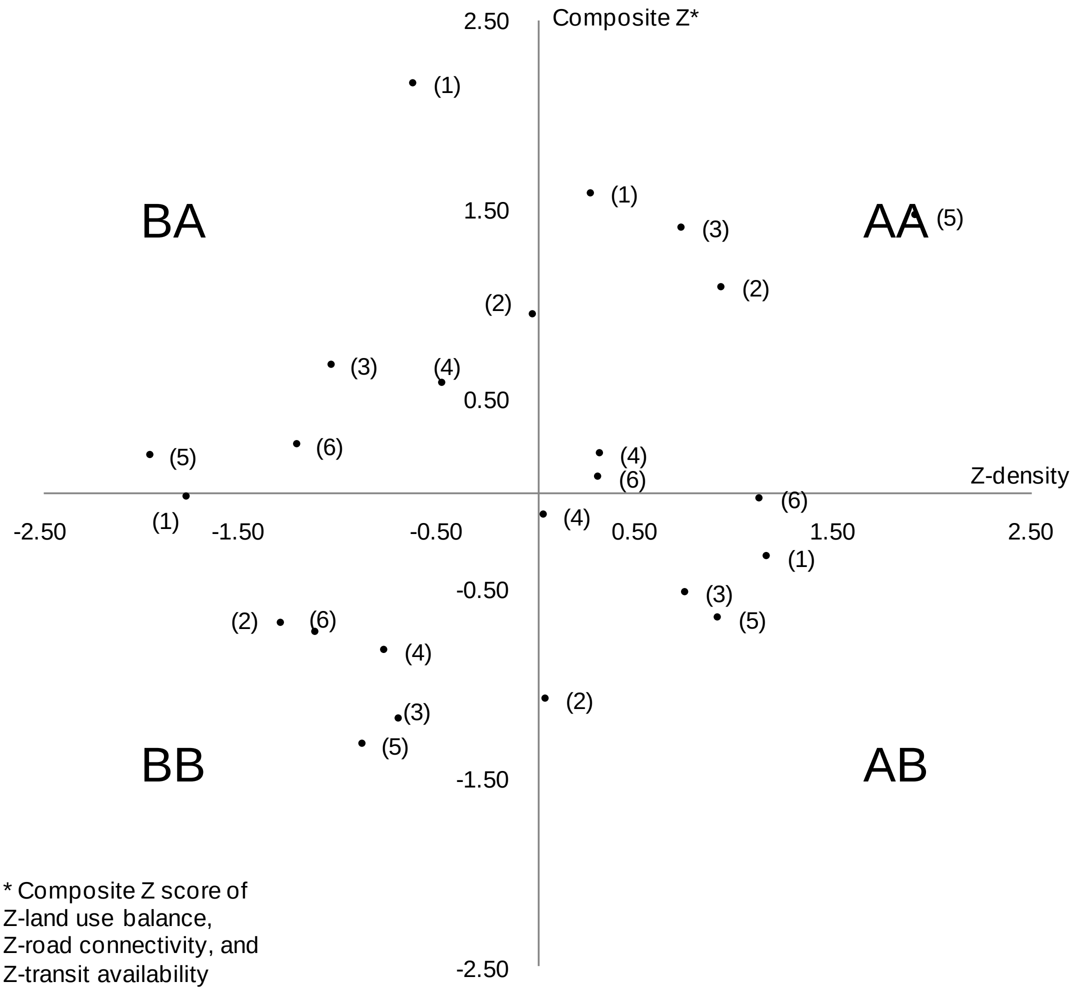


Figure A.13 Sampled Neighborhoods
(*N* = 24, 6 per neighborhood type)
Note: The neighborhood ID consists of the neighborhood type and the order (i.e., buffer ring) of the sampling; for example, in the lower right, AB (5) refers to a neighborhood (Samjeon) that was sampled in the fifth buffer ring of the AB type.

Figure A.14 carries individual maps of the 24 sampled neighborhoods on the same scale. (On each page, those in the same type are shown together.) The maps visualize the level of urban compactness and one can notice a similarity or difference between the inside and outside of each neighborhood.

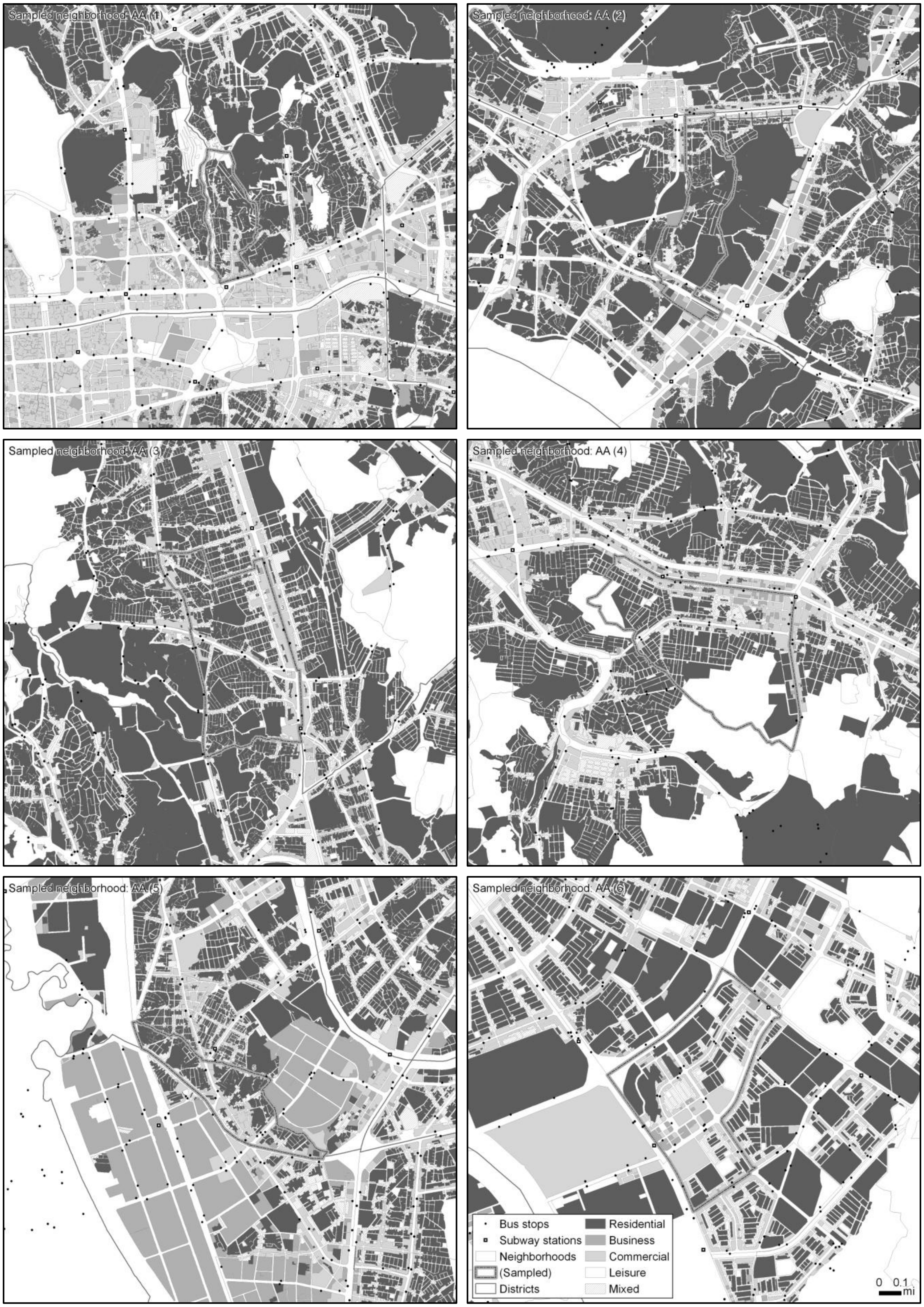


Figure A.14 (A) Neighborhood Maps: High Compactness

Figure A.14 (B) Neighborhood Maps: Unplanned Growth

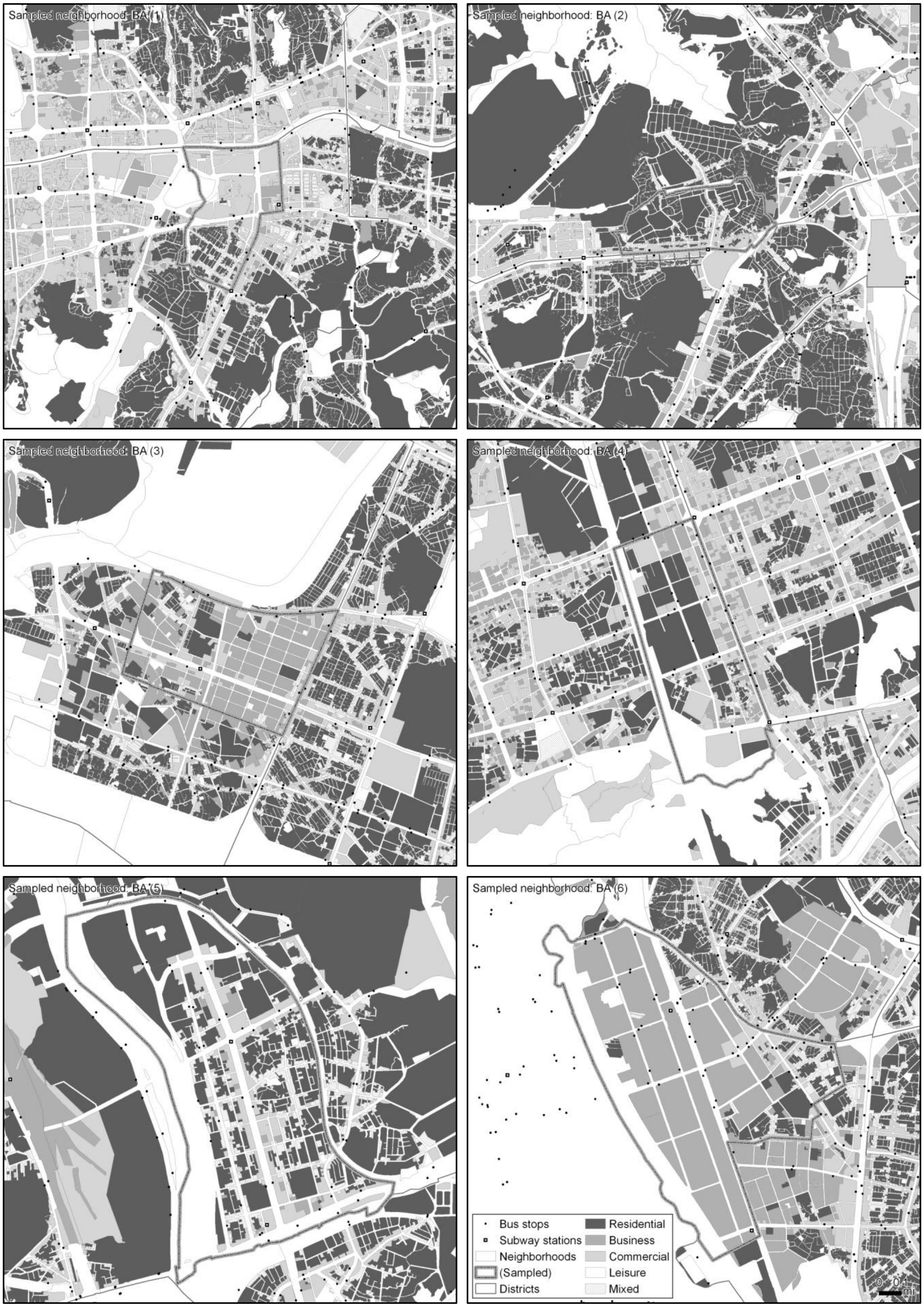


Figure A.14 (C) Neighborhood Maps: New Town

Figure A.14 (D) Neighborhood Maps: Low Compactness

A.3.5 Sampling Interviewees

After sampling 24 neighborhoods, this research selected two residential blocks that are located in the center of each neighborhood. In this process, it examined if the selected blocks well represent the neighborhood and if they have urban form characteristics that are not evaluated in empirical analysis. In particular, this research checked whether unusual events across the sampled blocks are in place, such as road maintenance and construction work and whether unique physical features are present, such as hyper-rise buildings, water bodies, and road obstacles that are not found elsewhere.

This research then contacted block heads, elected among residents in a block, to ask for their assistance in selecting interviewees and distributing survey questionnaires. Either of the two block heads agreed to assist.[64] In return, The Seoul Institute awarded the block head about 4,500 Korean won (≈ 4 U.S. dollars) per successful interview and survey response. This incentive considerably facilitated the interviews and survey: The block heads were highly motivated to recruit and contact suitable interviewees (according to the researcher's request), to distribute questionnaires and collect responses, and to initially review the completeness of the responses.

From each of the 24 blocks, one individual was recruited for an interview (total 24 interviews = 4 neighborhood types * 6 neighborhoods * 1 block * 1 individual). From Wednesday, February 6, 2013—the week after the Georgia Tech IRB approved the

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[64] In four neighborhoods—Hannam in the second set of the sampling, Cheongnyong and Seocho 2 in the fourth set, and Garibong in the fifth set—block heads who were contacted "later" provided assistance.

interviews and survey for this research (Protocol Number: H12341)—through Saturday, March 16, 2013, the researcher conducted six sets of interviews (1 set ≈ 1 week) and per set, he interviewed four individuals.

As stated earlier in "A.3.1.2 Sampling Interviewees", the first set of interviewees was selected so that household monthly income and number of automobiles are diverse in the set. Then, this research identified a target group for the second set based on other sociodemographics of the first-set interviewees, including gender, marital status, age group, and household size. A target group for the next set was established by examining the sociodemographic composition of the current sample (i.e., those underrepresented in the current sample) and is shown in the far right column of Table A.6.

To collect sociodemographic information for the sampling, this research did not directly ask about personal background at interviews, but used answers interviewees provided in the draft of the questionnaire. Indeed, people tend to give distorted responses in the face-to-face interview (Blair et al. 1977), especially for sensitive questions, that is, those about sociodemographics (Webster 1997). Whether or not the interviewer simply waits or intentionally uses foot-in-door techniques (nonverbal appeal for response) (Yu and Cooper 1983) and no matter how strongly anonymity is assured (Webster 1997), the truthfulness of the response decreases if the interviewer is present. Thus, this research solicited the interviewees to complete the draft before coming to the interviews, and with prior notice and subsequent verbal consent, it used their sociodemographic information.

Table A.6 Selecting Interviewees

Set	Inter-view ID	Neighborhoods		Households			Individuals			Target for the set
		Name	ID	Income (million won)	Auto-mobiles	Size	Gender	Marital status	Age group	
1	1	Changshin 2	AA (1)	4	2	3	Male	Married	60s	Diverse in household income and automobile ownership
	2	Shindang 3	AB (1)	8	3	4	Female	Married	50s	
	3	Shindang 1	BA (1)	2	1	1	Male	Single	40s	
	4	Samcheong	BB (1)	3	0	2	Male	Married	30s	
2	5	Yeomni	AA (2)	4	1	3	Female	Married	20s	Female, single, <=20s
	6	Bogwang	AB (2)	7	1	4	Female	Single	20s	
	7	Bukahyun	BA (2)	6	2	3	Female	Married	20s	
	8	Hannam	BB (2)	3	1	2	Male	Single	50s	
3	9	Songcheon	AA (3)	5	0	2	Female	Married	20s	5 (income), 0 or >=2 (automobiles)
	10	Mangwon 2	AB (3)	4	1	3	Female	Single	20s	
	11	Sungsu 2nd St. 3	BA (3)	6	2	4	Female	Married	40s	
	12	Banpo 2	BB (3)	7	2	5	Male	Single	10s	
4	13	Cheongnyong	AA (4)	5	2	6	Female	Married	30s	1 or >=4 (size), male, single, 30s or >=60s (not <=20s)
	14	Chang 1	AB (4)	2	1	1	Male	Single	30s	
	15	Seocho 2	BA (4)	3	0	1	Male	Single	40s	
	16	Susaek	BB (4)	1	1	1	Male	Single	70s	
5	17	Garibong	AA (5)	1	0	1	Female	Single	30s	<=2 or 5 (not >=6) (income), 0 (automobiles)
	18	Samjeon	AB (5)	2	0	1	Female	Single	40s	
	19	Gongneung	BA (5)	5	1	3	Female	Single	20s	
	20	Gaepo	BB (5)	4	1	3	Male	Married	50s	
6	21	Garakbon	AA (6)	3	0	4	Female	Married	60s	2 or >=4 (size), male, married, >=60s, 3 or 5 (not 4 or >=6) (income), not 1 (automobiles)
	22	Sinwol	AB (6)	2	0	1	Male	Single	40s	
	23	Gasan	BA (6)	5	0	2	Male	Married	60s	
	24	Banghwa 3	BB (6)	5	2	5	Male	Married	60s	

Figure A.15 shows that the sociodemographics of the interviewees are fairly diverse and comparable in number.

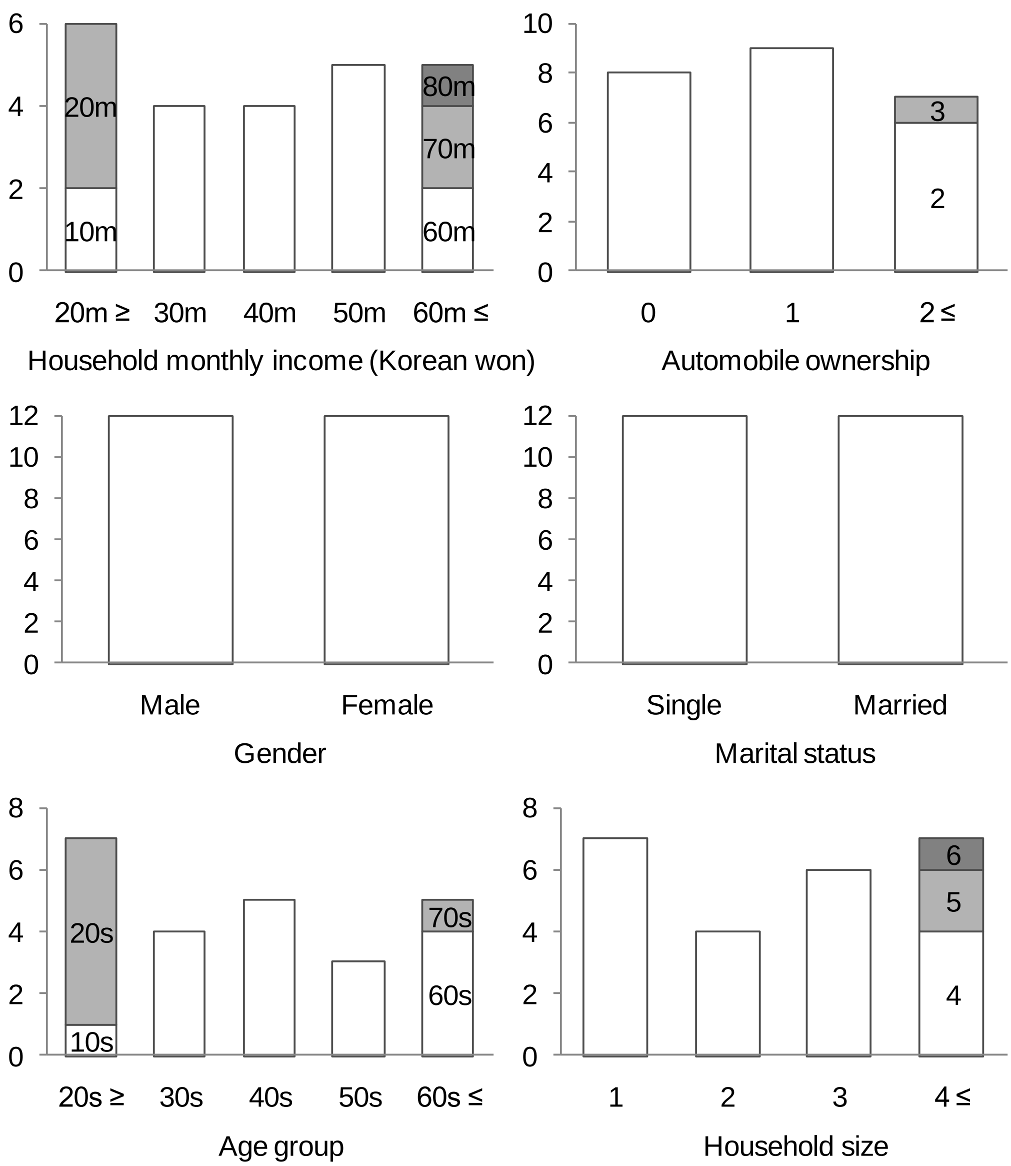

Figure A.15 Sociodemographic Composition of the Interviewees

A.4 Structured Survey

A unique feature of the structured survey was that it measured travel utility. The utility was defined by trip time and travel benefits and the benefits were further categorized into primary benefits (density, variety, quality, and uniqueness of activity locations at travel destinations) and secondary benefits (benefits produced on the way to the destinations and for its own sake). Secondary travel benefits are different according to urban and transportation settings in the study area, and this research conducted semi-structured personal interviews to verify those secondary benefits that were explored in the literature. Based on the outcomes of the interviews, it finalized questionnaire items for a structured survey to quantify each secondary benefit.

In this sense, the relationship between the interviews and survey differed from their typical relationship. For this research, the interviews were used as a pilot and preliminary test of the survey. Usually (e.g., Næss 2005), however, a survey is conducted first, and then a small number of respondents are selected for follow-up interviews that allow in-depth understanding of how and why the respondents gave such answers. Accordingly, one can discover actual meanings behind the answers in particular patterns. In contrast, this research did not interview about general experiences, knowledge, attitudes, and opinions, but its main purpose was to better design the questionnaire. In this vein, this research switched the roles of the survey and interviews.

A.4.1 Psychometrics

Most transportation studies (e.g., Handy, Weston, and Mokhtarian 2005, Johansson, Heldt, and Johansson 2006, Kitamura, Mokhtarian, and Laidet 1997, Sohn and Yun 2009, Van Exel, de Graaf, and Rietveld 2011, Steg, Vlek, and Slotegraaf 2001, Steg 2005) have employed psychometric techniques to evaluate psychological variables such as attitude, preference, intention, perception, and cognition as well as secondary benefit (Bohte, Maat, and van Wee 2009).[65]

The techniques measure multiple survey items on a rating scale, and then reduce them to factors. (Examples of psychometric items are shown in "APPENDIX B".) To extract factors, most studies (see above examples) used exploratory factor analysis (Bohte, Maat, and van Wee 2009); of two types of exploratory factor analysis, principal component analysis (PCA) and common factor analysis, PCA has been preferred in transportation studies (Bohte, Maat, and van Wee 2009) because it accounts for all variance in different items, whereas common factor analysis only explains their common variance (i.e., it does not explain the unique variance of the items) (Fabrigar et al. 1999). A few more sophisticated studies (e.g., Steg 2005, Anable and Gatersleben 2005) grouped psychometric items into conceptually predefined factors and verified the factor–item relationships by statistical analysis such as confirmatory factor analysis. This research followed this convention: To collect primary data on travel benefits, this research conducted a structured survey in which the benefits were evaluated by psychometric items on a seven-point Likert-type rating scale. Then, it checked the factor–

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[65] Although not common, a single item (e.g., I am a car lover) has been used to evaluate secondary benefits of travel: For example, (1) Van Wee et al. (2002) asked people which travel mode they like; (2) Schwanen and Mokhtarian (2005b) measured travel liking overall and by travel purpose and mode; and (3) Steg (2005) used one indirect question—to prevent socially desirable responses—by asking a respondent to evaluate the degree to which his or her significant others would regard the respondent as a car lover. This single-item approach considers that if a questionnaire carries multiple items, it becomes lengthy, and the ratio of nonresponses or hasty responses increases. However, it may fail to measure important dimensions of secondary travel benefits, given that the benefits are multi-dimensional.

item relationships through a mixed-methods approach (interviews and exploratory factor analysis) and verified them using confirmatory factor analysis.

Compared to secondary travel benefits, primary benefits are more explicit and limited in type. With regard to research hypotheses—particularly, those that detail urban compactness effects by considering spatial flexibility of travel destinations (i.e., H4–H6)—they were required to be measured in terms of whether current travel destinations for working, shopping, and leisure activities can be substituted by those in the neighborhood, that is, the degree to which local options are competitive. According to Næss (Næss 2005, 2009, Næss and Jensen 2004), this research asked respondents to evaluate the density, variety, quality, and uniqueness of the local options on a seven-point rating scale from "strongly disagree" to "strongly agree." (The draft and final version of the questionnaire were made in Korean; the originals and their English translations are shown in "APPENDIX C".)

This research formatted psychometric items differently from previous studies that analyzed travel benefits (e.g., Johansson, Heldt, and Johansson 2006, Mokhtarian and Salomon 2001, Mokhtarian, Salomon, and Redmond 2001, Ory and Mokhtarian 2005, Steg 2005, Steg, Vlek, and Slotegraaf 2001, Van Exel, de Graaf, and Rietveld 2011, Ory 2007). Virtually none of the studies measured the benefits separately by travel purpose. [An exception is Anable and Gatersleben (2005); they estimated differences in benefits for work travel and those for leisure travel. However, datasets utilized for the estimation were in different formats, one from a work trip survey and the other from a leisure trip survey, so they could not duly compare the benefits between the two purposes of travel.] This research hypothesized that secondary travel benefits are highlighted when people travel for shopping and leisure and urban compactness act more strongly on the benefits for these purposes of travel. To test this hypothesis, this research measured the benefits separately by travel purpose, using psychometric items on a seven-point rating scale from “very unsatisfied” to “very satisfied.”

A.4.2 Survey Process

The Seoul Institute delivered 1,200 questionnaires to 24 block heads (= 50 copies/block) and the block heads were asked to distribute the questionnaires to those participated in a monthly block meeting to be held on March 25, 2013 considering the household size of the participants. Between the meeting and that of the following month, this research made a weekly reminder call: It was among the following tools it employed to increase the response rate and the quality of the survey.

- Hand-delivered survey: This survey method produces the highest response rate among self-administered survey methods (Dunning and Cahalan 1973, Stover and Stone 1974). While personal interviews typically lead to a response rate of 70–90%, mail survey can hardly reach 50% (Stover and Stone 1974, Yu and Cooper 1983). Despite the same self-administered method as mail survey, hand-delivered survey yields an overall response rate of 70% (Stover and Stone 1974), and in a more controllable setting such as the military and schools, 85% (Dunning and Cahalan 1973).
- Assurance of legal confidentiality: Survey responses for this research are held in legal confidence, as provided in Article 33 of the Statistics Act (Protection of

Secrets) and as in Article 18, Paragraph 2 of the Personal Information Protection Act (Restrictions on Use and Provision of Personal Information).[66] According to the paragraph, public institutions, including The Seoul Institute, "may use personal information … or provide a third person with such information" in cases "4. [w]here personal information is necessary for compiling statistics, or scientific research purposes, etc., and the personal information is provided in a form by which a specific individual cannot be identified". This legal confidentiality may have contributed to higher response rates of those surveys administered by public institutions.

- Financial incentives: The Seoul Institute awarded a premium of 45,000 Korean won (≈ 40 U.S. dollars) to households once all household members completed the survey. Also, per successful survey (and interview), it offered 4,500 won to block heads.
- Reminder calls: This research made a weekly phone call to block heads to facilitate the survey. A review of studies on the response rate reported that this follow-up was one of two most effective techniques in increasing the rate (the other was a financial incentive) (Kanuk and Berenson 1975).

In total, 1,043 responses were returned at the next block meeting or manually collected by the block heads at their discretion (because some households missed the next meeting). It achieved a lower response rate (86.9%) than the 2006 MHTS (94.1%), but

[66] On March 30, 2012, the Personal Information Protection Act superseded the Act on the Protection of Personal Information Maintained by Public Institutions.

the rate was considerably higher than that of typical surveys. This research excluded 11 responses with a significant number of nonresponses, and identified 1,032 responses as effective; they were subsequently used for empirical analysis.

The effective response rate is sufficient for the purposes of this study. Although there is no widely accepted minimum response rate below which survey estimates are necessarily biased (Fowler 2002, Groves 2006), the higher the response rate, the better a study is, inasmuch as the risk of bias decreases (Groves and Peytcheva 2008). Heuristically, a threshold of 60% has been proposed for survey research, as has been done with the 5% threshold for statistical significance (i.e., $p < 0.05$) (Livingston and Wislar 2012). According to this rule-of-thumb, the minimum sample size for this research was 7,200.

Another cut-off for SEM is that the ratio of the number of cases to that of observed variables should be greater than five. Following this rule, Lin and Yang (2006) limited the number of variables to 18 because they collected 92 cases (cities in Taiwan) (92 / 5 = 18.4). This research used a total of 17 observed variables (= 4 indicator variables for urban compactness + 7 for sociodemographics + 3 for travel utility + 3 for travel behavior), and this research collected more than the minimum cases (85 = 17 * 5). A different criterion proposed by Kline (2011) is as follows: minimum sample size for SEM = $v (v + 1) / 2$, where v = number of observed variables. Then, the minimum sample size for this research was 153 (= 17 * 18 / 2). In conclusion, judged by different standards, the effective sample size of 1,032 cases may be sufficient.

APPENDIX B:

EXAMPLES OF PSYCHOMETRIC SURVEY ITEMS

Table B.1 Examples of Psychometric Survey Items

Handy et al. (2005)

(1) I like driving.
(2) I like taking transit.
(3) I like walking.
(4) Public transit can sometimes be easier for me than driving.
(5) Biking can sometimes be easier for me than driving.
(6) Walking can sometimes be easier for me than driving.
(7) I prefer to take transit rather than drive whenever possible.
(8) I prefer to bike rather than drive whenever possible.
(9) I prefer to walk rather than drive whenever possible.
(10) Traveling by car is safer overall than taking transit.
(11) Traveling by car is safer overall than riding a bicycle.
(12) Traveling by car is safer overall than walking.
(13) Getting to work without a car is a hassle.
(14) The region needs to build more highways to reduce traffic congestion.
(15) The price of gasoline affects the choices I make about my daily travel.
(16) Fuel efficiency is an important factor for me in choosing a vehicle.
(17) I try to limit my driving to help improve air quality.
(18) Vehicles should be taxed on the basis of the amount of pollution they produce.
(19) I need a car to do many of the things I like to do.
(20) We could manage pretty well with one fewer car than we have (or with no car).
(21) I prefer to organize my errands so that I make as few trips as possible.
(22) The only good thing about traveling is arriving at your destination.
(23) When I need to buy something, I usually prefer to get it at the closest store possible.
(24) I often use the telephone or the Internet to avoid having to travel somewhere.
(25) Travel time is generally wasted time.
(26) I use my trip to/from work productively.
(27) The trip to/from work is a useful transition between home and work.

Kitamura et al. (1997)*

(1) I would be willing to give up a day's pay to get a day off work.
(2) Buses and trains are pleasant to travel in.
(3) Driving allows me freedom.
(4) Driving allows me to get more done.
(5) Environmental protection costs too much.

Table B.1 (continued)

(6)	Environmental protection is good for California's economy.
(7)	Environmentalism hurts minority and small businesses.
(8)	Getting stuck in traffic doesn't bother me too much.
(9)	Having shops and services within walking distance would be important.
(10)	High density residential development should be encouraged.
(11)	I am not comfortable riding with strangers.
(12)	I can read and do other things when I use public transportation.
(13)	I feel that I am wasting time when I have to wait.
(14)	I like someone else to do the driving.
(15)	I like to spend most of my time working.
(16)	I need to have space between me and my neighbors.
(17)	I use public transportation when I cannot afford to drive.
(18)	I would be willing to pay a toll to drive on an uncongested road.
(19)	I would like to have more time for leisure.
(20)	I would only live in a multiple family unit as a last resort.
(21)	I would rather drive an electric vehicle than give up driving.
(22)	It costs more to use public transportation than to drive a car.
(23)	It's important for children to have a large backyard for playing.
(24)	More lanes should be set aside for carpools and buses.
(25)	People and jobs are more important than the environment.
(26)	Public transportation is unreliable.
(27)	Ridesharing saves money.
(28)	Stricter vehicle smog control laws should be introduced and enforced.
(29)	The rideshare car or van is often late.
(30)	Too many people drive alone.
(31)	Too much valuable agricultural land is consumed to supply housing.
(32)	Traffic congestion will take care of itself because people will adjust.
(33)	Using tax dollars to pay for public transportation is a good investment.
(34)	Vehicle emissions increase the need for health care.
(35)	We need to build more roads to help decrease congestion.
(36)	We should provide incentives to people who use electric vehicles.
(37)	We should raise the price of gasoline to reduce congestion and air pollution.
(38)	When busy at work, I get more done by cutting back on personal time.
(39)	Whoever causes environmental damage should repair the damage.
Sohn and Yun (2011)	
(1)	The car protects my privacy.
(2)	I feel safe while driving.
(3)	The car protects me against bad weather.
(4)	I can go anywhere by car.
(5)	The function of car is more important than its brand.
(6)	Driving gives me conveniences in my life.

Table B.1 (continued)

(7)	Driving is fun.
(8)	Driving is my hobby.
(9)	I enjoy driving.
(10)	I like to have a sports car.
(11)	I enjoy competitive sports games.
(12)	I enjoy speed.
(13)	I participate in recycling paper.
(14)	I participate in recycling batteries.
(15)	I try to save energy.
(16)	I am punctual.
(17)	The car is not just instrumental.
(18)	I can know a person by looking at his/her car.
(19)	My car shows who and what I am.
Van Exel et al. (2011)	
(1)	A car is not a necessity, but it does make life a whole lot easier.
(2)	All things considered, to me the car is superior to public transport.
(3)	Door to door travel time plays an important role in my mode choice.
(4)	For an active social life I need a car. Without a car I would visit my family and friends less often and would make fewer leisure trips.
(5)	For me, travelling by public transport is more expensive than travelling by car.
(6)	For private use I do not need a car.
(7)	I am not really price-or time-sensitive, environmental aspects are most important to me.
(8)	I find the reliability of travel time important.
(9)	I know very well where in my neighbourhood I can get on public transport to the rail station and I have a fairly good notion of the timetable.
(10)	I often feel unsafe when using public transport and on stations, especially at night.
(11)	On a day when I do not have my car at my disposal for a day, I am greatly inconvenienced.
(12)	Public transport is much too dirty and unsafe to be an alternative for the car.
(13)	Things like comfort, privacy and safety are more important to me than travel costs and travel time.
(14)	Travel costs play an important role in my mode choice.
(15)	What really matters is reaching my destination and getting back, the mode of travel does not matter much.
(16)	A big advantage of travelling by train is that you can do something useful en route: do some reading or take a nap.
(17)	A lovely view, a pleasant encounter, a surprising book, a brain wave. A train journey often is an experience.
(18)	Driving a car is a great pleasure. The sound of the engine, accelerating sportily at traffic lights, cruising on the highway, listen to music.

Table B.1 (continued)

(19) For me the car is more than a mode of transport, it is a part of my identity, a way to distinguish myself from others.
(20) I would rather look out of the compartment window to the passing Dutch landscape than to the bumper of the car before me.
(21) I recall the day I got my first car very well, I had been looking forward to that day for quite a while.
(22) In the train you sometimes meet nice people. I enjoy that. The car is much duller and more lonesome.
(23) Once you own a car, you'll use it for all your travel.
(24) Only the car takes me where I want, when I want it.
(25) You are what you drive.
(26) A better environment starts with yourself. Therefore, everyone should use public transport more often.
(27) For my work I need a representative mode of transport.
(28) I am a dedicated follower of the four-wheel-credo. The car can maybe do without me for a day, but I cannot do without my car.
(29) My family and friends appreciate it when I travel by public transport.
(30) Public transport is for people who cannot afford a car.
(31) The Netherlands is a car country. We could just as well pave all railroads and transform all stations into parking garages.
(32) As a result of all those different timetables and lines, travelling by public transport is too complicated.
(33) I am well aware of the costs of a trip, by car as well as by public transport.
(34) I find it pleasant to plan my trips in advance and to have everything well organized before I leave.
(35) I would rather not drive in big cities… lots of traffic, lots of traffic lights, problems with parking.
(36) I know the public transport system pretty well because I make use of it frequently.
(37) It is important to me to have control over my journey.
(38) The last time I travelled by public transport was a complete disaster.
(39) As far as I am concerned, car and public transport both are good transport alternatives.
(40) Before every trip, I draw a comparison between car and public transport regarding travel costs, time and so forth, and select the best alternative.
(41) For the greater part my travel behaviour is routine, I do not really give it much thought.
(42) I always travel in the same way and find it satisfactory.

* A partial list of survey items; Kitamura et al. (1997) used exploratory factor analysis to extract the items.

Note: Items are rearranged. As common among the examples, (1) indirect items were partially used and (2) responses were measured on a Likert-type rating scale.

APPENDIX C:

INTERVIEW PROTOCOL, INTERVIEW FORM, AND QUESTIONNAIRE DRAFT AND FINAL

C.1 Korean

The Georgia Institute of Technology Institutional Review Board approved the interviews and survey of this dissertation research (Protocol Number: H1234). According to The Seoul Institute Research Ethics Committee, it does not reveal interviewees' names.

Updates that were made to the final version of the questionnaire are highlighted in gray.

인터뷰 프로토콜

피면접자(이름, 직업): ______________________________
(기타 개인정보는 설문지 응답으로 확인)

면접원: 김태형

섹션 완료 여부:

______ A. 일차 편익의 종류
______ B. 시너지 편익(통행중 편익)의 종류
______ C-1. 도구적 편익의 종류
______ C-2. 상징적 편익의 종류
______ C-3. 규범적 편익의 종류
______ C-4. 정서적 편익의 종류
______ D. 설문지 관련 제안사항

인터뷰에서 나온 중요한 이야기:	인터뷰에서 나온 중요한 제안사항:

기타 논의사항:

첨부문서 획득 여부:

	기입된 인터뷰 폼
	설문지(초안) 응답

인터뷰 이후 커멘트 혹은 정보(leads):

인터뷰 시작 프로토콜

인터뷰를 허락해 주셔서 대단히 감사합니다. 인터뷰의 목적은 첫째, 통행의 동기와 욕구, 즉 사람들이 통행을 하는 이유가 무엇인지 조사하고 둘째, 설문지 초안에 어떤 문제가 있는지 살펴 보는 것입니다. 선생님께서 제안하신 바에 따라 설문지를 수정하게 됩니다. 설문조사는 「2012 유동인구조사」의 일환으로 실시되며 그 결과는 「서울시 도시교통 종합계획」에 반영됩니다. 선생님께서 피면접자로 선정된 이유는 다양하고 통찰력 있는 의견을 모으는 데 있어, 선생님께서 동네주민분들을 대표할 수 있는 말씀을 해 주실 것으로 파악되었기 때문입니다. 인터뷰 내용은 익명으로 처리되며, 15 분에서 20 분이 소요됩니다.

통행 편익의 종류

<u>A. 일차 편익의 종류</u>

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

<u>B. 시너지 편익(통행 목적지까지 가는 동안의 편익)의 종류</u>

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

<u>C-1. 도구적 편익의 종류</u>

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 토지이용 및 교통 상황을 볼 때, 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

<u>C-2. 상징적 편익의 종류</u>

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

<u>C-3. 규범적 편익의 종류</u>

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

C-4. 정서적 편익의 종류

- 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요?
- 탐침질문(probes): 왜 그렇게 생각하세요? 개인적 경험이나 가족, 친구, 동료 같은 다른 사람의 경험을 들려 주실 수 있을까요?

D. 탐침질문(probes): 과거 및 가정적 상황

- ______이 리스트에 더해질 수(빠질 수) 있다고 말씀하셨는데요, 그러면 그것이 예전에 사신 동네에서는 가능(불가능)했나요? 그랬다면, 무엇 때문일까요?
- 만약 선생님께서 다른 동네, 예를 들어 인구밀도, 토지이용의 다양성, 도로망의 연결성, 지하철역 및 버스정류장의 수가 지금과 다른 동네에 사신다고 가정해 보면, 아까 추가(제외)하신 편익의 종류에 대해 어떻게 생각하실까요? 여전히 추가(제외)하시나요?

설문지 관련 제안사항

내용, 단어·문맥, 문항(배치, 응답 완성도 및 응답시간), 포맷

- 설문지에 대해 어떻게 생각하세요? 선생님께서 조언해 주시는 내용이 더 좋은 설문지를 만드는 데 큰 도움이 될 것입니다.

_______ 질문 중에 특정 응답을 유도하거나, 위협적이거나, 편향되어 있거나, 특정 가치를 추구하거나, 이중적으로 해석될 수 있는 것들이 있었나요?

_______ 모든 분들이 이해할 수 있도록 평이하고 정확한 단어와 표현이 사용되었나요?

_______ 난해하거나 의미가 모호한 용어가 있었다면 설명을 달았나요?

_______ 질문들이 잘 배치되어 있어서 그 다음 문제에 쉽게 답할 수 있었나요? 그렇지 않았다면, 질문의 순서를 어떻게 바꾸는 것이 적절할까요?

_______ 응답하기 곤란한 질문이 있었나요? 그랬다면, 왜 그랬나요?

_______ 설문지를 끝내시는 데 시간이 총 얼마나 걸렸나요? 시간이 오래 필요한 질문이 있었나요?

_______ 응답란의 스타일과 전반적인 외관(글꼴 및 글씨 크기 포함)이 설문지를 보기 편하게 했나요? 그렇지 않았다면 어떻게 하면 모습이 더 좋아질까요?

_______ 그 밖의 문제점이나 제안사항은?

인터뷰 이후 커멘트 및 관찰사항(observations)

도시형태가 통행의 효용 및 행태에 미치는 영향 (자기기입식 인터뷰 폼)

다음 방문일시:	__월	__일	__시 __분	인터뷰 장소:	

안녕하세요, 서울연구원입니다.

연구조사 인터뷰에 자발적 참여를 부탁드리고자 이 글을 올립니다. 본 연구는 「2012 유동인구조사」와 「서울시 도시교통 종합계획」의 일환이며 서울시와 공동으로 진행됩니다. 연구의 목적은 도시의 물리적 환경이 통행의 효용 및 행태와 어떠한 관계를 갖는지 분석하는 것입니다. 저희는 궁극적으로 약 1,200명에 설문조사를 실시하려고 하며, 그 설문조사를 보다 잘 설계하기 위해 이뤄지는 이번 인터뷰에서는 24명 정도를 모실 예정입니다. 구체적으로 본 인터뷰는 (1) 시민이 통행을 하는 데 있어 그 동기와 욕구가 무엇인지 알아보는 본조사 이전의 예비조사, 그리고 (2) 동봉된 설문지의 내용을 개선하기 위해 문제점이 무엇인지 파악하는 사전조사의 성격을 갖습니다.

귀하의 응답은 통계법 33조(비밀의 보호)에 따라 철저히 비밀로 다뤄집니다. 귀하의 개인정보를 비밀로 하기 위해 다음 절차를 따르게 됩니다. 귀하에 관한 데이터는 법에서 정한 바에 따라 비공개로 처리됩니다. 프라이버시 보호를 위해 귀하와 관련된 기록은 이름이나 특정 일련번호가 아니라 무작위 코드로 취급됩니다. 기록은 잠금장치가 있는 서류함에 보관되고, 연구 관련자만 열람할 수 있습니다. 연구결과가 발표, 공개될 때 귀하를 나타낼지도 모르는 이름 및 기타 사실은 결코 드러나지 않습니다. 본 연구가 정당한 방법으로 수행되고 있는지를 확인하기 위해 서울연구원 연구윤리위원회에서 연구기록 감사를 실시할 수 있습니다.

인터뷰에 응하시는 경우, (1) 자기기입식 인터뷰 폼과 (2) 설문지 초안을 받으시게 됩니다. 귀하는 위에 정해 주신 시간과 장소에서 만나기 전까지 서울 상황을 고려하여 알맞게 교통편익을 더하거나 빼시며 인터뷰 폼을 작성하시고 설문지 초안의 문제점 발견을 위한 문항에 답하시게 됩니다. 개인면접에서 귀하는 추가 또는 제거하신 교통편익 그리고 설문지 초안에서 발견하신 문제점에 대한 질문을 받게 됩니다. 귀하는 인터뷰 폼 작성, 설문지 응답, 개인면접을 아무 이유 없이, 언제라도 중지하실 수 있습니다. 인터뷰 폼 작성에 20분, 설문지 응답에 25~30분이 걸릴 것으로 보입니다. 대별면접은 15~20분 동안 진행됩니다. 인터뷰가 끝나면 감사의 뜻으로 문화상품권(1만원 상당)이 지급됩니다. 본 인터뷰에 참여하는 데 필요한 시간 외에 귀하께서 들여야 하는 비용은 없습니다. 인터뷰 참여에 따르는 어떠한 위험이나 불안요인이 알려진 바 있거나 예상되지 않습니다. 귀하께서 연구에 참여하여 어떤 식으로든 이득을 얻을 것이라고 판단되지는 않습니다. 저희는 연구를 통해 발견한 사항이 서울시를 비롯한 개인 및 단체로 하여금 사람들의 태도와 선호가 통행행태에 미치는 방식을 이해함으로써 보다 나은 정책을 개발하는 데 도움이 될 수 있기를 바랍니다.

본 연구에 참여를 결정하시는 것은 전적으로 귀하 본인의 의사에 따르며, 원하시지 않으면 참여하지 않으셔도 됩니다. 그리고 어떤 이유 없이 아무 때라도 참여를 중단하실 수 있습니다. 참여하지 않으시거나 중도에 중단하시더라도 어떠한 처벌이 따르거나 귀하께 주어졌던 편익이 박탈되지 않습니다. 저희는 귀하께서 연구참여 의지에 대해 생각을 다시하게 만드는 신규 및 변경사항을 모두 알려 드릴 것입니다.

연구 및 연구참여자 권리에 관해 의문점이나 문제가 있으시면, 또는 연구참여의 결과로 상해를 입으시면 마지막에 나와 있는 전화번호나 이메일로 연락을 부탁드립니다. 연구관련 상해시 발생하는 비용의 지불을 위해 저희가 별도로 준비해 둔 계획은 없습니다.

맨 윗쪽 박스에 인터뷰 시간과 장소를 기재하시고 첨부된 자기기입식 인터뷰 폼과 설문지 초안을 작성하시는 경우, 이는 귀하께서 여기에 포함된 내용을 읽고 연구에 자발적으로 참여하겠다는 의사를 밝히신 것으로 해석됩니다. 협조해 주셔서 대단히 감사합니다.

담당: 김태형 연구원

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희망서울 서울연구원 The Seoul Institute

학계에 따르면 시민이 특정 교통수단(예: 자동차, 대중교통, 보행 및 자전거)으로 통행을 하는 이유는 다음과 같은 이득이 따르기 때문입니다.

A. 일차 통행편익: 통행 목적지에서 얻는 효용
B. '목적지까지 가는 동안'의 편익: 통행하는 동안 이뤄지는 활동을 통해 얻는 효용
C. '통행 그 자체'에서 만들어지는 편익: 인간이 본래 가진 통행 욕구에서 비롯되는 효용

아래에는 위에 열거한 세 종류의 통행 편익(A, B, C)이 설명되어 있습니다. 설명을 읽으신 후 바로 아래 빈 칸에 무엇이 추가될 수 있는지 또는 서울 상황을 고려해서 무엇이 빠져야 할지 적어 주십시오.

A. 일차 통행편익: 통행 목적지에서 얻는 효용
- A-1. 목적지에서 하려고 했던 활동: 업무, 쇼핑, 여가활동 등
- A-2. 목적지 근처에서 할 수 있는 부수적인 활동: 다채롭거나 새로운 볼거리 즐기기, 친구나 친척 만나기, 근처 명소에 가기 등
- 질문 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요? 적어 주시면 감사하겠습니다.
- 답

B. '목적지까지 가는 동안'의 편익: 통행하는 동안 이뤄지는 활동에서 비롯되는 효용
- B-1. 비활동: 안정을 취하기, 생각하기, 쪽잠자기 등
- B-2. 부수적인 활동: 전화, 인터넷이나 온라인 쇼핑, 사적인 대화, 책·신문·잡지 읽기, 음악·라디오 듣기, 방송·비디오 보기 등
- 질문 무엇이 빠져 있다고 생각하세요? 아니면, 서울의 상황에서 그럴듯 하지 않은 것이 있나요? 적어 주시면 감사하겠습니다.
- 답

'통행 그 자체'에서 만들어지는 편익(편익 C)은 다음과 같이 더 나뉠 수 있습니다.

C. '통행 그 자체'에서 만들어지는 편익: 인간이 본래 가진 통행 욕구에서 비롯되는 효용
   - C-1. 도구적 편익
   - C-2. 상징적 편익
   - C-3. 규범적 편익
   - C-4. 정서적 편익

아래에는 '통행 그 자체'에서 만들어지는 편익 4 종류(C-1 부터 C-4 까지)가 설명되어 있습니다. 설명을 읽으시고 바로 아래 빈 칸에 무엇이 추가될 수 있는지 또는 서울 상황을 고려해서 무엇이 빠져야 할지 적어 주십시오.

C-1. 도구적 편익: 도구적 편익은 보통 어떤 교통수단(예: 자가용, 대중교통, 보행, 자전거)을 이용하느냐에 따라 편익의 크기가 다르게 나타납니다.
   - a. 안락함
   - b. 편리함
   - c. 안전함
   - d. 프라이버시

   질문 도구적 편익으로서 안락함, 편리함, 안전함, 프라이버시 외에 무엇을 추가할 수 있을까요? 아니면, 서울의 토지이용 및 교통 상황을 볼 때, 이 중에서 그럴듯 하지 않은 것이 있나요? 적어 주시면 감사하겠습니다.

   답

C-2. 상징적 편익
   - a. 사회경제적 지위를 나타내기(예: 고급차를 타면서 자신을 드러내는 것)
   - b. 라이프스타일을 나타내기(예: 많은 곳을 가거나 또는 흥미로운 곳에 가면서 자기표현을 하는 것)
   - c. 능력과 위신을 상징적으로 나타내기

   질문 상징적 편익으로 무엇을 추가할 수 있을까요? 아니면, 이 중에서 서울에서는 그럴듯 하지 않은 것이 있나요?

   답

C-3. 규범적 편익

a. 환경관심: 환경보호를 위해 환경에 이롭게 통행하는 것
b. 사회규범: 가족이나 친구 등 내게 중요한 사람들이 내게 기대하는 대로 통행하는 것
c. 개인규범(사회규범이 내면화된 것): 내 자신에게 뿌듯할 수 있게 통행하는 것(자존감 고취)

질문 규범적 편익으로 무엇을 추가할 수 있을까요? 아니면, 이 중에서 서울에서는 그럴듯 하지 않은 것이 있나요?

답

C-4. 정서적 편익(통행에서 비롯되는 감정을 즐기기)

a. 모험(새로움): "통행·여행을 하는 즐거움은 단순히 목적지에 도달하는 것 이상에 있다"라는 생각
b. 다양성: 다른 길이나 장소를 선택함으로써 단조로운 일상을 바꾸는 것
c. 호기심: 특별한 목적 없이 하는 피상적이고 탐색적인 활동(예: 통행을 하면서 일어나는 일이나 지하철 안 승객·거리의 행인에게 대뜸 관심을 갖기, 나중에 도움이 될지 모르는 정보를 얻기)
d. 완충작용: 이전 활동·장소와 다음 활동·장소 사이에 전환하는 짬(예: 출근하는 길의 마음가짐 변화)
e. 특정한 경로에서 찾을 수 있는 쾌적함(아름다운 경치)
f. 실외에 노출되는 것: 바깥 환경을 느끼고 그곳을 지나면서 실내의 답답함에서 벗어나기
g. 원하는 대로 자유자재로 움직이기
h. 독립심: 남의 도움을 받지 않고 혼자 돌아다니기
i. 정복감: 경쟁적으로 통행하는 느낌(예: 자동차 경주의 느낌), 자전거 오래 타기, 잘 모르는 주위를 지나가기, 그리고 무력감, 내성적 기질, 두려움의 극복
j. 회피: 집이나 직장·학교에서 받는 의무·스트레스, 일상, 긴장으로부터 잠시 벗어나기
k. 운동(예: 일부러 목적지에서 떨어진 곳에 주차하거나 내리기, 일부러 걷기, 안 할 수도 있지만 통행을 하기)
l. 정신적 치료: 진정시키거나 마음을 북돋기 위한 통행

질문 정서적 편익으로 무엇을 추가할 수 있을까요? 아니면, 이 중에서 서울에서는 그럴듯 하지 않은 것이 있나요?

답

귀하를 설문 응답자인 것처럼 가정하고 동봉된 설문지에 모두 응답해 주시기를 부탁드립니다. 인터뷰를 할 때 응답을 하는 데 혼란스럽거나 어려운 점이 있었는지, 그리고 응답에 걸린 시간, 설문지 외관, 글씨체, 가독성 등에 대해 질문할 것입니다. 인터뷰는 설문지를 더 잘 만드는 데 큰 도움이 될 것입니다. 인터뷰 내용은 비밀이 철저히 보장됩니다.

질문 1 설문지를 끝마치는데 시간이 얼마나 걸렸나요? ________ 분

질문 2 설문지에 대해 어떻게 생각하세요? 개선점이 있으면 적어 주십시오.
답

- 해당되는 부분이 있으면 체크(✔)해 주세요.

_______ 질문 중에 특정 응답을 유도하거나, 위협적이거나, 편향되어 있거나, 특정 가치를 추구하거나, 이중적으로 해석될 수 있는 것들이 있었나요?

_______ 어렵거나 부정확한 단어와 표현이 사용되었나요?

_______ 난해하거나 의미가 모호한 용어가 있는데 설명이 달려 있지 않았나요?

_______ 질문들의 순서가 나빠서 그 다음 문제에 쉽게 답할 수 없었나요?

_______ 곤란한 질문이 있었나요?

_______ 시간이 오래 걸리는 질문이 있었나요?

_______ 응답란의 스타일과 전반적인 외관(글꼴 및 글씨 크기 포함) 때문에 설문지를 보기 불편했나요?

_______ 그 밖에 다른 문제점이나 제안사항이 있으신가요?

좋은 의견을 주셔서 대단히 감사합니다!

도시형태가 통행의 효용 및 행태에 미치는 영향 (설문지 초안)

안녕하세요. 서울연구원입니다.

본 연구원은 서울시와 함께 「2012 유동인구조사」와 「서울시 도시교통 종합계획」의 일환으로 연구조사를 실시하고 있습니다. 동 연구조사에 자발적 참여를 부탁드리고자 이 글을 올립니다. 연구의 목적은 시민의 통행 관련 태도와 선호에는 어떤 것들이 있는지, 그리고 그것들의 상대적 강도는 어떠한지 추정하는 데 있습니다. 저희는 본 연구에서 약 12,000 명에 설문을 받을 예정입니다.

귀하의 응답은 개인정보 보호법 18 조 2 항 4 호(개인정보의 이용·제공 제한)에 의거하여 숫자로만 취급되며 통계법 33 조(비밀의 보호)에 따라 철저히 비밀에 부쳐집니다. 귀하의 개인정보를 비밀로 하기 위해 다음 절차를 따르게 됩니다. 귀하에 관한 데이터는 법에서 정한 바에 따라 비공개로 처리됩니다. 프라이버시 보호를 위해 귀하와 관련된 기록은 이름이나 특정 일련번호가 아니라 무작위 코드로 취급됩니다. 기록은 잠금장치가 있는 서류함에 보관되고, 연구 관련자만 열람할 수 있습니다. 연구결과가 발표, 공개될 때 귀하를 나타낼지도 모르는 이름 및 기타 사실은 결코 드러나지 않습니다. 저희는 집단의 정보에만 관심이 있습니다. 설문결과 보고서에는 통계값만 나타나고 개별 응답자의 개인정보는 아무 것도 포함되지 않습니다. 본 연구가 정당한 방법으로 수행되는지를 확인하기 위해 서울연구원 연구윤리위원회에서 연구기록 감사를 실시할 수 있습니다.

연구에 참여하기로 결정하시는 경우, 반상회 자리에서 반장께서 설문지를 드리게 됩니다. 그러면 귀하는 설문지를 집으로 가져 가시어 다음 사항에 귀하의 판단을 구하는 문항에 답하시게 됩니다: 거주하시는 동네의 현황, 일반적인 통행에서 나타나는 다양한 측면 각각을 중요하게 보시는 정도, 최근의 통행횟수 및 통행시간. 귀하는 설문지 응답을 아무 이유 없이 언제라도 중지하실 수 있으며, 설문을 끝내는 데에는 약 25~30 분 정도가 걸립니다. 연구에 참여하는 데 필요한 시간 외에 귀하께서 들여야 하는 비용은 없습니다. 다음 달 반상회에서 반장께서 귀하 설문지를 회수하시게 됩니다. 응답이 누락되는 경우 해석이 어려우므로 모든 질문에 답해 주시기를 부탁드립니다. 연구 참여에 따라서는 어두 위험이나 불안요인도 알려지거나 예상되지 않습니다. 귀하께서 연구에 참여하심으로써 어떤 식으로든 이득을 얻을 것으로 보이지는 않습니다. <u>설문지는 만 18 세 이상인 가구원 모두가 자필로 작성하도록 합니다. 이후, 반장님을 통해 사례금 45,000 원을 받으시게 됩니다.</u>

본 연구에 참여를 결정하시는 것은 전적으로 귀하 본인의 의사에 따르며, 원하시지 않으면 참여하지 않으셔도 됩니다. 그리고 어떤 이유 없이 아무 때라도 참여를 중단하실 수 있습니다. 참여하지 않으시거나 중간에 중지하시더라도 어떠한 처벌이 따르거나 귀하께 주어졌던 편익이 박탈되지 않습니다. 저희는 귀하께서 연구참여 의지에 관해 마음을 바꿀 수 있도록 하는 모든 신규 및 변경사항을 알려 드릴 것입니다.

연구 및 연구참여자 권리 관련 의문점이나 문제가 있으시면, 혹은 연구참여의 결과로 상해를 입으시면 마지막에 기재된 전화번호나 이메일로 연락을 부탁드립니다. 연구관련 상해시 발생할 수 있는 비용 지불을 위해 저희가 따로 준비해 둔 내용은 없습니다.

첨부된 설문지에 응답하시는 경우, 이는 귀하께서 여기에 포함된 내용을 읽고 연구에 자발적으로 참여하겠다는 의사를 표현하신 것으로 해석됩니다. 협조해 주셔서 대단히 감사합니다.

담당: 김태형 연구원
(연구실) 02-2149-1105, (핸드폰) 010-6668-2533, (팩스) 02-2149-1120
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서울연구원 The Seoul Institute

응답방법 예시: 아래와 같이 체크(✓)해 주세요.

		매우 그렇지 않다 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 그렇다 [7]
사람들은 ㅇㅇ를 더 많이 마셔야 한다.	커피	✓						
	우유						✓	
	홍차				✓			

I. 귀하께서 동네에 있는 직장, 가게, 여가장소에 가시든 그렇지 않든 상관 없이 아래 설명에 동의하는 정도에 체크해 주세요.

		매우 그렇지 않다 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 그렇다 [7]
(1) 우리 동네에는 ㅇㅇ가 많다.	일자리							
	가게							
	여가장소							
(2) 우리 동네에는 ㅇㅇ가 다양하게 있다.	일자리							
	가게							
	여가장소							
(3) 우리 동네에는 좋은 ㅇㅇ가 있다.	일자리							
	가게							
	여가장소							
(4) 우리 동네에는 특색 있는 ㅇㅇ가 있다.	일자리							
	가게							
	여가장소							

귀하께 일반적인 출근(등교)과 보통의 쇼핑 및 여가 통행을 머리에 그려 주십시오. 그리고 출근(등교), 쇼핑, 여가 통행을 하실 때 아래 항목에 얼마나 만족하고 계시는지 답해 주십시오.

II. 평소 출근(등교) 통행을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 장보기, 자녀를 학원에 데려다 주기)							
(2) 목적지 근처에서 친구·친척을 만나거나, 근처에 있는 명소에 가볼 수 있는 것							
(3) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(4) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(5) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(6) 안락함							
(7) 프라이버시를 지킬 수 있는 것							
(8) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(9) 짐을 나를 수 있는 것							
(10) 통행시 안전에 대해 크게 걱정하지 않아도 되는 것							
(11) 내가 이용하는 교통수단이 남에게 드러나는 것							
(12) 내가 누군지, 어떤 사람인지 나타나는 것							
(13) 내 위신에 맞게 통행할 수 있는 것							
(14) 환경에 도움이 되게 통행하는 것							

(다음장에 계속)

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(15) 가족과 친구들이 기대하는 대로 통행할 수 있는 것							
(16) 자존감을 지킬 수 있는 것: 나는 내 통행방식으로 스스로에게 아쉽고 싶지 않다.							
(17) 단순히 재미삼아 통행할 수 있는 것							
(18) 가는 길을 스스로 정할 수 있는 것							
(19) 새로운 곳을 가볼 수 있는 것							
(20) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							
(21) 집에서 목적지까지 가는 동안의 마음가짐 전환							
(22) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(23) 실내에서 밖으로 나가는 것							
(24) 원하는 대로 자유자재로 이동할 수 있는 것							
(25) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(26) 스포츠처럼 통행할 수 있는 것(예: 카레이싱, 사이클 경주의 느낌)							
(27) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(28) 건강과 건강미를 지키는 것							
(29) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

III. 평소 쇼핑 통행을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 장보기, 자녀를 학원에 데려다 주기)							
(2) 목적지 근처에서 친구·친척을 만나거나, 근처에 있는 명소에 가볼 수 있는 것							
(3) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(4) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(5) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(6) 안락함							
(7) 프라이버시를 지킬 수 있는 것							
(8) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(9) 짐을 나를 수 있는 것							
(10) 통행시 안전에 대해 크게 걱정하지 않아도 되는 것							
(11) 내가 이용하는 교통수단이 남에게 드러나는 것							
(12) 내가 누군지, 어떤 사람인지 나타나는 것							
(13) 내 위신에 맞게 통행할 수 있는 것							
(14) 환경에 도움이 되게 통행하는 것							
(15) 가족과 친구들이 기대하는 대로 통행할 수 있는 것							

(다음장에 계속)

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(16) 자존감을 지킬 수 있는 것: 나는 내 통행방식으로 스스로에게 마쉽고 싶지 않다.							
(17) 단순히 재미삼아 통행할 수 있는 것							
(18) 가는 길을 스스로 정할 수 있는 것							
(19) 새로운 곳을 가볼 수 있는 것							
(20) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							
(21) 집에서 목적지까지 가는 동안의 마음가짐 전환							
(22) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(23) 실내에서 밖으로 나가는 것							
(24) 원하는 대로 자유자재로 이동할 수 있는 것							
(25) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(26) 스포츠처럼 통행할 수 있는 것(예: 카레이싱, 사이클 경주의 느낌)							
(27) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(28) 건강과 건강미를 지키는 것							
(29) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

IV. 평소 여가 통행을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 장보기, 자녀를 학원에 데려다 주기)							
(2) 목적지 근처에서 친구·친척을 만나거나, 근처에 있는 명소에 가볼 수 있는 것							
(3) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(4) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(5) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(6) 안락함							
(7) 프라이버시를 지킬 수 있는 것							
(8) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(9) 짐을 나를 수 있는 것							
(10) 통행시 안전에 대해 크게 걱정하지 않아도 되는 것							
(11) 내가 이용하는 교통수단이 남에게 드러나는 것							
(12) 내가 누군지, 어떤 사람인지 나타나는 것							
(13) 내 위신에 맞게 통행할 수 있는 것							
(14) 환경에 도움이 되게 통행하는 것							
(15) 가족과 친구들이 기대하는 대로 통행할 수 있는 것							

(다음장에 계속)

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(16) 자존감을 지킬 수 있는 것: 나는 내 통행방식으로 스스로에게 마쉽고 싶지 않다.							
(17) 단순히 재미삼아 통행할 수 있는 것							
(18) 가는 길을 스스로 정할 수 있는 것							
(19) 새로운 곳을 가볼 수 있는 것							
(20) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							
(21) 집에서 목적지까지 가는 동안의 마음가짐 전환							
(22) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(23) 실내에서 밖으로 나가는 것							
(24) 원하는 대로 자유자재로 이동할 수 있는 것							
(25) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(26) 스포츠처럼 통행할 수 있는 것(예: 카레이싱, 사이클 경주의 느낌)							
(27) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(28) 건강과 건강미를 지키는 것							
(29) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

다음 질문들은 통계분석의 목적으로만 사용되며, 분석과정에서 서로 섞이게 되므로 귀하의 응답이 절대 드러나지 않습니다.

<u>배경 정보</u>

V. 인구통계

(1) 가구 정보

자신을 포함한 가구원 수 ____________ 명

미취학 아동 수 ____________ 명

자가용 대수(승용차, 승합차만) ____________ 대

※ 택시, 오토바이, 화물트럭, 포크레인 등 특수차량은 포함하지 않습니다.

가구 월소득(세후 소득) ____________ 백만원

(2) 개인 정보

성별 남 ( ) / 여 ( ) 출생년도 1 9 __ __

운전면허증 있음 ( ) / 없음 ( )

근무형태 ( ) 재택근무 ( ) 전업주부

( ) 전일제 직장근무 ( ) 시간제 직장근무

( ) 무직 ( ) 기타 ____________

주소 서울특별시 ________ 구 ________ 동

본 설문은 교통수단 중 자가용(승용차, 승합차), 대중교통(버스, 지하철·전철, 철도), 비동력 교통(보행과 자전거, 그리고 킥보드, 롤러스케이트, 스케이트보드 등)에 대한 태도에 중점을 두고 있습니다. 택시, 오토바이, 화물트럭, 특수차량(포크레인 등)은 대상으로 하지 않습니다. 아래에 귀하께서 지난 한 주 동안(예: 오늘이 화요일이면 지난 주 화요일~어제) 자가용, 대중교통, 비동력 교통수단으로 집에서 시작한 통행횟수를 적어 주십시오.

(예시)

통행 횟수(출발지: 집)

VI. 지난 한 주(7일) 동안 집에서 시작한 통행횟수					
(1) 출근(등교) 횟수(집에서 출발시 보행 1회도 계산)					
자가용		대중교통		비동력 교통	
(2) 쇼핑 통행 횟수(집에서 출발시 보행 1회도 계산)					
자가용		대중교통		비동력 교통	
(3) 여가 통행 횟수(집에서 출발시 보행 1회도 계산)					
자가용		대중교통		비동력 교통	

귀하께서 지난 한 주(7일) 동안 집에서 시작하신 통행 각각에 대해 통행시간이 얼마나 걸렸는지 적어 주십시오.

통행시간(출발지: 집)

기재방법 예시

	통행 소요시간 (시 : 분)	환승?	통행 목적	통행 수단
	1 : 30	( ) 환승 (✓) 목적지	( ) 출근(등교) ( ) 쇼핑 (✓) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 (✓) 비동력 교통 ( ) 기타 ______

VII. 각 통행에 걸린 시간(집에서 출발시 보행 1회도 계산)				
순번	통행 소요시간 (시 : 분)	환승?	통행 목적	통행 수단
1	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
2	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
3	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______

(다음장에 계속)

4	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
5	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
6	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
7	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
8	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
9	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________

(다음장에 계속)

10	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
11	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
12	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________

(지난 한 주 동안 통행횟수가 12 회 이상이면 첨부된 용지를 이용해 기재해 주세요.)

모든 질문이 끝났습니다. 대단히 감사합니다!

설문지를 회수하시는 반장께서 설문 응답의 사례비, 가구당 45,000 원을 전달해 드립니다.
귀하께서는 사례비 수령에 관해 본인 및 가족들의 인적 정보 제공을 요구받지 않습니다.

도시형태가 통행의 효용 및 행태에 미치는 영향 (설문지 최종)

안녕하세요. 서울연구원입니다.

본 연구원은 서울시와 함께 「2012 유동인구조사」와 「서울시 도시교통 종합계획」의 일환으로 연구조사를 실시하고 있습니다. 동 연구조사에 자발적 참여를 부탁드리고자 이 글을 올립니다. 연구의 목적은 시민의 통행 관련 태도와 선호에는 어떤 것들이 있는지, 그리고 그것들의 상대적 강도는 어떠한지 추정하는 데 있습니다. 태도에 관한 전반적인 데이터를 수집함으로써 장기의 포괄적 계획을 세우는 데 기초로 삼으며, 따라서 현재에만 적용되는 트렌드 데이터는 수집하지 않습니다. 저희는 본 연구에서 약 12,000 명에 설문을 받을 예정입니다.

귀하의 응답은 개인정보 보호법 18 조 2 항 4 호(개인정보의 이용·제공 제한)에 의거하여 숫자로만 취급되며 통계법 33 조(비밀의 보호)에 따라 철저히 비밀에 부쳐집니다. 귀하의 개인정보를 비밀로 하기 위해 다음 절차를 따르게 됩니다. 귀하에 관한 데이터는 법에서 정한 바에 따라 비공개로 처리됩니다. 프라이버시 보호를 위해 귀하와 관련된 기록은 이름이나 특정 일련번호가 아니라 무작위 코드로 취급됩니다. 기록은 잠금장치가 있는 서류함에 보관되고, 연구 관련자만 열람할 수 있습니다. 연구결과가 발표, 공개될 때 귀하를 나타낼지도 모르는 이름 및 기타 사실은 결코 드러나지 않습니다. 저희는 집단의 정보에만 관심이 있습니다. 설문결과 보고시에는 통계값만 나타나고 개별 응답자의 개인정보는 아무 것도 포함되지 않습니다. 본 연구가 정당한 방법으로 수행되는지를 확인하기 위해 서울연구원 연구윤리위원회에서 연구기록 감사를 실시할 수 있습니다.

연구에 참여하기로 결정하시는 경우, 반상회 자리에서 반장께서 설문지를 드리게 됩니다. 그러면 귀하는 설문지를 집으로 가져 가시어 다음 사항에 귀하의 판단을 구하는 문항에 답하시게 됩니다: 거주하시는 동네의 현황, 일반적인 통행에서 나타나는 다양한 측면 각각을 중요하게 보시는 정도, 최근의 통행횟수 및 통행시간. 귀하는 설문지 응답을 아무 이유 없이 언제라도 중지하실 수 있으며, 설문을 끝내는 데에는 약 25~30 분 정도가 걸립니다. 연구에 참여하는 데 필요한 시간 외에 귀하께서 들여야 하는 비용은 없습니다. 다음 달 반상회에서 반장께서 귀하 설문지를 회수하시게 됩니다. 응답이 누락되는 경우 해석이 어려우므로 모든 질문에 답해 주시기를 부탁드립니다. 연구 참여에 따라서는 어무 위험이나 불안요인도 알려지거나 예상되지 않습니다. 귀하께서 연구에 참여하심으로써 어떤 식으로든 이득을 얻을 것으로 보이지는 않습니다. <u>설문지는 만 18 세 이상인 가구원 모두가 자필로 작성하도록 합니다. 이후, 반장님을 통해 사례금 45,000 원을 받으시게 됩니다.</u>

본 연구에 참여를 결정하시는 것은 전적으로 귀하 본인의 의사에 따르며, 원하시지 않으면 참여하지 않으셔도 됩니다. 그리고 어떤 이유 없이 아무 때라도 참여를 중단하실 수 있습니다. 참여하지 않으시거나 중간에 중지하시더라도 어떠한 처벌이 따르거나 귀하께 주어졌던 편익이 박탈되지 않습니다. 저희는 귀하께서 연구참여 의지에 관해 마음을 바꿀 수 있도록 하는 모든 신규 및 변경사항을 알려 드릴 것입니다.

연구 및 연구참여자 권리 관련 의문점이나 문제가 있으시면, 혹은 연구참여의 결과로 상해를 입으시면 마지막에 기재된 전화번호나 이메일로 연락을 부탁드립니다. 연구관련 상해시 발생할 수 있는 비용 지불을 위해 저희가 따로 준비해 둔 내용은 없습니다.

첨부된 설문지에 응답하시는 경우, 이는 귀하께서 여기에 포함된 내용을 읽고 연구에 자발적으로 참여하겠다는 의사를 표현하신 것으로 해석됩니다. 협조해 주셔서 대단히 감사합니다.

담당: 김태형 연구원

(연구실) 02-2149-1105, (핸드폰) 010-6668-2533, (팩스) 02-2149-1120

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서울연구원 The Seoul Institute

응답방법 예시: 아래와 같이 체크(✓)해 주세요.

		매우 그렇지 않다 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 그렇다 [7]
사람들은 ○○를 더 많이 마셔야 한다.	커피	✓						
	우유						✓	
	홍차				✓			

I. 귀하께서 동네에 있는 직장, 가게, 여가장소에 가시든 그렇지 않든 상관 없이 아래 설명에 동의하는 정도에 체크해 주세요.

		매우 그렇지 않다 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 그렇다 [7]
(1) 우리 동네에는 ○○가 많다.	일자리							
	가게							
	여가장소							
(2) 우리 동네에는 ○○의 종류가 다양하게 있다. (많든 그렇지 않든)	일자리							
	가게							
	여가장소							
(3) 우리 동네에는 좋은 ○○가 있다.	일자리							
	가게							
	여가장소							
(4) 우리 동네에는 다른 곳에서는 볼 수 없는 특색 있는 ○○가 있다.	일자리							
	가게							
	여가장소							

귀하께 일반적인 출근(등교)과 보통의 쇼핑 및 여가 통행을 머리에 그려 주십시오. 그리고 출근(등교), 쇼핑, 여가 통행을 하실 때 아래 항목에 얼마나 만족하고 계시는지 답해 주십시오.

II. 평소 출근(등교) 통행을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 식사/간식, 장보기, 자녀를 학원에 데려다 주기)							
(2) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(3) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(4) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(5) 쾌적함 또는 안락함							
(6) 프라이버시를 지키는 것(남을 신경쓰지 않아도 되는 것)							
(7) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(8) 통행을 하는 중에 갖는 안전하다는 느낌							
(9) 내가 이용하는 교통수단이 남에게 드러나는 것							
(10) 내가 누군지, 어떤 사람인지 나타나는 것							
(11) 내 뮈신에 맞게 통행할 수 있는 것							
(12) 환경에 도움이 되게 통행하는 것							
(13) 새로운 곳이나 새로운 길을 가볼 수 있는 것							
(14) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							

(다음장에 계속)

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(15) 집에서 목적지까지 가는 동안의 마음가짐 전환(일할 자세 갖기)							
(16) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(17) 실내에서 밖으로 나가는 것							
(18) 원하는 대로 자유자재로 이동할 수 있는 것							
(19) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(20) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(21) 건강과 좋은 신체 조건을 지키는 것							
(22) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

III. 평소 <u>쇼핑 통행</u>을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 식사/간식, 장보기, 자녀를 학원에 데려다 주기)							
(2) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(3) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(4) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(5) 쾌적함 또는 안락함							

(다음장에 계속)

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(6) 프라이버시를 지키는 것(남을 신경쓰지 않아도 되는 것)							
(7) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(8) 통행을 하는 중에 갖는 안전하다는 느낌							
(9) 내가 이용하는 교통수단이 남에게 드러나는 것							
(10) 내가 누군지, 어떤 사람인지 나타나는 것							
(11) 내 위신에 맞게 통행할 수 있는 것							
(12) 환경에 도움이 되게 통행하는 것							
(13) 새로운 곳이나 새로운 길을 가볼 수 있는 것							
(14) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							
(15) 집에서 목적지까지 가는 동안의 마음가짐 전환(쇼핑할 자세 갖기)							
(16) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(17) 실내에서 밖으로 나가는 것							
(18) 원하는 대로 자유자재로 이동할 수 있는 것							
(19) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(20) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(21) 건강과 좋은 신체 조건을 지키는 것							
(22) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

IV. 평소 여가 통행을 하는 데 있어 귀하가 만족하시는 것은?

	매우 불만족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(1) 중간에 다른 볼일을 볼 수 있는 것(예: 식사/간식, 장보기, 자녀를 학원에 데려다 주기)							
(2) 어떤 생각을 하거나 또는 반대로 마음을 비우는 시간을 갖게 되는 것							
(3) 휴식을 취하거나 쪽잠을 잘 수 있는 것							
(4) 유익한 일을 할 수 있는 것(일하기, 얘기하기, 읽기, 듣기 등)							
(5) 쾌적함 또는 안락함							
(6) 프라이버시를 지키는 것(남을 신경쓰지 않아도 되는 것)							
(7) 내가 원하는 곳에, 내가 원할 때 갈 수 있는 것							
(8) 통행을 하는 중에 갖는 안전하다는 느낌							
(9) 내가 이용하는 교통수단이 남에게 드러나는 것							
(10) 내가 누군지, 어떤 사람인지 나타나는 것							
(11) 내 위신에 맞게 통행할 수 있는 것							
(12) 환경에 도움이 되게 통행하는 것							
(13) 새로운 곳이나 새로운 길을 가볼 수 있는 것							
(14) 우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성							
(15) 집에서 목적지까지 가는 동안의 마음가짐 전환(여가 즐길 자세 갖기)							

(다음장에 계속)

	매우 불안족 [1]	[2]	[3]	보통 [4]	[5]	[6]	매우 만족 [7]
(16) 좋은 경치, 기분 좋은 볼거리, 신선한 풍경 …							
(17) 실내에서 밖으로 나가는 것							
(18) 원하는 대로 자유자재로 이동할 수 있는 것							
(19) 독립적으로, 남의 도움을 받지 않고 혼자 돌아다닐 수 있는 것							
(20) 단지 혼자 있고 싶어서 통행할 수 있는 것							
(21) 건강과 좋은 신체 조건을 지키는 것							
(22) 통행을 하면서 마음이 진정되거나 북돋아 지는 것							

다음 질문들은 통계분석의 목적으로만 사용되며, 분석과정에서 서로 섞이게 되므로 귀하의 응답이 절대 드러나지 않습니다.

배경 정보

V. 인구통계

(1) 가구 정보

자신을 포함한 가구원 수 ____________ 명

미취학 아동 수 ____________ 명

자가용 대수(승용차, 승합차만) ____________ 대
※ 택시, 오토바이, 화물트럭, 포크레인 등 특수차량은 포함하지 않습니다.

가구 월소득(세후 소득) ____________ 백만원

(2) 개인 정보

성별 남 (　) / 여 (　)　　출생년도 1 9 __ __

운전면허증 있음 (　) / 없음 (　)

근무형태 (　) 재택근무　(　) 전업주부
(　) 전일제 직장근무　(　) 시간제 직장근무
(　) 무직　(　) 기타 ____________

주소 서울특별시 ________ 구 ________ 동

본 설문은 교통수단 중 자가용(승용차, 승합차), 대중교통(버스, 지하철·전철, 철도), 비동력 교통(보행과 자전거, 그리고 킥보드, 롤러스케이트, 스케이트보드 등)에 대한 태도에 중점을 두고 있습니다. 택시, 오토바이, 화물트럭, 특수차량(포크레인 등)은 대상으로 하지 않습니다. 아래에 귀하께서 지난 한 주 동안(예: 오늘이 화요일이면 지난 주 화요일~어제) 자가용, 대중교통, 비동력 교통수단으로 집에서 시작한 통행횟수를 적어 주십시오.

(예시)

통행 횟수(출발지: 집)

VI. 지난 한 주(7일) 동안 집에서 시작한 통행횟수

(1) 출근(등교) 횟수(집에서 출발시 보행 1회도 계산)

자가용		대중교통		비동력 교통	

(2) 쇼핑 통행 횟수(집에서 출발시 보행 1회도 계산)

자가용		대중교통		비동력 교통	

(3) 여가 통행 횟수(집에서 출발시 보행 1회도 계산)

자가용		대중교통		비동력 교통	

귀하께서 지난 한 주(7일) 동안 집에서 시작하신 통행 각각에 대해 통행시간이 얼마나 걸렸는지 적어 주십시오.

<u>통행시간(출발지: 집)</u>

기재방법 예시

	통행 소요시간 (시 : 분)	환승?	통행 목적	통행 수단
	1 : 30	( ) 환승 (✓) 목적지	( ) 출근(등교) ( ) 쇼핑 (✓) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 (✓) 비동력 교통 ( ) 기타 ______

VII. 각 통행에 걸린 시간(집에서 출발시 보행 1 회도 계산)				
순번	통행 소요시간 (시 : 분)	환승?	통행 목적	통행 수단
1	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
2	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
3	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______

(다음장에 계속)

4	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
5	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
6	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
7	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
8	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______
9	:	( ) 환승 ( ) 목적지	( ) 출근(등교) ( ) 쇼핑 ( ) 여가 ( ) 기타 ______	( ) 자가용 ( ) 대중교통 ( ) 비동력 교통 ( ) 기타 ______

(다음장에 계속)

10	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
11	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________
12	:	(　) 환승 (　) 목적지	(　) 출근(등교) (　) 쇼핑 (　) 여가 (　) 기타 ________	(　) 자가용 (　) 대중교통 (　) 비동력 교통 (　) 기타 ________

(지난 한 주 동안 통행횟수가 12회 이상이면 첨부된 용지를 이용해 기재해 주세요.)

모든 질문이 끝났습니다. 대단히 감사합니다!

설문지를 회수하시는 반장께서 설문 응답의 사례비, 가구당 45,000 원을 전달해 드립니다.
귀하께서는 사례비 수령에 관해 본인 및 가족들의 인적 정보 제공을 요구받지 않습니다.

C.2 English

Updates that were made to the final version of the questionnaire are highlighted in gray.

INTERVIEW PROTOCOL

Interviewee (name and occupation): ______________________________

(Other information will be obtained from his or her answers in the questionnaire draft.)

Interviewer: ___Tae-Hyoung Tommy Gim___

Interview sections used:

______ A. Types of primary benefits

______ B. Types of synergy (on-the-way) benefits

______ C-1. Types of instrumental benefits

______ C-2. Types of symbolic benefits

______ C-3. Types of normative benefits

______ C-4. Types of affective benefits

______ D. Suggestions about the questionnaire

Valuable stories came out of the interview:	Valuable suggestions came out of the interview:

Other topics discussed:

Documents returned:

	Completed interview form
	Responses on the questionnaire draft

Post interview comments or leads:

Introductory Protocol

Thank you very much for agreeing to participate. The information you provide in this interview will be used to (1) to explore motives and desires for travel, that is, why people travel and (2) to identify issues of the draft of the survey questionnaire. Based on your suggestions, we will refine the questionnaire. This is a main part of the 2012 Seoul Pedestrian Survey and its outcomes will be used to set up the Seoul Comprehensive Urban Transportation Plan (2020 and 2030). You have been selected to interview because you were identified as representative of your neighborhood and you can be of the most help in collecting insightful suggestions. Your comments will be treated anonymously. This interview will be likely to take 15 minutes and up to 20 minutes.

Types of Travel Benefits

A. Types of primary benefits

- What do you think are missing? Or, is there anything unlikely in Seoul?
- Probes: Why or why not? Can you tell me your personal experience or experiences from others like family, friends, and colleagues?

B. Types of synergy benefits (on the way to travel destinations)

- What do you think are missing? Or, is there anything unlikely in Seoul?
- Probes: Why or why not? Can you tell me your personal experiences or experiences from others like family, friends, and colleagues?

C-1. Types of instrumental benefits

- What do you think are missing? Or, is there anything unlikely, considering land use and travel conditions in Seoul?
- Probes: Why or why not? Can you tell me your personal experiences or experiences from others like family, friends, and colleagues?

C-2. Types of symbolic benefits

- What do you think are missing? Or, is there anything unlikely in Seoul?
- Probes: Why or why not? Can you tell me your personal experiences or experiences from others like family, friends, and colleagues?

C-3. Types of normative benefits

- What do you think are missing? Or, is there anything unlikely in Seoul?
- Probes: Why or why not? Can you tell me your personal experiences or experiences from others like family, friends, and colleagues?

C-4. Types of affective benefits

- What do you think are missing? Or, is there anything unlikely in Seoul?
- Probes: Why or why not? Can you tell me your personal experiences or experiences from others like family, friends, and colleagues?

D. Probes: retrospective and hypothetical situations

- You mentioned ______ can be added (excluded) from the list. Then, was it possible (impossible) in your previous neighborhoods? If so, why?
- If you assume to live in other neighborhoods that have higher (lower) density, higher (lower) mix of land uses, better (less) connected roads, and more (less) subway stations and bus stops, what would you think about the benefit types you added (excluded)? Would you still do so?

Suggestions about the Questionnaire

Content, words/phrases, items (arrangement and response completeness and time), and format

- What do you think about the questionnaire? Please provide your insights for better designing the questionnaire.

_______ Does it have any questions that are leading (suggesting a particular answer), threatening, biased, value-loaded, or double-barreled?

_______ Does it use easy and accurate words and phrases so that everybody can understand?

_______ Does it explain terms that are difficult to understand or have ambiguous meanings?

_______ Are questions well arranged, so you can easily respond to the next questions? If not, what do you think is an appropriate sequence of the questions?

_______ Do you feel some questions are difficult to answer? If so, why?

_______ How long did it take to answer the questions? Is there any question for which you spent extended time?

_______ Do the style of the response boxes and overall appearance such as the font type and size make this questionnaire clearly legible? If not, can you recommend a better format?

_______ Any other concerns or suggestions?

Post Interview Comments and Observations

The Effects of Urban Form on Travel Utility and Behavior (Self-Administered Interview Form)

Next visit:	Month	Day	Hour : Minute	Interview venue:	

Dear Interviewee,

This is The Seoul Institute. You are being asked to volunteer to participate in the interview for this research study. The study is being conducted as part of the 2012 Seoul Pedestrian Survey and the Seoul Comprehensive Urban Transportation Plan (2020 and 2030) and in coordination with the Seoul Metropolitan Government. The purpose of the study is to estimate the relationship the built environment has with travel utility and behavior. We ultimately expect to enroll about 12,000 people for a survey, and to better design the survey, this interview will recruit about 24 people. Particularly, the interview is conducted (1) as a pilot test of the survey, that is, to explore travel motives and desires according to which people embark on travel and (2) as a pre-test to refine a survey questionnaire enclosed with this interview form.

Your responses will be held in the strictest confidence, as provided in Article 33 of the Statistics Act (Protection of Secrets). Specifically, the following procedures will be followed to keep your personal information confidential in this study. The data collected about you will be kept private to the extent allowed by law. For your privacy, your records will be kept under a randomly assigned code number, not by name or any other identifiers. Your records will be kept in locked files and only study staff will be allowed to access them. Your name and any other fact that might point to you will never appear when results of this study are presented or published. To make sure that this research is being carried out in the proper way, The Seoul Institute Research Ethics Committee may review study records.

If you choose to be an interviewee, you will receive (1) the self-administered interview form and (2) the draft of the survey questionnaire. Between now and the time at which we will visit the place you named above, you will fill out the interview form by adding or deleting travel benefits that are likely or unlikely in Seoul and answer questions to find issues with the questionnaire draft. At the personal interview, we will ask about the travel benefits you added or deleted and the issues you found in the questionnaire. You may discontinue filling out the interview form or questionnaire or you may stop the personal interview at any time and for any reason. The periods of time to be taken to complete the interview form and questionnaire will be about 20 minutes and 25–30 minutes, respectively. The personal interview itself will last about 15–20 minutes. A premium (culture vouchers of 10,000 won) will be awarded after the interview. There are no costs to you, other than your time, for being in the interview of this study. There are no known or anticipated risks or discomforts associated with participation. You are not likely to benefit in any way from joining this study. We hope that what we find will help the Seoul Metropolitan Government and others design better policies and plans by understanding the way people's attitudes and preferences affect travel behavior.

Your participation in this research is entirely voluntary, and you do not have to participate if you do not want to. Also, you may discontinue participation at any time without giving any reason. Refusal to participate or continue participation will involve no penalty or loss of benefits to which you are otherwise entitled. We will provide any new and updated information that may make you change your mind about being in this research.

If you have any questions or concerns about the research and research participants' rights, or if you are injured as a result of being in this research, please contact me at the phone numbers or email addresses given at the end of this letter. No provision has been made for payment of costs associated with any injury resulting from participation in this research study.

If you write in boxes on the top of this letter the time and place for the interview and complete the attached self-administered interview form and questionnaire draft, it means that you have read the information contained in this letter, and would like to be a volunteer in this research study. Thank you very much for your input.

Tae-Hyoung (Tommy) Gim, Investigator
(office) +82-2-2149-1105, (cell) +82-11-6668-2533, (fax) +82-2-2149-1120, (emails) tgim@si.re.kr, taehyoung.gim@gmail.com

희망서울 서울연구원 The Seoul Institute

Research found that people embark on travel using a specific mode of transportation (e.g., automobile, public transit, and walk/bike), because of the following types of motives and desires.

A. Primary travel benefits: utility at travel destinations
B. Secondary travel benefits on the way to the destinations: utility from activities while traveling
C. Secondary travel benefits produced by travel for its own sake: utility based on people's intrinsic travel desire

Below, the three types of the travel benefits (Types A–C) are explained in detail. Please read them carefully, and write in the blank (at the bottom of each list) "what are missing or irrelevant in Seoul."

A. Primary travel benefits: utility at travel destinations
   - A-1. Activities you plan to do at the destinations: working, shopping, enjoying leisure, etc.
   - A-2. Auxiliary activities near the destinations: variety- and novelty-seeking, socializing, going to nearby cultural, aesthetic, and symbolic attractions, etc.

- *What do you think are missing? Or, is there anything unlikely in Seoul? Please write down.*

B. Secondary travel benefits on the way to the destinations: utility from activities while traveling
   - B-1. Anti-activity: relaxing, thinking, napping, etc.
   - B-2. External activities: phone calls; internet surfing or online/offline shopping; private conversation; reading; listening to such content as music, talk shows, CD books, and radio; watching television or videos; and others

- *What do you think are missing? Or, is there anything unlikely in Seoul? Please write down.*

Secondary benefits produced by travel for its own sake (Type C) are further categorized as follows.

C. Secondary travel benefits produced by traveling for its own sake: utility based on people's intrinsic travel desire
  - C-1. Instrumental (safety, convenience, comfort, and privacy)
  - C-2. Symbolic (self-expression, prestige, and power)
  - C-3. Normative (environmental concerns and norms)
  - C-4. Affective (enjoyment of emotions evoked by travel)

Below, each of the four Type C travel benefits (Type C-1 to Type C-4) is explained in detail. Please read them carefully, and write in the blank (at the bottom of each list) "what are missing or irrelevant in Seoul."

C-1. Instrumental benefits: The following benefits may differ by travel mode (e.g., private automobile, public transit, walk, and bike).
  - a. Feeling comfort
  - b. Feeling convenience
  - c. Feeling safety
  - d. Feeling privacy being kept

The modes of road transportation are separated as follows.

Private automobile	• Sedan • Van	• Taxi, motorbike, truck, and special vehicles are NOT considered.	
Public transit	• Bus (commuter/school bus, city bus, intercity bus, express bus, minibus, and shuttle bus) • Subway • Train • Rail (including high speed rail)		
Nonmotorized modes	• Walk • Bike	• Kick scooter • Roller skates	• Skateboard • Etc.

- *As instrumental benefits, what would you add to comfort, convenience, safety, and privacy? Or, is there anything unlikely, considering land use and travel conditions in Seoul? Please write down.*

(Continued on next page)

C-2. Symbolic benefits

a. Expressing a socioeconomic status people favor (e.g., traveling in a luxury car to show off)
b. Expressing a lifestyle people favor (e.g., traveling a lot and traveling to interesting locations)
c. Symbolizing power or prestige

- *What would you add as symbolic benefits? Or, is there anything unlikely in Seoul? Please write down.*

C-3. Normative benefits

a. Environmental concerns: sense of helping the environment
b. Social norms: what significant others (e.g., family and friends) expect
c. Personal norms (internalized social norms): beliefs that increase or decrease self-esteem according to whether a particular behavior is conducted

- *What would you add as normative benefits? Or, is there anything unlikely in Seoul? Please write down.*

(Continued on next page)

C-4. Affective benefits (enjoyment of emotions evoked by travel)

a. Adventure-seeking (novelty-seeking): the mind of "getting there is half the fun"
b. Variety-seeking: changing from a monotonous routine by selecting different routes or locations
c. Curiosity: superfluous and exploratory activity without any particular goal (e.g., idly curious about what happens while traveling and information-gathering or problem-solving for later use)
d. Buffer: transition from the previous activity and place to the next (e.g., from home to work)
e. Amenities (e.g., scenic beauty) on a particular route
f. Exposure to the outdoors: escaping from "cabin fever" by moving through and feeling the environment
g. Controlling the movement in a demand and skillful way
h. Independence: getting around on one's own
i. Conquest: a sense from competitive travel (e.g., auto-racing), a lengthy biking, and navigation through unfamiliar surroundings as well as the conquest of inertia, introversion, and fear
j. Escape: temporary getting out of obligations, routines, and tensions at home or work
k. Physical exercise (e.g., parking or getting off intentionally farther from travel destinations, walking on purpose, and making trips although it could be foregone)
l. Mental therapy: soothing or stimulative quality of travel

- *What would you add as affective benefits? Or, is there anything unlikely in Seoul? Please write down.*

Enclosed with this interview form, please respond to questionnaire items as if you are a survey respondent. At the second visit, I will ask about any confusions or difficulties you had in answering as well as issues with time consumption, format, font, readability, etc. Your input will greatly help to design a better questionnaire.
Your responses on the questionnaire will be coded only as numbers and shown in the form of statistical summaries. They will be held in the strictest confidence.

- *How long did it take to complete the survey?* ______ minutes
- *What do you think about the questionnaire? Please provide suggestions for better designing the questionnaire.*

- *Please mark (✓) if applied.*

_______ Does it have any questions that are leading (suggesting a particular answer), threatening, biased, value-loaded, or double-barreled?

_______ Does it use difficult or inaccurate words and phrases?

_______ Does it not explain terms that are difficult to understand or have ambiguous meanings?

_______ Are questions poorly arranged, so you cannot easily respond to the next questions?

_______ Do you feel some questions are difficult to answer?

_______ Is there any question for which you spent extended time?

_______ Do the style of the response boxes and overall appearance such as the font type and size make this questionnaire less legible?

_______ Do you have any other concerns or suggestions?

Thank you very much for the input!

The Effects of Urban Form on Travel Utility and Behavior (Questionnaire Draft)

Dear Subject,

In coordination with the Seoul Metropolitan Government, The Seoul Institute is conducting a research study as part of the 2012 Seoul Pedestrian Survey and the Seoul Comprehensive Urban Transportation Plan (2020 and 2030). You are being asked to be a volunteer in this research study. The purpose of the study is to estimate the types and relative magnitudes of the attitudes and preferences according to which people embark on travel. We expect to enroll about 12,000 people in this study.

Your responses will be coded only as numbers—as provided in Article 18, Paragraph 2 of the Personal Information Protection Act (Restrictions on Use and Provision of Personal Information)—and held in the strictest confidence—as provided in Article 33 of the Statistics Act (Protection of Secrets). Specifically, the following procedures will be followed to keep your personal information confidential in this study. The data collected about you will be kept private to the extent allowed by the above-stated laws. For your privacy, your records will be kept under a randomly assigned code number, not by name or any other identifiers. Your records will be kept in locked files and only study staff will be allowed to access them. Your name and any other fact that might point to you will never appear when results of this study are presented or published. We are only interested in group information. The reporting of the survey results will only contain statistical summaries and will contain no personal information about individual respondents. To make sure that this research is being carried out in the proper way, The Seoul Institute Research Ethics Committee may review study records.

If you choose to participate in this study, the head of your block will deliver the survey questionnaire at a block meeting. You will then bring it home and answer questionnaire items asking your judgment on the settings of your neighborhood, the importance that you put on each aspect of your usual trips, and the number and duration of the trips you made recently. You may stop answering at any time and for any reason, and to complete all the responses, you will likely spend about 25–30 minutes. There are no costs to you, other than your time, for being in this study. You will return the questionnaire to the block head at the block meeting of the next month. You are recommended to answer all the items because otherwise, your responses may not be correctly interpreted. There are no known or anticipated risks or discomforts associated with participation. You are not likely to benefit in any way from joining this study. We hope that what we find will help the Seoul Metropolitan Government and others design better transportation policies and plans by understanding the way people's attitudes and preferences affect travel behavior. All household members over the age of seventeen are asked to complete the survey. Then, a premium of 45,000 won will be awarded through the block head.

Your participation in this research is entirely voluntary, and you do not have to participate if you do not want to. Also, you may discontinue participation at any time without giving any reason. Refusal to participate or continue participation will involve no penalty or loss of benefits to which you are otherwise entitled. We will provide any new and updated information that may make you change your mind about being in this research.

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If you complete the attached survey, it means that you have read the information contained in this letter, and would like to be a volunteer in this research study. Thank you very much for your input.

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서울연구원
The Seoul Institute

Intro to how to fill out: Please check (✓) as follows.

		Strongly disagree [1]	[2]	[3]	Neither agree nor disagree [4]	[5]	[6]	Strongly agree [7]
People should drink more …	Coffee	✓						
	Milk						✓	
	Tea				✓			

I. Please rate the degree to which you **agree** with each statement, regardless of whether you go there yourself.

		Strongly disagree [1]	[2]	[3]	Neither agree nor disagree [4]	[5]	[6]	Strongly agree [7]
(1) My neighborhood has lots of …	Jobs							
	Stores							
	Leisure places							
(2) My neighborhood has a wide variety of …	Jobs							
	Stores							
	Leisure places							
(3) My neighborhood has high-quality …	Jobs							
	Stores							
	Leisure places							
(4) My neighborhood has unique …	Jobs							
	Stores							
	Leisure places							

Please consider your **typical commute to work and two or three common kinds of shopping travel and leisure travel**. And, for each of the three types of travel, please rate the degree to which you are **satisfied** with the following items. The same questions are given three times for each travel type.

II. In my **typical commute to work,** I am satisfied with …

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., running errands at stores and leaving/collecting children at school)							
(2) Possibility of meeting family and friends or visiting attractions near the travel destination							
(3) A chance of having time to think or clear my head							
(4) A chance of taking a rest or nap							
(5) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(6) Comfort							
(7) Possibility of keeping privacy							
(8) Possibility of traveling where I want, when I want							
(9) Carrying capacity (luggage, purchases, etc.)							
(10)No particular worries about safety while traveling							
(11)Showing off a means of transportation							
(12)Expressing who I am, what I am							
(13)Giving me prestige by the travel							
(14)Helping the environment by managing my travel							
(15)Family and friends' appreciation of my way of traveling							
(16)Self-esteem, I do not want to feel sorry to myself by the way of traveling							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(17)Possibility of traveling just for the fun of it							
(18)Possibility of choosing my own route to a familiar destination							
(19)Possibility of exploring new places							
(20)A chance of meeting nice people or happening to know something							
(21)Transition between home and the destination							
(22)A lovely view, a pleasant encounter, a surprising look							
(23)Getting outdoors							
(24)Possibility of having control over my journey							
(25)Possibility of not being dependent on others for travel							
(26)Possibility of traveling sportily							
(27)Possibility of traveling mainly to be alone							
(28)Keeping health and fitness							
(29)Soothing or stimulative quality of travel							

III. In my **common travel for shopping,** I am satisfied with ...

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., running errands at stores and leaving/collecting children at school)							
(2) Possibility of meeting family and friends or visiting attractions near the travel destination							
(3) A chance of having time to think or clear my head							
(4) A chance of taking a rest or nap							
(5) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(6) Comfort							
(7) Possibility of keeping privacy							
(8) Possibility of traveling where I want, when I want							
(9) Carrying capacity (luggage, purchases, etc.)							
(10)No particular worries about safety while traveling							
(11)Showing off a means of transportation							
(12)Expressing who I am, what I am							
(13)Giving me prestige by the travel							
(14)Helping the environment by managing my travel							
(15)Family and friends' appreciation of my way of traveling							
(16)Self-esteem, I do not want to feel sorry to myself by the way of traveling							
(17)Possibility of traveling just for the fun of it							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(18)Possibility of choosing my own route to a familiar destination							
(19)Possibility of exploring new places							
(20)A chance of meeting nice people or happening to know something							
(21)Transition between home and the destination							
(22)A lovely view, a pleasant encounter, a surprising look							
(23)Getting outdoors							
(24)Possibility of having control over my journey							
(25)Possibility of not being dependent on others for travel							
(26)Possibility of traveling sportily							
(27)Possibility of traveling mainly to be alone							
(28)Keeping health and fitness							
(29)Soothing or stimulative quality of travel							

IV. In my **typical travel to leisure places,** I am satisfied with …

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., running errands at stores and leaving/collecting children at school)							
(2) Possibility of meeting family and friends or visiting attractions near the travel destination							
(3) A chance of having time to think or clear my head							
(4) A chance of taking a rest or nap							
(5) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(6) Comfort							
(7) Possibility of keeping privacy							
(8) Possibility of traveling where I want, when I want							
(9) Carrying capacity (luggage, purchases, etc.)							
(10)No particular worries about safety while traveling							
(11)Showing off a means of transportation							
(12)Expressing who I am, what I am							
(13)Giving me prestige by the travel							
(14)Helping the environment by managing my travel							
(15)Family and friends' appreciation of my way of traveling							
(16)Self-esteem, I do not want to feel sorry to myself by the way of traveling							
(17)Possibility of traveling just for the fun of it							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(18)Possibility of choosing my own route to a familiar destination							
(19)Possibility of exploring new places							
(20)A chance of meeting nice people or happening to know something							
(21)Transition between home and the destination							
(22)A lovely view, a pleasant encounter, a surprising look							
(23)Getting outdoors							
(24)Possibility of having control over my journey							
(25)Possibility of not being dependent on others for travel							
(26)Possibility of traveling sportily							
(27)Possibility of traveling mainly to be alone							
(28)Keeping health and fitness							
(29)Soothing or stimulative quality of travel							

The following questions are only for statistical purposes, and your responses will be shown in the form of statistical summaries.

BACKGROUND INFORMATION

V. Demographics

Household information

(1) Number of household members (including myself) ____________

(2) Number of children under school age ____________

(3) Number of private automobiles (sedans and vans) ____________
(Please do NOT count taxis, motorbikes, trucks, and special vehicles such as forklifts.)

(4) Monthly household income (after tax) ____________ million won

Personal information

(5) Gender male ( ) / female ( ) (6) Birth year 1 9 __ __

(7) Do you have a driver's license? yes ( ) / no ( )

(8) Employment type ( ) telework ( ) homemaker
( ) full-time ( ) part-time
( ) no job ( ) others ____________

(9) Address ____________ district ____________ neighborhood

This survey is particularly interested in attitudes and preferences about **private automobiles** (sedans and vans), **public transit** (buses, subways and trains) and **nonmotorized travel** (walking and biking, and travel by such means as kick scooters, roller skates and skateboards). It does NOT examine attitudes and preferences about taxis, motorbikes, trucks, and special vehicles (such as forklifts).

Below, please write the number of trips you started from home for the last one week or seven days (e.g., if today is Tuesday, from Tuesday of the last week through yesterday), using private automobiles, public transit and nonmotorized travel modes.

(Examples)

TRAVEL BEHAVIOR (DEPARTURE: HOME)

VI. Number of trips started from home for the last one week					
(1) Number **commuting** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	
(2) Number **shopping** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	
(3) Number **leisure** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	

Please provide travel time of each of the trips you started from home for the last one week.

TRIP TIME (DEPARTURE: HOME)

Intro to how to fill out

	Time consumed (hh:mm)	Transfer?	Travel purpose	Travel mode
	00 : 15	(✓) Transfer ( ) Final	( ) Commuting (✓) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit (✓) Nonmotorized mode ( ) Others _________

VII. Time spent for each trip (considering walking from home one trip)				
	Time consumed (hh:mm)	Transfer?	Travel purpose	Travel mode
1	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________
2	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________
3	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________
4	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________
5	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________
6	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others _________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others _________

(Continued on next page)

7	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
8	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
9	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
10	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
11	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
12	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
13	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
14	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
15	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________

(Please use separate sheets provided with this questionnaire, if you made more than 15 trips.)

You answered all questions. Thank you very much!

A premium of 45,000 won will be awarded through the head of your block. You will not be asked to provide any personal information about you or your family.

The Effects of Urban Form on Travel Utility and Behavior (Questionnaire Final)

Dear Subject,

In coordination with the Seoul Metropolitan Government, The Seoul Institute is conducting a research study as part of the 2012 Seoul Pedestrian Survey and the Seoul Comprehensive Urban Transportation Plan (2020 and 2030). You are being asked to be a volunteer in this research study. The purpose of the study is to estimate the types and relative magnitudes of the attitudes and preferences according to which people embark on travel; General data on the attitudes will be collected to provide a basis for building the long-range overarching plan rather than trend data that apply at the present time. We expect to enroll about 12,000 people in this study.

Your responses will be coded only as numbers—as provided in Article 18, Paragraph 2 of the Personal Information Protection Act (Restrictions on Use and Provision of Personal Information)—and held in the strictest confidence—as provided in Article 33 of the Statistics Act (Protection of Secrets). Specifically, the following procedures will be followed to keep your personal information confidential in this study. The data collected about you will be kept private to the extent allowed by the above-stated laws. For your privacy, your records will be kept under a randomly assigned code number, not by name or any other identifiers. Your records will be kept in locked files and only study staff will be allowed to access them. Your name and any other fact that might point to you will never appear when results of this study are presented or published. We are only interested in group information. The reporting of the survey results will only contain statistical summaries and will contain no personal information about individual respondents. To make sure that this research is being carried out in the proper way, The Seoul Institute Research Ethics Committee may review study records.

If you choose to participate in this study, the head of your block will deliver the survey questionnaire at a block meeting. You will then bring it home and answer questionnaire items asking your judgment on the settings of your neighborhood, the importance that you put on each aspect of your usual trips, and the number and duration of the trips you made recently. You may stop answering at any time and for any reason, and to complete all the responses, you will likely spend about 25–30 minutes. There are no costs to you, other than your time, for being in this study. You will return the questionnaire to the block head at the block meeting of the next month. You are recommended to answer all the items because otherwise, your responses may not be correctly interpreted. There are no known or anticipated risks or discomforts associated with participation. You are not likely to benefit in any way from joining this study. We hope that what we find will help the Seoul Metropolitan Government and others design better transportation policies and plans by understanding the way people's attitudes and preferences affect travel behavior. All household members over the age of seventeen are asked to complete the survey. Then, a premium of 45,000 won will be awarded through the block head.

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If you complete the attached survey, it means that you have read the information contained in this letter, and would like to be a volunteer in this research study. Thank you very much for your input.

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Intro to how to fill out: Please check (✓) as follows.

		Strongly disagree [1]	[2]	[3]	Neither agree nor disagree [4]	[5]	[6]	Strongly agree [7]
People should drink more …	Coffee	✓						
	Milk						✓	
	Tea				✓			

I. Please rate the degree to which you **agree** with each statement, regardless of whether you go there yourself.

		Strongly disagree [1]	[2]	[3]	Neither agree nor disagree [4]	[5]	[6]	Strongly agree [7]
(1) My neighborhood has lots of …	Jobs							
	Stores							
	Leisure places							
(2) My neighborhood has a wide variety of … in type (whether dense or not).	Jobs							
	Stores							
	Leisure places							
(3) My neighborhood has high-quality …	Jobs							
	Stores							
	Leisure places							
(4) My neighborhood has unique … that are not found elsewhere.	Jobs							
	Stores							
	Leisure places							

Please consider your **typical commute to work and two or three common kinds of shopping travel and leisure travel**. And, for each of the three types of travel, please rate the degree to which you are **satisfied** with the following items. The same questions are given three times for each travel type.

II. In my **typical commute to work,** I am satisfied with …

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., having meals/snacks, running errands at stores, and leaving/collecting children at school)							
(2) A chance of having time to think or clear my head							
(3) A chance of taking a rest or nap							
(4) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(5) Pleasantness or comfort							
(6) Possibility of keeping privacy (not being bothered by others)							
(7) Possibility of traveling where I want, when I want							
(8) Feeling safe while going to the place of the destination							
(9) Showing off a means of transportation							
(10)Expressing who I am, what I am							
(11)Giving me prestige by the travel							
(12)Helping the environment by managing my travel							
(13)Possibility of exploring new places or new routes							
(14)A chance of meeting nice people or happening to know something							
(15)Transition between home and the destination (and get ready to work)							
(16)A lovely view, a pleasant encounter, a surprising look							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(17)Getting outdoors							
(18)Possibility of having control over my journey							
(19)Possibility of not being dependent on others for travel							
(20)Possibility of traveling mainly to be alone							
(21)Keeping health and good physical condition							
(22)Soothing or stimulative quality of travel							

III. In my **common travel for shopping,** I am satisfied with ...

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., having meals/snacks, running errands at stores, and leaving/collecting children at school)							
(2) A chance of having time to think or clear my head							
(3) A chance of taking a rest or nap							
(4) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(5) Pleasantness or comfort							
(6) Possibility of keeping privacy (not being bothered by others)							
(7) Possibility of traveling where I want, when I want							
(8) Feeling safe while going to the place of the destination							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(9) Showing off a means of transportation							
(10)Expressing who I am, what I am							
(11)Giving me prestige by the travel							
(12)Helping the environment by managing my travel							
(13)Possibility of exploring new places or new routes							
(14)A chance of meeting nice people or happening to know something							
(15)Transition between home and the destination (and get ready to shop)							
(16)A lovely view, a pleasant encounter, a surprising look							
(17)Getting outdoors							
(18)Possibility of having control over my journey							
(19)Possibility of not being dependent on others for travel							
(20)Possibility of traveling mainly to be alone							
(21)Keeping health and good physical condition							
(22)Soothing or stimulative quality of travel							

IV. In my **typical travel to leisure places,** I am satisfied with …

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(1) Possibility of doing something else at stopovers (e.g., having meals/snacks, running errands at stores, and leaving/collecting children at school)							
(2) A chance of having time to think or clear my head							
(3) A chance of taking a rest or nap							
(4) Possibility of doing something useful en route, such as working, talking, reading, and listening							
(5) Pleasantness or comfort							
(6) Possibility of keeping privacy (not being bothered by others)							
(7) Possibility of traveling where I want, when I want							
(8) Feeling safe while going to the place of the destination							
(9) Showing off a means of transportation							
(10) Expressing who I am, what I am							
(11) Giving me prestige by the travel							
(12) Helping the environment by managing my travel							
(13) Possibility of exploring new places or new routes							
(14) A chance of meeting nice people or happening to know something							
(15) Transition between home and the destination (and get ready to enjoy leisure)							
(16) A lovely view, a pleasant encounter, a surprising look							
(17) Getting outdoors							

(Continued on next page)

	Very unsatisfied [1]	[2]	[3]	Neither satisfied nor unsatisfied [4]	[5]	[6]	Very satisfied [7]
(18)Possibility of having control over my journey							
(19)Possibility of not being dependent on others for travel							
(20)Possibility of traveling mainly to be alone							
(21)Keeping health and good physical condition							
(22)Soothing or stimulative quality of travel							

The following questions are only for statistical purposes, and your responses will be shown in the form of statistical summaries.

BACKGROUND INFORMATION

V. Demographics

Household information

(1) Number of household members (including myself) ______________

(2) Number of children under school age ______________

(3) Number of private automobiles (sedans and vans) ______________
(Please do NOT count taxis, motorbikes, trucks, and special vehicles such as forklifts.)

(4) Monthly household income (after tax) ______________ million won

Personal information

(5) Gender male ( ) / female ( ) (6) Birth year 1 9 __ __

(7) Do you have a driver's license? yes ( ) / no ( )

(8) Employment type ( ) telework ( ) homemaker
( ) full-time ( ) part-time
( ) no job ( ) others ______________

(9) Address ______________ district ______________ neighborhood

This survey is particularly interested in attitudes and preferences about **private automobiles** (sedans and vans), **public transit** (buses, subways and trains) and **nonmotorized travel** (walking and biking, and travel by such means as kick scooters, roller skates and skateboards). It does NOT examine attitudes and preferences about taxis, motorbikes, trucks, and special vehicles (such as forklifts).

Below, please write the number of trips you started from home for the last one week or seven days (e.g., if today is Tuesday, from Tuesday of the last week through yesterday), using private automobiles, public transit and nonmotorized travel modes.

(Examples)

TRAVEL BEHAVIOR (DEPARTURE: HOME)

VI. Number of trips started from home for the last one week					
(1) Number **commuting** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	
(2) Number **shopping** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	
(3) Number **leisure** trips (counting walking from home as one trip) by ...					
Private automobile		Public transit		Nonmotorized mode	

Please provide travel time of each of the trips you started from home for the last one week.

TRIP TIME (DEPARTURE: HOME)

Intro to how to fill out

	Time consumed (hh:mm)	Transfer?	Travel purpose	Travel mode
	00 : 15	(✓) Transfer ( ) Final	( ) Commuting (✓) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit (✓) Nonmotorized mode ( ) Others ________

VII. Time spent for each trip (considering walking from home one trip)				
	Time consumed (hh:mm)	Transfer?	Travel purpose	Travel mode
1	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
2	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
3	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
4	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
5	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
6	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________

(Continued on next page)

7	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
8	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
9	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
10	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
11	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
12	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
13	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
14	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________
15	:	( ) Transfer ( ) Final	( ) Commuting ( ) Shopping ( ) Leisure ( ) Others ________	( ) Private automobile ( ) Public transit ( ) Nonmotorized mode ( ) Others ________

(Please use separate sheets provided with this questionnaire, if you made more than 15 trips.)

You answered all questions. Thank you very much!

A premium of 45,000 won will be awarded through the head of your block. You will not be asked to provide any personal information about you or your family.

APPENDIX D:

INTERVIEW OUTCOMES AND NOTES

D.1 Interview Outcomes

D.1.1 Interview Settings

Interviews require human interactions, and this implies that they are affected by similarities and differences between the interviewer and interviewees. The researcher considered that he would be treated as an outsider at interviews because he is not a resident of any of the sampled neighborhoods. Thus, before each interview, the researcher familiarized himself with the current land use and transportation issues of the neighborhoods (for ice breaking), and indeed, this helped him show a sincere interest in the neighborhoods. Secondly, he suspected that he could be alienated by those who are in different age groups (i.e., the age difference as a possible source of the barrier to the interviews in Korean settings). However, the age difference was rather beneficial, in the sense that it made older interviewees to provide a greater deal of information: During probes, particularly when asked about reflective topics, they were willing to share detailed personal stories. Thirdly, the gender difference between the researcher and female interviewees was not found as a barrier to the interviews. Actually, he noticed that the female interviewees tended to give fuller information and appeared to be more natural: They changed their postures and voice tones and made facial expressions more frequently. In contrast, a few male interviewees were succinct as if they were in professional settings. Lastly, the researcher shared several characteristics with interviewees in that he is native

Korean, has spent due time in Seoul, and has Seoul accent in his language. Possibly because of this similarity, most interviewees appeared to feel comfortable in describing negative aspects of the transportation settings in Seoul (e.g., congestion).

Although the researcher's status and role were stated verbally and in a written form, seven interviewees (Interviews 4, 6, 7, 14, 16, 17, and 21) regarded him as if he is a public worker for the Seoul Metropolitan Government or at least, he would have a voice in policy making. Two of them (Interviews 4 and 16) expressed negative impressions on the survey itself because they believed that a more adequate survey is one that directly asks about practical issues (e.g., seeking opinions on what current problems are in respective neighborhoods and what policies and plans should have higher priority in relation to the problems) rather than the current survey with abstract questions. Accordingly, the researcher revised the cover page of the questionnaire to highlight the survey purpose: collecting general data for a research project that would provide a basis for building a long-range overarching plan rather than trend data that apply only to selected neighborhoods at the present time. Meanwhile, because of the fact that the interviews were conducted as part of the research project and by the institution affiliated to the Seoul Metropolitan Government, five interviewees (Interviews 6, 7, 14, 16, and 21) were highly cooperative in the hope that their opinions might be reflected in policies and plans in favor of their neighborhoods.

Notably, whether interviewees were generally unsatisfied with the topic of the survey (Interviews 4 and 16) or highly motivated during the interview (Interviews 6, 7, 14, 16, and 21), their reactions suggest that the contribution of this research is limited to better predicting how people would behave in a certain built environment. In this sense, it cannot have any normative implications about how to manipulate urban forms and/or travel behavior.

Interview venues were chosen by interviewees from one of the following: their homes, coffee shops nearby, and the lobby or conference rooms of the research institution. Interviews lasted an average of 37.3 minutes (σ = 9.3; range = 20.2–53.4). They were longer than the expected 20 minutes (originally calculated based on the researcher's preliminary interviews with eight people in 2010 to develop the dissertation proposal). The interviews were longer partially because every interview began with an ice breaking about the current issues of the particular neighborhood. Other differences between the 2010 interviews and the current ones (i.e., possible sources of the increase in interview lengths) were that current interviewees were given (1) the self-administered interview form and questionnaire draft before the interviews (to allow due time to think about interview topics) and (2) a financial incentive for the interviews. The wide range and high standard deviation can be attributed to cases in which interviewees were more cooperative in sharing personal stories, as stated above. (Regardless of whether the stories were related to the interview topics, the researcher stayed attentive.)

Previous studies (Mokhtarian and Salomon 2001, Mokhtarian, Salomon, and Redmond 2001, Ory and Mokhtarian 2005) suspected that instrumental benefits such as convenience, comfort, privacy, and safety may be prominent for automobile travel rather than for its counterparts such as transit and nonmotorized travel. Thus, this research expected that in relation to the instrumental benefits, interviews would be centered on stories and examples about automobile travel. However, when providing reasons for their responses and answers to probing questions, interviewees had in mind public transit and nonmotorized modes: They described how transit or nonmotorized travel is or is not convenient, safe, and comfortable without regard to their gender, age, and marital and socioeconomic status. Likewise, regarding synergy benefits, the interviewees tended to give examples of on-the-way activities and anti-activities that are expected while traveling in public transit (e.g., knitting, reading a book or newspaper, studying for an exam, hearing the sound of the subway moving on rails, and watching or chatting with friends or strangers).

D.1.2 Pilot Test

The 24 interviewees confirmed the comprehensiveness of the list of the benefits that this research provided in the self-administered interview form. The completeness of the list is important for SEM, because accurately estimating how urban compactness affects travel benefits and behavior requires that all "important" benefit items (in magnitude as well as in statistical significance) be measured. This is particularly important if urban compactness affects these benefits differently by travel mode or purpose. At the same time, missing "minor" items of travel benefits, if any, might not be a serious issue. This research made all concepts (i.e., urban compactness, sociodemographics, travel utility, and travel behavior) factors rather than variables to duly utilize SEM. One major benefit of SEM over path analysis is that by specifying a concept as a factor with multiple indicator variables that are accompanied by error terms, it controls for measurement error for the concept. Accordingly, it relaxes the implausible assumption that the concept is measured without error, a limitation of path analysis, and uses the remaining covariance for parameter estimation. (Another well-known benefit is "measurement by triangulation". Because a concept is defined by a factor, that is, by a multiple number of indicator variables, various dimensions of the concept can be considered in its measurement.)

In regard suggestions to remove benefit items from the list, few such suggestions were made. However, most suggestions of the interviewees were associated not with the exclusion, but with the incorporation of similar or redundant items. This research excluded or transformed an item if more than 15% of the interviewees (i.e., at least four) recommended so and if it was confirmed at a group meeting with six experts at The Seoul Institute.

Overall, travel benefits recommended for exclusion were those that are more plausible in areas with less traffic volumes. Among them, this research finally removed one item, conquest, because as expected, interviewees suspected the conquest desire, which encourages competitive forms of travel, is insignificant or at the very least, its magnitude may be negligible in Seoul due to its congestion. This research considered that it can be safely removed because as discussed in “2.2.1 Derived versus Intrinsic Utility of Travel: Approaches to Positive Utility of Travel”, it overlaps with four other affective benefits: independence, control, curiosity, and mental therapy. According to the interviewees, other affective benefits are also related to the conquest desire, including physical exercise, variety-seeking (destinations and routes), and exposure to outdoors.

Seven other items were recommended to be removed, but this research kept them. Interviewee 10 suggested that all of the four items of on-the-way benefits (i.e., anti-activity—relaxation, anti-activity—thinking, external activities—while traveling, and external activities—at stopovers) and the mental therapy item may be insignificant (i.e., potential for the exclusion). In addition, the item of environmental concerns was recommended to be removed by Interview 16 and the convenience item by Interview 16. However, these recommendations were given only once by the very interviewees and a group meeting at The Seoul Institute concluded that they are significant benefits expected in Seoul. Thus, the items were kept in the final form of the questionnaire.

Regarding the transformation of travel benefit items, this research combined seven items with other analogous items or with each other: (1) potential for auxiliary activities, (2) carrying capacity, (3) social norms, (4) personal norms, (5) adventure for fun, (6) variety-seeking—routes, and (7) variety-seeking—destinations.

- The item of “potential for auxiliary activities near the destination” (in the questionnaire, “Possibility of meeting family and friends or visiting attractions near the travel destination”) was combined with the item of “external activities—at stopovers”, in the sense that places near the destination are stopovers anyway. Thus, the final questionnaire used the following item: potential for auxiliary activities at stopovers or near the destination.
- As an instrumental benefit, carrying capacity [in the questionnaire, “Carrying capacity (luggage, purchases, etc.)”], was incorporated to another instrumental benefit, convenience, since carrying capacity is part of and contributes to the convenience benefit.
- Two normative benefit items, social norms (in the questionnaire, “Family and friends’ appreciation of my way of traveling”) and personal norms (“Self-esteem, I do not want to feel sorry to myself by the way of traveling”) were considered to be inherently symbolic benefits and combined with two symbolic benefit items:

lifestyle expression ("Expressing who I am, what I am") and prestige symbolization ("Giving me prestige by the travel").

- Among affective benefit items, firstly, adventure-seeking was filtered out because if "getting there is half the fun", it encompasses other affective benefits, that is, because the item is equivalent to the affective benefit factor per se and duplicative of the other, more detailed affective benefits listed. Secondly, the survey originally attempted to measure the variety-seeking item with two questions, the possibility of changing destinations (variety-seeking—destinations) and that of changing routes (variety-seeking—routes), but according to interviewees' suggestions, they were combined into one: variety-seeking (in the questionnaire, "Possibility of exploring new places or new routes").

One suggestion for the item transformation was not accepted. Specifically, three interviewees (Interviews 12, 13, and 18) considered that the physical exercise item and the mental therapy item can be combined. However, the former (physical exercise) may be a sufficient condition for the latter (mental therapy), but it is not a necessary condition.

- Interview 12: "… many people are riding it (the bike) on weekend partly for exercise and partly for play."
- Interview 13: "… I walk on purpose if the distance is short. This is aerobic exercise and it also lets me refresh myself."
- Interview 18: "When I get some sun (by taking a walk), I sleep well at night. Taking a walk, I meet and chat with various people, and I can take my mind off depression."

Lastly, two interviewees (Interviews 16 and 23) regarded the similarity of some items as an issue although they could not specify them. Presumably, the update of the seven items was enough to address the issue.

In conclusion, out of a total of 29 secondary benefit items, 7 items were either excluded or incorporated into others. Along with the remaining 22 secondary benefit items (= 29 − 7), the final questionnaire retained all of the 4 primary benefit items. Thus, the questionnaire comprised three sets of 26 psychometric items (= 4 primary benefits + 22 secondary benefits), and items about the respondent's sociodemographics and trip frequencies and durations.

D.1.3 Preliminary Test

As a preliminary test, the purpose of the interviews was to identify issues with the survey questionnaire so that they can be addressed before the full-scale survey. Overall, out of a total of 24 interviewees, 6 people or 25.00% (Interviews 1, 2, 6, 7, 18, and 21) accepted the questionnaire as is, but the other 18 interviewees provided one or two inputs.

D.1.3.1 Issue of abstract questions

Presumably, the survey was not easy and clear enough for a variety of people to answer, in light of a large variation in time needed to complete the survey, although the mean was as expected (mean = 16.4 minutes; S.D. = 10.7; range = 5–35).[67]

[67] The time consumed for survey completion was asked as an open-ended question in the self-administered interview form. Meanwhile, one interviewee (Interview 20) answered that the time was 30–40 minutes and this research used its mean (i.e., 35 minutes) to calculate the overall mean, standard deviation, and range.

The issue of the survey abstractness was directly raised by four interviewees (Interviews 4, 16, 19, and 23). Firstly, as stated in "D.1.1 Interview Settings", two of the interviewees (Interviews 4 and 16) considered that such an abstract survey would not be useful in practice; then, people may not be willing to participate in the survey. Thus, to encourage participation in the full-scale survey, this research revised the cover page by highlighting how the survey contributes: providing a basis for the development of a long-term overarching urban transportation plan.

Secondly, the other two interviewees (Interviews 19 and 23) suspected that because of the abstractness, it is taken an extended time for survey completion. This issue was addressed, using two approaches: by employing adequate survey methods and by clarifying terms used in the questionnaire. (1) Acknowledging the respondent's effort and time, this research employed a hand-delivered survey method, in the sense that compared to face-to-face, phone, on-line, and street surveys, this method provides respondents with due time for survey completion. Also, to encourage survey participation, it arranged regular reminders and financial incentives. (2) In addition, based on a suggestion of Interview 19, this research revised survey items by using clearer and fuller terms that are accessible to a wider public.

In fact, eight others (Interviews 8, 9, 10, 11, 17, 20, 22, and 24) pointed out one to three items that were unclear. Subsequently, the researcher asked them about alternatives to the original items (i.e., probing) and made revisions according to their recommendations. Revised items were three sets of the following eight benefit items: buffer, comfort, privacy, physical exercise, safety, and three of the four primary benefit items, specifically, destination density, variety, and uniqueness. [In contrast to these eight interviewees who asked to describe the meaning of the items in more detail—by using a fuller form of description or by adding qualifiers—one interviewee (Interview 3) stated that sometimes “items are a bit lengthy”. However, he subsequently said that overall, the length is appropriate. One interviewee (Interview 20) considered that although not unclear, the item of external activities—at stopovers should carry “having meals or snacks” as another example. Thus, the given example was added to the current list of examples.]

Regarding the buffer item, one person (Interview 11) asked to provide the meaning of “transition between home and the destination”, and this research added to the item “(and get ready to work/shop/enjoy leisure)”.

Four interviewees (Interview 8, 9, 17, and 24) considered that the expression of the comfort item should be revised and among them, two (Interview 9 and 17) identified the same issue with the privacy item. Another interviewee (Interview 11) also thought the privacy item as one of two that should be revised.[68] For the comfort item, this research updated the expression “Comfort” to “Pleasantness or comfort” as suggested by Interview 8. Also, for the privacy item, it changed the expression “Possibility of keeping privacy” to “Possibility of keeping privacy (not being bothered by others)” because Interview 17 recommended describing its meaning.

One interviewee (Interview 20) raised the same issue of the unclear expression concerning the safety item, “No particular worries about safety while traveling”, and

[68] The other benefit the interviewee (i.e., Interview 11) asked to revise was carrying capacity. As discussed above, this research incorporated it into the convenience benefit due to their similarity in meaning (i.e., carrying capacity is an element of the convenience benefit).

suggested a more direct—not twisted—description. As recommended, it was updated to "Feeling safe while going to the place of the destination".

Another interviewee (Interview 10) considered that while the physical exercise item was given in the questionnaire as "Keeping health and fitness", the meaning of fitness was unclear. She asked to describe its meaning or to use a lay term, and this research changed "fitness" to "good physical condition".

The same interviewee (Interview 10) and another (Interview 22) found issues with primary benefit items. The former considered that destination density and destination variety are similar in meaning, and to differentiate them, this research added to the expression of the destination variety item "(whether dense or not)". The latter interviewee indicated that destination variety is interchangeable with or contributes to destination uniqueness and suggested adding qualifiers to separate the two items. Accordingly, each of their expressions was updated as follows: "a wide variety of … *in type*" and "unique … *that are not found elsewhere*" (additions are in italic).

Lastly, two others (Interviews 16 and 23) stated that some items are considerably similar, but could not indicate which items should be combined. The above transformations would suffice in serving their requests.

D.1.3.2 Issue of too many questions

Some interviewees raised concerns not that items were too abstract, but that they were too many items (Interviews 5, 13, and 14). As discussed in "D.1.2 Pilot Test", this research determined to exclude the conquest item (= 3 items for the three purposes of travel) and to combine six items with others (= a total of 18 items). That is, respondents in the full-scale survey would save answering to 21 questions in total (= 7 items * 3 purposes of travel). Also, while this research arranged the hand-delivered survey method, regular reminders, and financial incentives to respond to the issue of the item abstractness, these tools basically aim at encouraging survey participation and completion. Thus, they would also be beneficial in encouraging participation in the lengthy survey.

D.1.3.3 Other Issues

After a confirmation from a group meeting at The Seoul Institute, this research determined not to reflect some suggestions: a total of five inputs provided by four interviewees (one by each of Interviews 12, 13, and 14; two by Interview 15).

Interview 13 suggested that among travel purposes, commuting does not allow "exploring new places", and the interviewee recommended excluding the item of variety-seeking—destinations. Actually, a unique feature of the survey was to ask the same item (i.e., one benefit) three times for three different purposes of travel (as opposed to previous studies that used one item only once). Furthermore, even the interviewee responded to the very item anyhow and the response was as expected, that is, she was "very unsatisfied" with the "Possibility of exploring new places" for commuting travel. Thus, this research determined to ask the item for commuting travel.

One interviewee (Interview 15) suspected that answers to the same item would be similar for all travel purposes. If so, surveys using one question only once will be more efficient since they can considerably reduce the length of the questionnaire. However, answers that other interviewees gave in the questionnaire draft differed according to travel purposes and his suspicion may not apply to a large proportion of the population.

Three interviewees suggested changing the format of the survey. First, the above interviewee (Interview 15) recommended increasing the period for which respondents would provide their travel information (i.e., trip frequencies and durations; currently, seven days). However, extending the period may increase response bias. In particular, while this research examines three modes of travel together, it is harder to provide detailed information on nonmotorized travel than automobile and transit travel, so the bias is likely to make nonmotorized travel misestimated. Thus, this research kept the period as seven days.

Second, another interviewee (Interview 12) suspected that changing response options to “yes” and “no” would considerably shorten the response time because giving answers to yes/no questions are much easier. However, psychometrics is a measurement based on a rating-scale, and travel behavior studies based on psychometrics (e.g., Gim 2011b, Handy, Cao, and Mokhtarian 2005, Kitamura, Mokhtarian, and Laidet 1997, Sohn and Yun 2009, Van Exel, de Graaf, and Rietveld 2011) consistently employed a 5-point or 7-point scale and reported its feasibility (for examples in the literature, see “APPENDIX B”). Besides, SEM, the main analytical technique of this research, is based on continuous variables, not dichotomous variables. Accordingly, this research kept using the Likert-type rating scale.

Last, one interviewee (Interview 14) recommended designing different questionnaires by age group, in the sense that answers to the same item would differ by age. For example, if a neighborhood is filled with leisure options for senior citizens, younger respondents may consider that density of leisure facilities is low. Based on SEM, however, this research statistically controls for all sociodemographic variables, including age.

D.2 Interview Notes: Korean

This section shows a total of 24 interview notes in chronological order, that is, according to the date and time of the interviews.

인터뷰 1: AA (1) (종로구 창신2동)

성명: ○○○(직업: 공인중개사)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 4	차량(대): 2	구성원(명): 3
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 6

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
비용, 도구적 편익	여기 한동안 빌라가 많이 생기면서 방업소 나가는 아가씨들이 몇 백 명씩 살곤 했는데, 화장품가게 주인이 아가씨들한테 마스카라만 팔아도 살 수 있고, 임대료를 내기에 충분했던 시절이 있었어. 지금은 집세가 올라 싹 빠져나갔어. 다른 동으로. 빌라들을 많이 지었으니까. 3~4년 됐어. 서울은 살기 어려우니까 지방으로도 가고. 안전사고가 있었어. 여름에 창문 통해서 낮에 옷 집어서 훔쳐가고 하는 좀도둑도 있었어. 뭐, 사람 사는 데는 다 똑같지만.	도시압축성변수 중 밀도가 개인의 인구통계변수와 상호작용하여 안전과 관계를 가질 수 있다는 점을 암시하고 있다. 하지만 범죄관련 안전을 의미하는 것이며, 교통안전과 직결되는 것은 아니다.	
도구적 편익	환경 생각해서 차 안 타고 일부러 자전거 타는 사람들이 늘어나나봐. 매연 생각해서. (자전거 통행을 진작시키기 위해) 정부에서도 자전거 도로 늘리고 그러잖아. 회사에도 (사원들이 자전거로 통근하는 것을) 좋아하고.	응답자는 환경친화성이 교통수단의 기계적 특성에 달려 있다고 가정한다. 즉, 환경관심 변수를 도구적 편익의 차원에서 바라보고 있다.	도구적 편익(요인) —> 환경관심

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 2: AB (1) (중구 신당3동)

성명: ○○○(직업: 전업주부, 남편은 개업의)				
행정동	(1) 유형: 고암축 / 비계획 / 뉴타운 / 저암축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 8	차량(대): 3	구성원(명): 4
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 5

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	저는 가족, 형제들과 이동할 땐 버스나 택시 대신 자가용을 이용해요. 친근함, 정서적 유대감을 느낄 수 있거든요. 형제들이 다 서울에 사는데 잠실, 개포, 상암, 이렇게 가까이 살아서 자주 만나요.	통행중 편익의 유의성을 인정하며 이러한 편익이 수단선택에 영향을 미친다는 점을 밝힌다.	
도구적 편익	옛날에 프로판가스, LPG가스 쓸 때는 보도에 통이 있어서 불편했는데 지금은 도시가스라 좋아요.	도로상황은 주요 분석대상이 아니다.	
	이 동네는 옛날에는 일반 밀집주택이 많아서 한집에 4가구, 7가구 이렇게 살았었는데 이동인구가 늘면서 빌라가 많이 생겨서 지금은 10가구 사는 집도 있고 그래서 안전사고가 많이 생겨요. 저녁 어스름 때 좀도둑도 좀 있어요. 도시가스 배관을 타고 세 집을 털었던 좀도둑도 있었어요. 여름에 문이 열린 집만 골라서 애들만 있고 그런 집을 골라 들락날락 하는 케이스도 있고요.	밀도가 안전문제를 증가시킬 수 있음을 보여주지만 특별히 교통안전에 영향을 미치는 것은 아니다.	

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 3: BA (1) (중구 신당1동)

성명: ○○○(직업: 사무직 프리랜서)				
행정동	(1) 유형: 고밀축 / 비계획 / 뉴타운 / 저밀축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 2	차량(대): 1	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 4

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
일차 편익	미리 의도하지는 않았지만 목적지에서 새롭게 발견해서 하는 활동도 넣을 수 있습니다.	이미 설문지에 고려되어 있다.	
통행중 편익	부수적인 일이 아니라 업무처럼 미리 계획한 일도 넣을 수 있습니다.	상동	
도구적 편익	(정서적 편익이 아니라) 도구적 편익에 건강이 포함되는 것 같습니다: 건강 및 보건, 그리고 마음의 힐링 같은 재충전 요소요.	"신체 운동"과 "정신적 치유"는 원래 정서적 편익으로 판단하였으나 인터뷰 응답자는 도구적 편익으로 본다.	도구적 편익(요인) --> 신체 운동 도구적 편익(요인) --> 정신적 치유
상징적 편익	개성적 요소에 대한 표현 또는 자기만족을 넣을 수 있습니다.	이미 설문지에 반영되어 있다.	
	사람을 만나는 것, 사회에 소속되기와 같은 사회적 욕구를 추가할 수 있습니다.	상동	
정서적 편익	학습적 욕구를 넣을 수 있습니다. 새로운 공간 및 요소에 대한 의식적이거나 무의식적인 정보 습득 욕구 같은 거요.	상동	

설문지

인터뷰 발췌	노트
문항 중에 길이가 약간 길게 느껴지는 부분이 있습니다만 전체적으로는 (길이에) 만족합니다.	

인터뷰 4: BB (1) (종로구 삼청동)

성명: ○○○(직업: 웹디자이너)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / <u>저압축</u>			
	(2) 중심까지 거리(마일): <u>≤ 1.7</u> / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 3	차량(대): 0	구성원(명): 2
	(2) 개인	성별: <u>남</u> / 여	결혼: <u>기혼</u> / 독신	연령대(10세): 3

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	교통수단에 따라 걸어야 하는 거리가 달라지고, 또 자리에 앉을 수 있는 기회도 어떤 교통수단을 이용하느냐에 따라 달라지니까, "신체 운동"은 도구적 편익일 것 같습니다.	"신체 운동"을 정서적 편익이 아닌 도구적 편익으로 간주하고 있다.	도구적 편익(요인) --> 신체 운동

설문지

인터뷰 발췌	노트
이론적으로 (설문) 의도는 알겠는데 항목들이 실생활 적용이 안 됩니다. 추상적인 거는 한 다섯 가지 정도 물어보고 "어떠어떠한 여가시설이 있었으면 좋겠느냐", "여기 (이 동네)에는 어떠한 일자리가 있으면 좋겠느냐"같은 것을 물어 봤으면 좋겠습니다.	커버레터에 설문이 기여하는 바를 분명히 한다(정책개발의 기초 제공).

인터뷰 5: AA (2) (마포구 염리동)

성명: ○○○(직업: 전업주부)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 4	차량(대): 1	구성원(명): 3
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
비용, 도구적 편익, 정서적 편익	애기 엄마들은 기본적으로 환경도 생각하고 있지만 아이들 때문에 애들 학교 데려다 줄 때나 이동할 때는 자가용이 불편해서 자전거를 타세요. 일방통행 도로도 많고, 학교 앞 같은 경우는 주정차 금지니까 좁은 길도 빨리빨리 갈 수 있는 자전거를 선호하세요. 아이들 학교 데려다 주고 도서관에 책 읽어 주러 다녀야 되고 시장도 보고 학원도 보내야 되고 집안일도 해야 되고 너무 많은 일을 빠른 시간 내에 처리해야 하니까 이동이 편리한 자전거를 이용하세요. 특별히 환경을 생각해서 자전거를 타지는 않아요. 자전거가 시간도 절약되고 편리하고 좁은 길도 자유자재로 빨리 다닐 수 있으니까 선호하세요. 거창한 환경보다는 편의성 때문에요. 자전거 이용. 환경? 좋긴 하죠. 매연 덜 나오고요.	첫째, 응답자는 환경관심 항목 관련 편익의 가치를 낮게 평가하며, 질문하지 않아도 무방한 것으로 본다. 둘째, 응답자는 교통체증 상황에서 자가용 대비 자전거의 편리성을 강조한다. 시간 절약과 관련하여 응답자의 진술은 단거리 통행에서 자전거 통행의 비용이 자동차 통행보다 더 낮을 수 있음을 보여준다.	
도구적 편익	우리 동네는 … 자전거로 아이들을 태우고 다니는 엄마들이 유난히 많으세요. 자전거에 애들 앉는 바구니를 두 개씩 만들어서 두 명씩 태우고 다니는 엄마들도 쉽게 볼 수 있어요. 한 명 태우고 다니는 엄마들도 많고요.	응답자에 따르면 압축적 도시형태가 자전거의 수용력(carrying capacity)을 늘리거나 또는 기존 수용력을 보다 잘 이용할 수 있게 하는 것으로 볼 수 있다. 이는 본 연구에서 주장하는 바를 예증하는 것이다: 압축적 도시형태가 자동차 대안수단의 통행관련 효용을 증가시킨다. (한편, 설문지 최종 포맷에서 수용력 항목은 편의성 항목과 결합된다.)	
	걷는 것 보다는 힘이 덜 든다고 (엄마들이) 자전거로 애들 학교 태워다 주는데, 자전거 탈 상황이 아닐 때는 자동차가 아니라 걸어서 다닌다고 하세요. 자동차가 더 불편하니까요.	압축적 도시형태를 보이는 장소에서는 편리성이 자전거, 보행, 자가용 순으로 높다고 언급하고 있다. 이는 자동차가 가장 편리하다는 일반적인 믿음과는 상반된(그리고 본고의 주장을 뒷받침하는) 진술이다.	

상징적 편익	강남 대치동 엄마들은 과시욕이 많아서 자전거보다는 차를 많이 이용하시고 우리 동네 엄마들은 조금 더 서민들이라서 그런지 모르겠지만 자전거를 이용하시는 분이 많으세요.	상징적 편익이 개인의 사회경제적 수준에 따라 달라질 수 있음을 보여준다.

설문지

인터뷰 발췌	노트
요즘 학부형들은 가정통신문도 한 장짜리를 선호해요. 긴 걸 싫어해요. 왜냐하면 모두들 바쁘게 사니까요. 설문은 짧은 게 좋아요. 사람들이 일단 설문자체를 싫어하고요. 또, 자기 시간 소비해야하고 해서요.	서울에서 기대되지 않는 항목을 제외하고 유사항목들을 합친다. 또한, 충분한 응답시간을 제공하고 응답률을 높이기 위해 배포조사, 정기적 리마인더, 금전적 인센티브를 설계한다.

인터뷰 6: AB (2) (용산구 보광동)

성명: ○○○(직업: 제약회사 사무직)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 7	차량(대): 1	구성원(명): 4
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	전 버스나 지하철에 앉아서 다른 분들 패션이나 화장을 보게 돼요. 봄이 오면 여성 옷차림부터 달라진다고 하잖아요. 어떤 스타일, 어떤 컬러가 유행할지 알 수 있어요.	"정보 호기심"이 유의한 편익임을 인정한다.	
도구적 편익	(잦은 보수공사가 이뤄진) 보도블록 건, 안타깝죠. 세금낭비에요. 사실, 고르게 공사하는 마인드가 없어요. 몇 개월 지나면 푹 빠져버려요. 힐 신고 다니는 여성들 안전사고 우려가 있어요. 우레탄이나 변하지 않는 걸 썼으면 좋겠어요.	도로상황은 주요 분석대상이 아니다.	

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 7: BA (2) (서대문구 북아현동)

성명: ○○○(직업: 커피숍 운영)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 6	차량(대): 2	구성원(명): 3
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	우리 동네는 도로가 잘되어 있어요. 신림동은 엄마들이 자전거를 많이 안타고 다니는데 여기는 도로사정이 좋아서 자전거 바구니에 애기들을 하나, 둘씩 태우고 다니세요.	"편리성"과 관련하여 압축적 도시형태가 비동력교통의 도구적 편익을 늘려주고 있음을 언급하고 있다.	
	그런데 자전거 보관장소가 많이 없어요. 그래서 너무 아무데나 자전거를 묶어 놓으니까 통행에 지장이 있어요. 보도 난간에 묶어 놓기도 하고 나무에 묶어 놓는 경우도 있고 해서 미관상도 안 좋고 도로가 좁아져서 불편해요. 특히 고등학교 앞쪽은 학교 안에 자전거 보관장소가 없어서 학교 아이들이 (학교 앞) 난간에 묶어 놓을 수밖에 없어요.	인프라 구축의 필요성을 주장하지만 이 진술이 내포하는 바는 인프라 미비가 자전거 이용에 영향을 미치지 않을 것(즉, 인프라 미비에도 자전거를 이용한다)이라는 점이다.	

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 8: BB (2) (용산구 한남동)

성명: ○○○(직업: 고등학교 교사)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 3	차량(대): 1	구성원(명): 2
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 5

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	효용은 쇼핑이나 여가 활동시에만 가능한 것이고요, 출근을 위해 통행을 한다면 빠른 이동이 가장 중요한 거겠죠. 퇴근시 효용이라면 먹을거리, 즐길거리 정보 같은 걸 얻는 게 있겠네요. 그리고 부수적인 활동은 요즘에는 스마트폰으로 하는 게 거의 다인 것 같아요.	쇼핑 및 여가목적의 통행에 비해 통근목적인 경우 통행중 편익이 상대적으로 작다는 점을 강조하고 있다.	
상징적 편익	교통 혼잡을 생각해서나 타인을 배려해서 자가용이 있지만 대중교통 이용하면서 본보기가 되는 걸 들 수 있어요.	"라이프스타일 표현" 관련 편익의 유의성을 예로 보여주고 있다.	

설문지

인터뷰 발췌	노트
교통수단으로 "안락함"까지 바라는 건 너무 호사 아닐는지 모르겠어요. "쾌적함"이 더 나은 표현 같아요. 대중교통 중에 고속버스, KTX, 비행기 같은 것들은 더 쾌적하잖아요?	표현을 "쾌적함 또는 안락함"으로 수정한다.

인터뷰 9: AA (3) (강북구 송천동)

성명: ○○○(직업: 보습학원 언어영역 강사, 결혼 9개월차)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 5	차량(대): 0	구성원(명): 2
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	완벽하게 "원하는 대로 자유자재로 움직이기"는 걸을 때만 가능한 것 아닌가요? 버스나 지하철을 타면 노선을 따라 갈 수밖에 없잖아요. 자동차는 좀 가능하겠지만… 그래도, 차는 좁은 길이나 차도가 없으면 못 가는 거고, 그리고 주차장이 없으면 근처에 갈 수가 없잖아요. 자전거도 댈 곳이 없으면 어려운 거네요. 그러니까 이건 걸을 때만 가능한 도구적 편익인 것 같이 보이는데요.	"제어"가 정서적 편익이 아닌 도구적 편익일 수 있음을 언급하고 있다.	도구적 편익(요인) --> 제어
	환경보호도 도구적 편익인 것 같아요. 환경보호를 하려면 자동차 안타기, 이동할 때 되도록 대중교통 이용하기가 돼야 하니까요.	응답자는 환경관심이 정서적 편익이 아닌 도구적 편익으로 간주되어야 한다고 주장한다.	도구적 편익(요인) --> 환경관심

설문지

인터뷰 발췌	노트
보통 (설문지에는) 질문자의 의도 먼저, 뒷부분에 "그렇다, 그렇지 않다"(라는 문장으로) 되는데요. 질문하는 부분이 단답형으로 나와 있는 것은 처음 봤습니다. "안락함"이라고만 달랑 있으니까 무슨 뜻인지 모르겠습니다. "프라이버시"도 설문 자체가 뭘 원하는지를 모르겠습니다. 질문하는 부분이 좀 더 자세하게 서술형으로 나와 있으면 의도를 파악하는 게 좀 더 쉬울 것 같습니다.	"안락함"을 "쾌적함 또는 안락함"으로, "프라이버시"를 "프라이버시(남을 신경 쓰지 않아도 되는 것)"로 수정한다.

인터뷰 10: AB (3) (마포구 망원동)

성명: ○○○(직업: 대학생)				
행정동	(1) 유형: 고압축 / <u>비계획</u> / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / <u>≤ 5.1</u> / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 4	차량(대): 1	구성원(명): 3
	(2) 개인	성별: 남 / <u>여</u>	결혼: 기혼 / <u>독신</u>	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	"시간단축"이 중요하기 때문에 이런 걸 즐길 시간이 없을 것 같아요.	만약 이 의견이 본조사에서 응답자의 상당수가 동의하는 것이라면, SEM에서 통행중 편익이 유의하지 않게 도출될 것이다.	
정서적 편익	"자유로움", "사색 즐기기"를 추가해야 해요.	본 연구는 "사색"을 통행중 편익으로 판단하였으나 인터뷰 응답자는 정서적 편익으로 본다.	정서적 편익(요인) —> 비활동—사색
	"정신적 치유"는 서울의 복잡한 교통 환경, 많은 유동인구 등을 고려할 때, 이런 기능은 적어요.	응답자에 따르면 이 변수가 SEM에서 유의하지 않게 도출될 수도 있다.	

설문지

인터뷰 발췌	노트
"○○가 많다"랑 "○○가 다양하다"는 의미 중복 가능성이 있어요. … 시설이 다양해지면 수도 많아지는 것이고, 그리고 보통 많아지면 다양성도 높아지지는 것 아닌가요? … "많다"랑 "다양하다" 질문에 비슷하게 대답할 것 같아요.	다양성 항목에 "(많든 그렇지 않든)"이라는 구절을 추가한다.
"건강미"는 의미가 모호해요. 풀어서 쓰는 게 좋을 거 같아요. 아니면 괄호 안에 부가 설명을 넣는 게 좋을 것 같아요. (탐침질문의 대답으로) 다른 것들은 그대로 사용해도 괜찮을 것 같은데요.	"건강미"를 "좋은 신체조건"으로 변경한다.

인터뷰 11: BA (3) (성동구 성수2가3동)

성명: ○○○(직업: 전업주부)				
행정동	(1) 유형: 고압축 / 비계획 / <u>뉴타운</u> / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / <u>≤ 5.1</u> / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 6	차량(대): 2	구성원(명): 4
	(2) 개인	성별: 남 / <u>여</u>	결혼: <u>기혼</u> / 독신	연령대(10세): 4

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	독립적으로 '스스로 하는' 통행은 운전하는 걸 말하는 것 같습니다. 그럼 이건 자동차가 가진 장점 때문인 것 같은데요.	탐색적 요인분석으로 독립심이 도구적 편익으로 추출되는지 확인할 것이다.	도구적 편익(요인) --> 독립심

설문지

인터뷰 발췌	노트
질문을 단어만 달랑 써 놓은 것 중에는 이해가 안 되는 것이 있습니다. "프라이버시", 그리고 "짐을 나를 수 있는 것"은 애매모호해서 잘 못 알아듣겠습니다. 무슨 뜻인지 설명을 들어야 이해가 가는 질문입니다.	"프라이버시"를 "프라이버시(남을 신경 쓰지 않아도 되는 것)"로 수정한다. 한편, "짐을 나를 수 있는 것"은 편의성 항목과 묶어 질문하기로 하였다.
"집에서 목적지까지 가는 동안의 마음가짐 전환"은 읽었을 때 무슨 의도로 질문했는지 모르겠습니다.	"(이를 통해 일할/쇼핑할/여가를 즐길 마음을 갖추는 것)"이라는 표현을 추가한다.

인터뷰 12: BB (3) (서초구 반포2동)

성명: ○○○(직업: 대학생)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 7	차량(대): 2	구성원(명): 5
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 1

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	요즘 자전거 도로랑 산책로가 많이 놓여서 오가면서 경치구경, 길거리구경을 하기가 좋아졌어요.	응답자는 "어메니티"가 (자동차 및 대중교통 통행의 편익임에 더해) 비동력 통행의 편익임을 보여주고 있다.	
비용, 도구적 편익, 정서적 편익	자전거를 이용하면 가고 싶은 곳을 빨리 갈 수 있고 운동도 되어 좋고요. 또, 승용차처럼 기름이 드는 것도 아니잖아요. 그래서 많이 자주 타는 편인데요. 요즘 돌아다니다 보면 길가는 물론 보도에 자전거가 대어져 있는 걸 많이 봐요. 학원에 다니는 애들이 학원 앞 같은 데에 자전거를 아무렇게나 대놓다 보니까 어떤 때는 학원이 끝난 애들이랑 학원차랑 자전거가 엉키는 듯한 상황이 많았어요. 물론 자전거가 여러 면에서 용이한 점은 있지만 (자동차) 교통에 지장을 주는 것도 사실이에요	응답자는 첫째, 자전거 통행의 비용절약(시간 및 연료), 편리성, 운동효과를 강조하고 있다. 둘째, 그는 기존연구 고찰 부분에서 논의된 주장에 동의한다: 혼잡도 상승이 자동차 통행(및 그 효용)에 부정적 영향을 미칠 수 있다.	
정서적 편익	(탐침질문의 대답으로) 등교용으로 (자전거를) 이용하는 애들도 있고요, 주말에 운동 겸 스트레스 해소 겸 해서 타는 사람들도 많아요.	"신체 운동"은 "정신적 치유"의 충분조건일지 모르지만 필요조건은 아니다. 따라서 두 항목은 설문지 초안에서와 같이 별도로 질문할 것이다.	

설문지

인터뷰 발췌	노트
질문은 예/아니요로만 하면 대답하기가 훨씬 쉬울 것 같아요.	본 연구의 주요 분석기법인 SEM은 이항변수가 아닌 연속형 변수에 기반을 둔다. 따라서, 리커트식 평정척도를 그대로 사용한다.

인터뷰 13: AA (4) (관악구 청룡동)

성명: ○○○(직업: 전업주부, 첫돌 지난 갓난아이를 포함한 세 아이의 엄마)				
행정동	(1) 유형: <u>고압축</u> / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / <u>≤ 6.8</u> / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 5	차량(대): 2	구성원(명): 6
	(2) 개인	성별: 남 / <u>여</u>	결혼: <u>기혼</u> / 독신	연령대(10세): 3

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	서울은 사람도 많고, 차도 많아서 공기가 더럽다. 환경을 살리려면 자동차 대신 다른 걸 이용해야 한다. TV에서 선전도 많이 하던데… 매연 안 나오는 전기자동차나 수소자동차, 천연가스 버스 타는 게 환경을 돕는 것이다. 그렇지만 우선 가격이 내려가야 한다. 그러면 자동차를 타면서도 공해도 줄일 수 있다.	응답자는 환경친화성이 교통수단의 기계적 특성에 달려 있다고 간주한다. 따라서 본고는 환경관심 변수가 정서적 편익이 아닌 도구적 편익에 속할 가능성을 테스트할 것이다.	도구적 편익(요인) --> 환경관심
정서적 편익	요즘 같이 날이 좋을 때에는 가까운 거리는 일부러 걷는다. 그러면 유산소 운동도 되면서 기분전환도 할 수 있다.	신체 운동 및 정신적 치유가 실제로 유의한 편익이라고 보고 있다.	

설문지

인터뷰 발췌	노트
새로운 곳을 가보는 것이라는 항목은 출근이라는 내용이랑은 연결이 안 된다.	인터뷰 응답자조차 본 설문항목에 응답을 하였고 또 그 결과도 기대와 같았으므로 현재 포맷을 유지한다.
응답방법 예문은 좋은데 질문이 많아서 시간과 종이가 아깝다.	서울에서 기대되지 않는 항목을 제외하고 유사항목들을 합친다. 또한, 충분한 응답시간을 제공하고 응답률을 높이기 위해 배포조사, 정기적 리마인더, 금전적 인센티브를 설계한다.

인터뷰 14: AB (4) (도봉구 창1동)

성명: ○○○(직업: 법인택시 기사)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 2	차량(대): 1	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 3

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	"신체 운동"은 도구적 편익으로 볼 수 있을 것 같습니다. 자전거를 타거나 산책이나 조깅을 하는 건 이런 것 때문 아닌가요?	인터뷰 응답자는 신체 운동을 정서적 편익 보다는 도구적 편익으로 보고 있다.	도구적 편익(요인) --> 신체 운동

설문지

인터뷰 발췌	노트
한국 사람들은 성격이 급해요. 설문도 빨리빨리 쉬워야 해요. 결국은 나라에서 어떠어떠한 점을 개선했으면 좋겠느냐는 의도잖아요. "당신은 무슨 수단 이용하느냐?"라고 물으면 쉽잖아요?	서울에서 기대되지 않는 항목을 제외하고 유사항목들을 합친다. 또한, 충분한 응답시간을 제공하고 응답률을 높이기 위해 배포조사, 정기적 리마인더, 금전적 인센티브를 설계한다.
여가시설 어떠냐에 대해서 20대, 30대, 40대 연령별로 물어보든지요? 여기는 구민회관이 가깝지만(구민회관은 옆 동네인 창5동에 입지) 노인들을 위한 시설이고 사실 젊은 사람들이 갈 여가시설이 별로 없어요.	연령을 비롯한 인구통계적 변수는 SEM에서 통계적 통제가 이뤄진다.

인터뷰 15: BA (4) (서초구 서초2동)

성명: ○○○(직업: 약사)				
행정동	(1) 유형: 고압축 / 비계획 / <u>뉴타운</u> / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / <u>≤ 6.8</u> / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 3	차량(대): 0	구성원(명): 1
	(2) 개인	성별: <u>남</u> / 여	결혼: 기혼 / <u>독신</u>	연령대(10세): 4

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	승객으로 대중교통을 이용하거나 차에 동승자로 타는 것은 '의존적'인 통행이니까 '독립적'인 것은 어떤 교통수단을 쓰느냐가 중요할 것 같다.	독립심이 정서적 편익 대신 도구적 편익인지에 대해 테스트하기로 한다.	도구적 편익(요인) --> 독립심

설문지

인터뷰 발췌	노트
한 가지 종류의 질문이 3가지 유형에 사용되지만 답 선택은 비슷하게 나온다.	다른 인터뷰 참가자들은 질문에 사뭇 다르게 응답하였으며, 따라서 이 의견은 응답자의 특이성에서 비롯된 것(모집단의 상당수에 적용되지 않는 것)으로 취급한다.
(일주일 간 발생한 통행의 빈도와 시간을 묻는) 이 질문은 7일 동안 여행을 가거나 병원에 입원한 경우 등 특별한 경우가 있다면 일반적인 때와 다른 결과가 나온다. 기간을 일주일 이상으로 했으면 좋겠다.	기간을 늘리는 경우 기억의 한계 때문에 응답오차가 커질 수 있으므로 대상기간을 7일로 유지한다.

인터뷰 16: BB (4) (은평구 수색동)

성명: ○○○(직업: 정년퇴직, 연금 및 자녀의 금전적 지원으로 생활)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 1	차량(대): 1	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 7

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	교통에 관한 거면 (청부가) 노선이 중복되지 않게 하고 중앙 환승장을 만들어서 이용할 수 있게 해주면 좋겠어.	응답자는 대중교통의 불편을 강조하지만 설문에 응답한 것(통행빈도 및 시간)을 보면 대중교통에 의존적인 통행자인 것으로 나타난다. 즉, 추측컨대 편리성이 수단선택에 결정적인 변수가 아닐 수도 있다.	
	이 동네는 시끄럽지 않고 살기가 좋아. 자전거 도로가 잘되어 있고, 구에서 자전거 거치대를 많이 만들어 줬어. 근데, 자전거 거치대를 지하철 쪽에만 하지 말고 정류장 쪽에도 몇 개 만들어 주면 좋겠어.	차고 및 주차장을 포함, 개인교통의 인프라—여기서는 자전거 거치대—는 분석에 포함되지 않는다.	

설문지

인터뷰 발췌	노트
설문의 목적을 이해하기 어려워. 설문 자체가 "휴식을 취하거나 쪽잠을 자는 것", "유익한 일을 하는 것(일하기, 얘기하기, 읽기, 듣기 등)", "안락함", "프라이버시", "내가 원하는 곳에, 내가 원할 때 가는 것", "짐을 나를 수 있는 것", 이런 것들은 별로 필요 없는 안이한 질문인 것 같아 아쉬워.	커버레터에 설문이 기여하는 바를 분명히 한다(정책개발의 기초 제공).
설문이 중복이 돼 있는 것 같아.	항목을 검토, 유사 항목끼리 합친다.

인터뷰 17: AA (5) (구로구 가리봉동)

성명: ○○○(직업: 임용고사 준비 중에 편의점에서 파트타임 점원으로 근무)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 1	차량(대): 0	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 3

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
일차 편익	업무, 쇼핑, 여가활동 외에 나중에는 자기관리도 조사해 주셨으면 좋겠습니다.		
통행중 편익	여기 "호기심"은 피상적이고 탐색적이지만 "활동"이니까 통행중 편익에 속해야 할 것 같습니다.	정보 호기심 항목이 통행중 편익 카테고리에 속하는지 테스트하기로 한다.	통행중 편익(요인) --> 정보 호기심
	같은 관점에서, "아름다운 경치"를 보는 것도 (통행중 편익) 카테고리에 포함돼야 할 것 같습니다.	"어메너티"를 정서적 편익이라기보다는 통행중 편익으로 간주하고 있다.	통행중 편익(요인) --> 어메너티

설문지

인터뷰 발췌	노트
"안락함", "프라이버시"라는 말 말고 내용을 넣는 게 좋을 것 같아요.	"안락함"을 "쾌적함 또는 안락함"으로, "프라이버시"를 "프라이버시(남을 신경 쓰지 않아도 되는 것)"로 수정한다.

인터뷰 18: AB (5) (송파구 삼전동)

성명: ○○○(직업: 텔레마케터)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 2	차량(대): 0	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 4

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	(저는) 자격증 취득이나 자기 계발을 위해 문화센터에 다니면서 새로운 친구들을 만나고 동호회를 만들기도 해요. 동호회를 만들지 않더라도 문화센터나 새로운 동네를 가면 다양한 사람들과 친교를 할 수 있어요.	목적지 근처나 도중에 들르는 장소에서 할 수 있는 활동의 예를 들고 있다.	
	저는 몸매를 교정하기 위해서 자세를 바르게 하고 앉아요.	응답자는 원래 정서적 편익으로 파악된 "신체 운동"이 통행중 편익에 속할 수 있다고 주장한다.	통행중 편익(요인) --> 신체 운동
	그리고 (같은 버스나 지하철에 탄) 주위 사람들을 관찰하면서 트렌드를 캐치해요. 예를 들어 남들은 어떤 옷을 입고 가방을 뭘 들고, 휴대폰은 어떤 것인지 취향을 볼 수 있어요.	구체적인 예를 들어 "정보 호기심"이 유의한 편익이라고 언급한다.	
	그리고 주부들 중에서 지하철에서 뜨개질이나 십자수를 하는 분들도 있고요.	이는 통행중 편익의 일례로 든 것이며, 따라서 이러한 종류의 편익이 실제로 존재함을 확인시켜 준다.	
	저는 개인적으로 지하철이나 버스에서 처음 만나는 사람들과 대화하는 걸 중요하게 생각해요. 지하철 경로석에서 어른들이 자리 비었을 때 앉으라고 하실 때 어른들 얘기 들어주고 호응하고, 일종의 말벗이 돼드려요. 그리고 스마트폰 잘 모를 땐 옆에 앉은 어린 애들한테 물어보면 웃으면서 친절하게 잘 가르쳐 줘요. 이런 "세대 간 소통"이 가능해요.	통행중 편익이 유의하다고 인정하며 나아가 이러한 편익이 수단선택에 영향을 미칠 수 있음을 보여준다.	
상징적 편익	사람들은 차의 종류를 통해서 직업이나 부를 드러내요. 예를 들어서, 백화점 갈 때 티코 타고 가면 아줌마라고 하지만 그랜저 타면 사모님이라고 한다고 하잖아요. 열등감을 충족하려고 하는 거죠. (탐침질문의 대답으로) 서울이라 더 그런 거 같아요.	상징적 편익의 유의성을 확인시켜 주고 있다.	
	자라나는 세대들이 보고	이는 "지위 과시"의 특수한	

	배우고 있다는 인지 하에 FM대로 통행하는 거요. 그것 때문에 자전거를 일부러 타면 그게 편익이겠죠.	사례로 볼 수 있다.
정서적 편익	(더할 수 있는 것으로) 길거리 산책이요. 전 햇볕 쬐기를 하면 밤에 잠을 잘 자요. 걸어 다니면서 다양한 사람들 만나고, 얘기하고, 우울증을 해소해요.	정서적 편익이 전반적으로 유의하다고 확인시켜 주고 있다.

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 19: BA (5) (노원구 공릉동)

성명: ○○○(직업: 파트타임, 공무원시험 준비 중으로 재택근무와 시간제 직장근무 병행)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 5	차량(대): 1	구성원(명): 3
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 2

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	1~2시간 거리의 장거리를 이동할 때는 이동하면서 여러 가지 일을 동시에 할 수 있어요. 공부하기나 식사하기요. 이동하는 시간을 활용해 끼니를 때우기도 하고, 학생들은 시험공부를 하기도 하고, 중요한 비즈니스가 있는 사람은 만남의 장소가 되기도 하고, (교통수단이) 바쁜 도시 사람들한테 이동하면서 귀중한 시간을 쓸 수 있는 "특정 장소"가 되는 것 같습니다. 사실, (인터뷰 폼에 주어진 예를 보면) 빠진 것이 없는 것 같긴 하지만.	인터뷰 응답자는 목적지까지 가는 동안의 편익이 중요하다는 점을 강조한다.	
도구적 편익	(위에서 언급한) 특정 장소 제공이 (도구적 편익 카테고리에) 들어갈 수 있나요? 이건 편리함에 속하나요?	목적지까지 가는 동안의 편익을 도구적 편익에 따른 것(즉, 통행모드의 기계적 특성에 따른 것)으로 판단하고 있다.	도구적 편익(요인) —> 통행중 편익 항목 모두

설문지

인터뷰 발췌	노트
질문식으로 만들어서, 현재와 다른 식으로 "…라고 생각하는가?"라고 하는 게 이해하기 쉬울 것 같아요.	단어 대신 항목을 구로 표현한다.
질문이 추상적인 것들이라 생각을 많은 시간을 하게 됩니다.	보다 많은 이들이 이해할 수 있는 분명하고 쉬운 설명을 사용하여 항목을 구성한다. 또한, 충분한 응답시간을 제공하고 응답률을 높이기 위해 배포조사, 정기적 리마인더, 금전적 인센티브를 설계한다.

인터뷰 20: BB (5) (강남구 개포동)

성명: ○○○(직업: 무직, 1998년 서울시 공무원으로 명예퇴직)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 4	차량(대): 1	구성원(명): 3
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 5

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	"경치구경"을 덧붙여야 해요.	본고는 "어메니티"를 정서적 편익으로 판단하였으나 인터뷰 응답자는 통행중 편익으로 본다.	통행중 편익(요인) ---> 어메니티
도구적 편익	("통행시 안전에 대해 걱정하지 않아도 되는 것" 문항에 대해) 서울에서 안전은 정말 중요한 거 아닌가요? (탐침질문의 대답으로) 옛날에는 안 그랬는데 요즘은 (교통이) 안전하지 않아요. 더 쾌적해졌지만 안전하지는 않아요.	교통사고와 관련하여 안전의 중요성을 강조하며 본 질문을 "물을 필요가 없는 것"으로 판단한다. 그러나 나머지 23명 인터뷰 응답자는 유사한 제안을 하지 않았으며, 따라서 이 항목을 제외하지 않기로 한다.	
상징적 편익	(개인의) "취향"이 들어가야 해요.	설문지에 이미 반영되어 있다.	
정서적 편익	"안락하고 편안한 것"이 여기 있어야 해요.	"안락함"은 본고에서 도구적 편익으로 간주한 항목인데, 인터뷰 응답자는 이를 정서적 편익으로 판단한다.	정서적 편익(요인) ---> 안락

설문지

인터뷰 발췌	노트
(목적지 근처에서 할 수 있는 것으로) "식사 및 간식을 하는 것"이 빠져 있어요.	언급된 활동을 현재 예시에 추가한다.
꼬는 듯한 문항이 있어요. "통행시 안전에 대해 걱정하지 않아도 되는 것"이란 표현 말고 직접적으로 물었으면 좋겠어요.	"목적지에 가는 동안 안전함을 느끼는 것"으로 표현을 바꾼다.

인터뷰 21: AA (6) (송파구 가락본동)

성명: ○○○(직업: 동네 한식당 점원)				
행정동	(1) 유형: <u>고압축</u> / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / <u>≤ 10.2</u>			
인구통계	(1) 가구	월소득(백만원): 3	차량(대): 0	구성원(명): 4
	(2) 개인	성별: 남 / <u>여</u>	결혼: <u>기혼</u> / 독신	연령대(10세): 6

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
비용	여긴 가락동 농수산물시장이 가까워 걸어가기 좋고 살기가 좋아요.	목적지에 가까이 사는 것이 보행을 촉진한다고 언급하고 있으며, 이는 본 연구에서 주장하는 바와 일치한다.	
도구적 편익	그리고, 공기가 깨끗하고요. (그렇지만) 하수구 청소 좀 해야 해요. 일반 집은 일주일에 한 번 청소하는데요. 그 많은 가구가 쓰는 하수구 청소를 1년에 한번 밖에 안 해주냐고요. (정부가) 위생 생각을 못 해요. 걸어갈 때 하수구에서 악취가 나요. 그렇지만 예전에 비해서는 많이 나아진 거예요.	도로상황이 통행행태에 영향을 미칠 수 있으나, 주요 분석대상이 아니다.	
	여름 물난리 방지, 산사태도 신경 써야 해요.	자연재해 및 이에 관련된 안전이 통행행태에 영향을 미칠 수 있으나, 주요 분석대상이 아니다.	

설문지

인터뷰 발췌	노트
제안사항 없음	

인터뷰 22: AB (6) (양천구 신월동)

성명: ○○○(직업: 재택근무, 번역가)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
인구통계	(1) 가구	월소득(백만원): 2	차량(대): 0	구성원(명): 1
	(2) 개인	성별: 남 / 여	결혼: 기혼 / 독신	연령대(10세): 4

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
일차 편익	원래 의도하지 않은 다른 목적이 주요 목적이 될 수도 있는데, 이런 점을 고려할 필요도 있습니다.	설문지는 사람들의 "전형적" 또는 "평상시"의 통행행태를 묻는 것이므로 응답자가 지적한 가능성이 이슈화될 여지가 없다.	
	목적지에서 구할 수 있는 다양한 정보습득으로 인한 편익을 들 수 있습니다. 영화 시간을 확인하거나 다음 목적지로 이동하는 데 필요한 교통정보 등을 얻을 수 있습니다.	정서적 편익 중 "정보 호기심"(설문지에서 "우연히 흥미로운 사람을 보거나 무언가를 알게 될 가능성")이 사실 일차편익에 속할 수 있음을 보여준다.	일차 편익(요인) --> 정보 호기심
통행중 편익	(다른 예로) 급작스럽게 발생한 "특이활동"을 낳을 수 있습니다. 특히 버스나 자가용을 이용할 때 교통이 혼잡하면 (급작스럽게 내려서) 도보 이동을 하게 되는데, 이러한 도보 이동을 낳을 수 있습니다.	본 진술은 통행중 활동의 사례를 추가하기 위한 것이다. 한편, 본 연구는 "전형적" 혹은 "평상시" 통행행태에 관심을 두며, 특이상황은 분석하지 않는다.	
상징적 편익	(추가할 것으로) 특정지역에 거주하면서 특정취미를 공유하는 것이 있습니다. 예를 들어서, 강남의 어떤 지역에 거주하면서 모모 골프클럽 회원에 가입하는 것이 상징적 편익입니다.	상징적 편익의 존재를 확인시켜 주고 있다.	
도구적 편익	안전이 중요합니다. 본인의 의사와 상관없는 시설요인, 물건을 쌓아 두거나 하는 것 때문에 안전을 확보하려고 통행 방식을 달리할 수 있습니다.	도구적 편익 중 안전을 강조하고 있다.	
정서적 편익	친구나 상대자 같이 중요하게 생각하는 사람과 함께 통행할 때 대화를 하거나 어떤 것을 같이 함으로써 "교감"을 갖는 것이 중요하게 여겨질 수 있습니다.	통행중 편익의 유의성을 인정하고 있다.	

설문지

인터뷰 발췌	노트
설문 문항 중에 같은 의미의 설명이 중복, 확장되어 구성되어 응답할 때 일부 혼란과 어려움이 발생할 수 있다고 봅니다. "다양하다"와 "특색 있다"는 일반인의 입장에서는 의미의 모호성을 느낄 수 있는 부분이라고 생각합니다. "정도"를 나타내는	"종류가 다양하게" 및 "다른 곳에는 없는 특색 있는"이라고 구체적으로 표현하기로 한다. (추가사항 밑줄)

단어로 조금 더 구체적으로 표현하면 더 좋지 않을까 합니다.

인터뷰 23: BA (6) (금천구 가산동)

성명: ○○○(직업: 배달음식 전문점 운영)				
행정동	(1) 유형: 고압축 / 비계획 / <u>뉴타운</u> / 저압축			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / <u>≤ 10.2</u>			
인구통계	(1) 가구	월소득(백만원): 5	차량(대): 0	구성원(명): 2
	(2) 개인	성별: <u>남</u> / 여	결혼: <u>기혼</u> / 독신	연령대(10세): 6

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
통행중 편익	지하철에 타면 가는 동안 사람들이 어떻게 살아 가나를 볼 수 있어서 좋아요. 모습이 아침에 다르고 저녁에 달라요.	응답자는 "정보 호기심"이 유의한 편익이라는 데 동의한다.	
정서적 편익	간접경험을 통해 사회 돌아가는 상황 알아보기가 돼요. 택시를 타면 운전기사님들이 다양한 계층을 만나시니까요. 예를 들어 "기사님, 어느 정당에 관심 있으세요?", "택시경기가 어떠세요?", "손님들은 어떠세요?" 물어보면 다 얘기해 주세요. 사회 전반적으로 돌아가는 얘기들요. 저는 그래서 택시를 일부러 많이 타요. 시간이 남아도요. 택시 기사님들한테 요즘 트렌드를 들으려고요. 택시기사님들이 트렌드를 잘 알거든요.	통행중 편익이 실제로 유의하다고 인정하며, 나아가 이러한 편익이 수단선택에 영향을 미친다고 주장하고 있다.	

설문지

인터뷰 발췌	노트
설문이 진부해요. 쓸데없이 비슷한 질문을 말만 다르게 적어놨네요. 2~3개면 괜찮은데 4~5개 정도로 나와 비효율적이에요.	항목을 검토, 유사 항목끼리 합친다.
어떤 거는 내용을 이해 못해서 한참 생각하고 적었어요.	보다 많은 이들이 이해할 수 있는 분명하고 쉬운 설명을 사용하여 항목을 구성한다. 또한, 충분한 응답시간을 제공하고 응답률을 높이기 위해 배포조사, 정기적 리마인더, 금전적 인센티브를 설계한다.

인터뷰 24: BB (6) (강서구 방화3동)

성명: ○○○(직업: 은행원으로 정년퇴직, 현재 빌딩 경비원으로 근무)				
행정동	(1) 유형: 고압축 / 비계획 / 뉴타운 / <u>저압축</u>			
	(2) 중심까지 거리(마일): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / <u>≤ 10.2</u>			
인구통계	(1) 가구	월소득(백만원): 5	차량(대): 2	구성원(명): 5
	(2) 개인	성별: <u>남</u> / 여	결혼: <u>기혼</u> / 독신	연령대(10세): 6

효용

카테고리(요인)	인터뷰 발췌	노트	카테고리 변경
도구적 편익	컨트롤하는 재미를 느끼는 건 차 밖에 없는데, 이건 굳이 교통수단에 따라 다르게 물을 이유가 있나요? 자전거도 조금은 되겠네요. 그러면 이건 정서적 편익이 아니라 도구적 편익으로 봐야 하지 않나요?	"제어"가 도구적 편익 카테고리에 속해야 한다고 주장하고 있다.	도구적 편익(요인) --> 제어

설문지

인터뷰 발췌	노트
보통 "안락함"이라는 말을 잘 안 쓰니까 문제를 이해하기 어려운 것 같습니다. 평상시 시민들이 쓰는 언어로 설문을 작성해 주셨으면 합니다. 학술적 용어를 쓰지 말아주세요.	표현을 "쾌적함 또는 안락함"으로 수정한다.

D.3 Interview Notes: English

Interview 1: AA (1) (Changshin 2, Jongno)

Name: XX, XXXX (Occupation: certified realtor)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 4	Automobiles: 2	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 6

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Costs and instrumental benefits	For quite a while, two-story apartments increased a lot and hundreds of hostesses working at nightclubs used to live here. There was a time when cosmetic shop owners could live on sales of mascaras for the ladies, and it was enough to pay the rent. Rents for the apartments went up, and they (the hostesses) all moved out, out to other neighborhoods because they built two-story apartments a lot. It's been 3 or 4 years. Because it is hard to live in Seoul, some have gone down to the country. There was a burglary. Some thieves sneaked in through windows in the daytime and picked clothes. Well, people are the same all over the world, though.	This remark implies that among urban compactness variables, density may be associated with safety issues through its interaction with sociodemographic variables. However, he refers to crime-related safety, which is not directly connected to transportation safety.	
Instrumental benefits	I see there are an increasing number of people who don't drive and instead, use a bicycle on purpose, to consider the environment, to reduce air pollution. (To increase bike travel) the government also increases bike paths or so. Companies like them (employees to commute by bike), too.	The interviewee assumes that environmental friendliness depends on the mechanical characteristics of travel modes. That is, he sees the environmental concerns variable from the perspective of instrumental benefits.	Instrumental benefits (factor) --> environmental concerns

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 2: AB (1) (Shindang 3, Jung)

Name: XX, XX-XX (Occupation: full-time mother, wife of a medical practitioner)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 8	Automobiles: 3	Members: 4
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 5

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	I use a private car when I travel with brothers and sisters instead of a bus or a taxi because I can feel intimacy (and) form an affectional bond. My siblings live in Seoul like Jamsil, Gaepo, and Sangam and because we all live this close, we get together often times.	The interviewee acknowledges that on-the-way benefits are significant and further shows that such benefits affect the mode choice.	
Instrumental benefits	Previously, when propane gas, LPG (Liquefied Petroleum Gas), was used, people put gas cylinders on the street, so it was uncomfortable to walk through, but now is better because we use urban gas. (Urban gas refers to LNG or Liquefied Natural Gas, which is distributed from a central station, and people do not have to individually purchase and install a gas cylinder.)	Road conditions are not the main focus of the analysis.	
	This neighborhood used to be filled with houses and at that time, one house had four families, seven families, or so, but afterwards, population grew and many two-story condos were built, and these days, even 10 families are living in one condo, so safety issues and accidents happen quite a lot. (These two-story condos are a common type of affordable housing: Interestingly, they are called "villas" in Korea.) At dusk, there are some petty thieves.	Her remark shows that density may increase safety issues, but it does not particularly affect transportation safety.	

Categories (factors)	Interview excerpts	Notes	Possible reclassification
	One day, some thieves broke into three homes by climbing up the gas pipe. In the summer, these guys target houses with windows open for a breeze or when kids are left alone.		

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 3: BA (1) (Shindang 1, Jung)

Name: XX, XXXX (Occupation: freelance office worker)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 2	Automobiles: 1	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 4

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Primary benefits	As not intended, an activity that people newly find and do at the destination can be included.	The recommendation is already reflected in the questionnaire.	
On-the-way benefits	Not only extra activities, but also those that people have planned to do, like work, can be added.	Same as above	
Instrumental benefits	(Not to the affective benefits category, but) to the instrumental benefits category, health seems to go; health and fitness and cheering-up things for mental healing, too.	This research initially regarded "physical exercise" and "mental therapy" as affective benefits, but he considers them instrumental benefits.	Instrumental benefits (factor) --> physical exercise Instrumental benefits (factor) --> mental therapy
Symbolic benefits	Expression of personality aspects or self-satisfaction can be added.	The recommendation is already reflected in the questionnaire.	
	Social desires can be added, like those for meeting people and socializing.	Same as above	
Affective benefits	Learning desires can be included, such as those for intentional or unintentional gaining of information about a new place or something like that.	Same as above	

Questionnaire

Interview excerpts	Notes
There's a part where I feel items are a bit lengthy, but overall, I am happy with it (the length).	

Interview 4: BB (1) (Samcheong, Jongno)

Name: XX, XXXX (Occupation: web designer)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 3	Automobiles: 0	Members: 2
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 3

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	By travel mode, you got different distances to walk and also, the chance you can take a seat are different according to which mode you're taking, so "physical exercise" seems an instrumental benefit.	This interviewee sees "physical exercise" as an instrumental benefit, not as an affective benefit.	Instrumental benefits (factor) --> physical exercise

Questionnaire

Interview excerpts	Notes
I understand the intention (of the survey) in theory, but items are not applicable in practice. I wish you asked about five of these abstract questions and asked "what kind of leisure facilities I would like", "what jobs I want to see here (in this neighborhood)", and such.	This research will clarify in the cover letter how the survey contributes (providing a basis for policy development).

Interview 5: AA (2) (Yeomni, Mapo)

Name: XX, XXXX (Occupation: full-time mother)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 4	Automobiles: 1	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Costs, instrumental benefits, and affective benefits	Moms, though they basically think about the environment, they ride the bike for their kids when taking the kids to school or going somewhere because cars are inconvenient. There are many one-way streets and before the school, parking and stopping are not allowed, so they prefer the bike because they can pass quickly even through alleys. They should take their kids to school, go to a library to read them a book, go shopping, take the kids to private academies, do house chores, and they should do these too many things at a short time, so they use the bike, which are convenient to move about. They don't ride the bike because they particularly care for the environment. They prefer it because they can save time and go quickly and freely even on narrow streets, that is, for convenience, not for the grand purpose of saving the environment. Using the bike for the environment? That's good, though because it emits less.	First, the interviewee does not highly value benefits related to the environmental concerns item and considers that it can be not asked. Second, she highlights the convenience of bicycle travel compared to automobile travel in congestion situations. In terms of time savings, her remark confirms that in shorter trips, costs for bicycle travel may be less than those for automobile travel.	
Instrumental benefits	In my neighborhood …, there are exceptionally many moms who carry kids on bikes. It's not hard to see those putting two baby seats on a bike to carry two kids. Moms taking one are also a	According to her, compact urban form may increase the carrying capacity of the bike or make possible a better use of the existing capacity. This is one example that supports the main	

Categories (factors)	Interview excerpts	Notes	Possible reclassification
	lot.	argument of this research: Compact urban form increases travel-related utility by alternative modes to the automobile. (Meanwhile, in the final format of the questionnaire, the carrying capacity item is combined with the convenience item.)	
	Because it's easier than walking, they (moms) are biking their kids to school and if conditions are not favorable, they say that they are walking rather than driving a car because driving is even less convenient.	She considers that in a place of high compactness, bicycle, walk, and automobile are put in descending order of convenience. This is the opposite of a common belief that the automobile is the most convenient (and supports the main argument of this research).	
Symbolic benefits	Moms living in the Neighborhood of Daechi, Gangnam enjoy showing off, and the ladies use private cars a lot, but maybe because moms in my neighborhood are more of laypeople, many of them use bicycles.	Her remark shows that the magnitudes of the symbolic benefits would differ by socioeconomic status.	

Questionnaire

Interview excerpts	Notes
These days, moms prefer a parent's notice that's not over a page. They hate long letters. Because all people are busy living their lives, it's good to make the questionnaire short. The first thing is people wouldn't like a survey itself. Besides, they should spend their time.	This research will exclude items that are not expected in Seoul and combine similar items. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.

Interview 6: AB (2) (Bogwang, Yongsan)

Name: XX, XX-XX (Occupation: office worker at a pharmaceutical company)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 7	Automobiles: 1	Members: 4
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	In a bus or subway, I take a look at others' clothing and make-ups. You know the saying that when spring comes, what changes first is women's clothing. I get to know what style and what color will be in fashion.	The interviewee acknowledges that "curiosity for information" is indeed a significant benefit.	
Instrumental benefits	About (the frequent maintenance of) the sidewalk thing, I feel sorry about it. It's a waste of tax dollars. Actually, they don't have a mind of leveling the sidewalk when doing maintenance work. After a few months, (my feet) sink in (potholes). Women on heels are particularly unsafe. It would better use urethane foam or other permanent materials.	Road conditions are not the main focus of the analysis.	

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 7: BA (2) (Bukahyun, Seodaemun)

Name: XX, XXXX (Occupation: coffee shop owner)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 6	Automobiles: 2	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	In my neighborhood, the road is in a good condition. In the Neighborhood of Sillim, moms don't ride bikes that much, but the road condition is good here, and moms bike around while taking one or two of their babies in bicycle baskets.	The interviewee suggests that in relation to "convenience", compact urban form may increase this instrumental benefit for nonmotorized travel.	
	But, there are not enough bicycle racks. So, people park their bikes any which way, which interferes with the traffic. These bikes, often parked at curbs or trees, are not nice to see and make it hard to pass through, for streets get narrow. Especially, talking about the front side of the high school, there is no bicycle rack in the property, and the high schoolers cannot help but lock their bikes at the steel fence (of the school).	She argues on the need for building bicycle facilities, but her remark actually implies that a lack of the facilities per se may not reduce the use of the bicycle (i.e., bikes may be used regardless of the deficiency).	

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 8: BB (2) (Hannam, Yongsan)

Name: XX, XXXX (Occupation: high school teacher)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 3	Automobiles: 1	Members: 2
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 5

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	Utility is possible to obtain only in the case of travel for shopping or leisure and if they travel to go to work, a rapid movement is most important. Utility of travel from work to home may be getting information about something to eat or enjoy. And, these days, extra activities are mostly limited to those done by the smartphone.	She highlights that on-the-way benefits are smaller when people travel for commuting than for shopping and leisure.	
Symbolic benefits	I'd put being a good example by using public transportation although they have a car so that they feel they reduce traffic or consider others' travel.	With an example, the interviewee shows the significance of the benefits related to "lifestyle expression".	

Questionnaire

Interview excerpts	Notes
Expecting "comfort" in the means of transportation would be too much. "Pleasantness" may be a better expression. Among public transportation modes, express buses, KTX (Korea Train eXpress) trains, and airplanes are more pleasant, aren't they?	The expression will be changed to "pleasantness or comfort".

Interview 9: AA (3) (Songcheon, Gangbuk)

Name: XX, XXXX (Occupation: Korean SAT Verbal instructor at a local private academy, married for nine months)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 0	Members: 2
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	Complete "movement as you'd like and freely", isn't it possible only when you are walking? When taking a bus or survey, I cannot help but go by the route. Maybe, cars are kind of possible, though… But, cars cannot go if streets are too narrow and if there is no driveway; and, if there is no parking lot, you cannot go nearby. It is also difficult to use a bike if there is no bicycle rack. So, this thing sounds like an instrumental benefit because it is possible only when people walk.	The interviewee states that "control" may be an instrumental benefit rather than an affective benefit.	Instrumental benefits (factor) --> control
	And also, environmental protection looks like an instrumental benefit. To protect the environment, what must be done are no driving and using public transportation, if possible.	She argues that environmental concerns should be considered an instrumental benefit, not an affective benefit.	Instrumental benefits (factor) --> environmental concerns

Questionnaire

Interview excerpts	Notes
Usually, (in a questionnaire) the researcher's intention is shown first, and later, "something is and something is not" (sentences) follow. It's my first time seeing that the question section is just words. I don't get what "comfort" means. Also, it (the questionnaire) just shows "privacy", so it's hard to catch what the survey is all about. If the question section has sentences in a little more detail, then it will be easier to understand the intention.	This research will change "comfort" to "pleasantness or comfort" and "privacy" to "privacy (not being bothered by others)", respectively.

Interview 10: AB (3) (Mangwon 2, Mapo)

Name: XX, XXXX (Occupation: college student)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 4	Automobiles: 1	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	Because it's important to "reduce time," people may have no time to enjoy things like these.	If this opinion is agreed by a significant number of respondents in the main survey, SEM will find on-the-way benefits to be insignificant.	
Affective benefits	It'd better add "freedom" and "thinking deeply".	This research classified "thinking" as an on-the-way benefit, but the interviewee sees it as an affective benefit.	Affective benefits (factor) --> anti-activity—thinking
	Talking about "mental therapy", given Seoul's traffic congestion, many pedestrians, and such conditions, I do not think its effect is noteworthy.	According to the interviewee, this item could turn out to be insignificant in SEM.	

Questionnaire

Interview excerpts	Notes
"Lots of …" and "a wide variety of …" are possibly duplicated in meaning. … If facilities get various, it also means that the number of the facilities increases and if they increase in number, doesn't their variety usually go up? … I'd give similar answers to these "lots of" and "a wide variety of" questions.	To the variety item, the following will be added: "(whether dense or not)".
"Fitness" is ambiguous in meaning. It seems to be better to make it in detail. Or, it will be better to put an additional explanation in parentheses. Others look fine as they are.	This research will change "fitness" to "good physical condition".

Interview 11: BA (3) (Sungsu 2nd Street 3, Sungdong)

Name: XX, XXXX (Occupation: full-time mother)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 6	Automobiles: 2	Members: 4
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 4

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	Traveling independently, "on their own", seems like talking about driving. Then, it is because of the benefits automobiles have.	This research will check through exploratory factor analysis if independence is extracted as an instrumental benefit.	Instrumental benefits (factor) --> independence

Questionnaire

Interview excerpts	Notes
Of the questions that are shown just as a word, some are not clear. "Privacy" and "carrying capacity" are ambiguous, and I cannot get them quickly. They are questions I cannot understand until I listen to explanations.	This research will change "privacy" to "privacy (not being bothered by others)". Meanwhile, "carrying capacity" has been combined with the convenience item.
When I read "transition between home and the destination", I couldn't understand what this question is for.	The following expression will be added: "(and get ready to work/shop/enjoy leisure)".

Interview 12: BB (3) (Banpo 2, Seocho)

Name: XX, XXXX (Occupation: college student)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 7	Automobiles: 2	Members: 5
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 1

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	Recently, they built a lot of bike lanes and foot paths, and it became easier to enjoy the landscape and streetscape while going around.	The interviewee shows that "amenities" is a benefit for nonmotorized travel (in addition to that for automobile and public transit travel).	
Costs, instrumental benefits, and affective benefits	When I use the bike, I can quickly get to the place of my destination and can do exercise. And, you know, it doesn't need gas unlike the car. So, I tend to ride it a lot. But, while going around these days, I see many bikes are parked on the street sides and sidewalks. Because guys going to private academies carelessly put their bikes in front of the academies or nearby, what happens at times is that guys who finished their classes, academy shuttles, and bikers are jammed up together. For sure, bikes are convenient in many ways, but it's also true that they interfere with (car) traffic.	First, the interviewee highlights cost savings (time and gas), convenience, and exercise benefits of bike travel. Second, he supports an argument discussed in the literature review section: Increases in congestion may result in less automobile travel (and its utility).	
Affective benefits	(As a response to a probe) there're guys who use it (the bicycle) to go to school and as far as I am concerned, many people are riding it on weekend partly for exercise and partly for play.	Even if "physical exercise" may be a sufficient condition for "mental therapy", that is not a necessary condition. Thus, the two items will be separately asked as in the questionnaire draft.	

Questionnaire

Interview excerpts	Notes
It will be much easier to answer if the survey has	SEM, the main analytical technique of this

Interview excerpts	Notes
yes/no questions, only.	research, is based on continuous variables, not dichotomous variables. Thus, this research will keep using the Likert-type rating scale.

Interview 13: AA (4) (Cheongnyong, Gwanak)

Name: XX, XXXX (Occupation: full-time mother raising three children, including a one-year-old baby)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 2	Members: 6
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 3

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	Seoul has lots of people and lots of cars, so the air is not clean. To save the environment, we should use other than the automobile. I see TV campaigns… Taking those that do not emit smoke, like electric cars, hydrogen cars, and natural gas buses is helping the environment. But, first, their prices should go down. Then, we can reduce air pollution even when driving the automobile.	The interviewee considers that environmental friendliness hinges on the mechanical characteristics of travel modes. Thus, this research will test the possibility that the environmental concerns item is included not in the affective benefits category, but in the instrumental benefits category.	Instrumental benefits (factor) --> environmental concerns
Affective benefits	When the weather's fine like these days, I walk on purpose if the distance is short. This is aerobic exercise and it also lets me refresh myself.	She considers that physical exercise and mental therapy are indeed significant benefits.	

Questionnaire

Interview excerpts	Notes
"Going to a new place" isn't associated with commuting.	Even this interviewee responded to the question and the response was as expected, so this research will keep the current format.
The example of how to answer is good, but it asks too many questions, which is a waste of time and paper.	This research will exclude items that are not expected in Seoul and combine similar items. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.

Interview 14: AB (4) (Chang 1, Dobong)

Name: XX, XXXX (Occupation: corporate taxi driver)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 2	Automobiles: 1	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 3

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	"Physical exercise" can be seen as instrumental benefits. Riding a bicycle, taking a walk, and going jogging are mostly for this reason, isn't it?	The interviewee considers physical exercise an instrumental benefit rather than an affective benefit.	Instrumental benefits (factor) --> physical exercise

Questionnaire

Interview excerpts	Notes
Koreans are hot-tempered. The survey should also be quick and easy. You ultimately intend to know about what people want the government to improve. Isn't it easy if you ask "which means of transportation do I use?"	This research will exclude items that are not expected in Seoul and combine similar items. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.
About leisure facilities, why don't you ask separately by age like 20s, 30s, and 40s? This neighborhood is close to a community leisure center (the center is located in a next neighborhood, Chang 5), but it's for the elderly, and actually, young people don't have many places to go.	Sociodemographic variables, including age group, are statistically controlled for in SEM.

Interview 15: BA (4) (Seocho 2, Gangnam)

Name: XX, XXXX (Occupation: pharmacist)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 3	Automobiles: 0	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 4

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	Using public transportation or taking cars as a passenger is "dependent" travel, and for "independent" travel, which means is taken seems a major point.	This research will test if independence is an instrumental benefit instead of an affective benefit.	Instrumental benefits (factor) --> independence

Questionnaire

Interview excerpts	Notes
One kind of question is asked for three types, but answers to them are similar.	Other interviewees answered the questions quite differently, so this research considers that this comment originates from his idiosyncrasy (as not applied to a large portion of the population).
To these questions (that ask the number of trips for a week and their durations), answers will be different than usual in case something special happens for the seven days, like going on a trip or into a hospital. I wish the period would be more than a week.	Extending the period may increase response bias because of a limited memory, and this research will keep the period as seven days.

Interview 16: BB (4) (Susaek, Eunpyeong)

Name: XX, XXXX (Occupation: retired and lives on pensions and financial supports from children)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 1	Automobiles: 1	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 7

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	If this survey is about transportation, I would like them (the government) to make bus routes not overlap and to build a transfer center for us to use.	The interviewee highlights the inconvenience of travel by public transportation, but according to her answers in the survey (trip frequencies and durations), she is highly dependent on it. That is, presumably, convenience could not be a determinant of mode choice.	
	This neighborhood is not noisy and pleasant to live in. Bicycle paths are well built. The district government made bicycle racks a lot. By the way, I hope they install the racks not only at the subway station, but put a couple near bus stops, also.	Including garages and parking lots, facilities for private transportation—in this case, bicycle racks—are not included in the analysis.	

Questionnaire

Interview excerpts	Notes
It's hard to understand the purpose of the survey. I am sorry about questions like "taking a rest or nap", "doing something useful en route, such as working, talking, reading, and listening", "comfort", "privacy", "traveling where I want, when I want", and "capacity to carry luggage", for I feel these are not really necessary, not serious questions.	This research will clarify in the cover letter how the survey contributes (providing a basis for policy development).
It looks like quite a few questions are duplicated.	This research will check the full list of the items and combine analogous items.

Interview 17: AA (5) (Garibong, Guro)

Name: XX, XXXX (Occupation: part-time clerk at a convenience store while preparing for the teacher employment test)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 1	Automobiles: 0	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 3

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Primary benefits	In addition to commuting, shopping, and leisure activities, I wish they (the Seoul Metropolitan Government) would investigate in the future those for personal management and development.		
On-the-way benefits	Here, although superfluous and exploratory, "curiosity" is shown as an "activity", so I think it should be included in the on-the-way benefits category.	This research will test if the item of curiosity for information is included in the on-the-way benefits category.	On-the-way benefits (factor) --> curiosity for information
	From the same perspective, seeing the "scenic beauty" would be included in that (on-the-way benefits) category.	The interviewee regards "amenities" as an on-the-way benefit rather than as an affective benefit.	On-the-way benefits (factor) --> amenities

Questionnaire

Interview excerpts	Notes
Rather than the words "comfort" and "privacy", it will be better to put them in sentences.	This research will change "comfort" to "pleasantness or comfort" and "privacy" to "privacy (not being bothered by others)", respectively.

Interview 18: AB (5) (Samjeon, Songpa)

Name: XX, XXXX (Occupation: telemarketer)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 2	Automobiles: 0	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 4

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	While going to culture centers (affiliated to public libraries or department stores to take courses) for certification exams or for personal development, (I) meet new friends and sometimes form a club with them. Even though not making such a club, I can be on friendly terms with a variety of people when I go to the cultural centers or new neighborhoods.	The interviewee gives examples of activities near travel destinations or at stopovers.	
On-the-way benefits	I sit erect for a good body shape.	She argues that "physical exercise", which was initially understood as an affective benefit, can rather fall into the on-the-way benefits category.	On-the-way benefits (factor) --> physical exercise
	Also, I observe people around me (in the same bus or subway) and catch a trend. For example, I look at how others wear, what types of bags they carry, and what kinds of cell phones they use.	With a particular example, the interviewee states that "curiosity for information" is a significant benefit.	
	I also see moms who're knitting or stitching in a subway.	This is given as an example of on-the-way benefits, and accordingly confirms the existence of this kind of benefits.	
	Personally, I take it serious to have a conversation with strangers in a subway or a bus. In a subway, when reserved seats are available and the elderly ask me to sit on, I listen to them and respond to what they say, and I become kind of a	The interviewee acknowledges that on-the-way benefits are significant and further shows that such benefits may affect the mode choice.	

Categories (factors)	Interview excerpts	Notes	Possible reclassification
	companion. And, if I have a problem with my smartphone, I ask young kids sitting next to me, and then, they kindly teach me with a smile. This "intergenerational understanding" is possible.		
Symbolic benefits	Through the type of their car, people disclose their job and wealth. An example is as you know, when parking at a department store, females are called Ajumma (a politically incorrect term referring to a married woman, literally meaning a housewife) if they ride in a Daewoo Tico (the first city car in Korea), but those driving a Hyundai Grandeur (in the U.S., Azera) are called Samonim (a complimentary term for a married woman, literally meaning the wife of a president). People may do this to hide or make up for their inferiority. (As a response to a probe) it may be more so because it's Seoul.	The significance of symbolic benefits is confirmed.	
	In an understanding of the fact that the next generation is watching and learning, people may travel as exemplary role models. If they ride a bicycle on purpose, then it would be a benefit.	It can be considered a unique example of "status show-off".	
Affective benefits	(To be added) is taking a walk on the street. When I get some sun, I sleep well at night. Taking a walk, I meet and chat with various people, and I can take my mind off depression.	The interviewee confirms that affective benefits are significant on the whole.	

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 19: BA (5) (Gongneung, Nowon)

Name: XX, XXXX (Occupation: part-time freelancer while studying for civil service exams)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 1	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 2

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	While traveling a long distance for an hour or two, people can do many things together, like studying and eating. Using the time, they can have a meal, students can study for an exam, and it becomes a meeting place for those who have an important business meeting, so they (the means of transportation) are like becoming a "particular place" that busy city people can use their precious time while traveling. Actually, (when I read the examples of the benefits shown in the interview form) it seems like nothing missing.	The interviewee highlights the importance of the on-the-way benefits.	
Instrumental benefits	Can offering a particular place (as stated above) go here (to the instrumental benefits category)? Is it one of the convenience benefits?	She considers on-the-way benefits under the influence of instrumental benefits (i.e., mechanical characteristics of travel modes).	Instrumental benefits (factor) --> all on-the-way benefits

Questionnaire

Interview excerpts	Notes
It may be easier to understand if you make survey items in sentences like "do you think …?", different from the current format.	Items will be given in phrases.
Because questions are kind of abstract, I have to think long.	This research will revise items by using clearer and fuller terms that are accessible to a wider public. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.

Interview 20: BB (5) (Gaepo, Gangnam)

Name: XX, XXXX (Occupation: no job, retired in 1998 as a public worker for the Seoul Metropolitan Government)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 4	Automobiles: 1	Members: 3
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 5

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	"Seeing the landscape" would be added.	The interviewee regards "amenities", initially considered an affective benefit in this research, as an on-the-way benefit.	On-the-way benefits (factor) --> amenities
Instrumental benefits	(Regarding a questionnaire item, "no worries about my safety when I travel") isn't the safety really important in Seoul? (As a response to a probe) it was not a concern in the past, but these days, (traffic) isn't safe. It came to be more pleasant, but not safe.	He emphasizes the importance of safety in relation to traffic accidents and considers that the question is "not necessary to ask." However, no similar suggestions were given by the other 23 interviewees, and this research will not exclude it from the questionnaire.	
Symbolic benefits	(Personal) "tastes" should be considered.	It is already reflected in the questionnaire.	
Affective benefits	"Pleasant and comfortable things" should be here.	This research initially considered "comfort" an instrumental benefit, but the interviewee sees it as an affective benefit.	Affective benefits (factor) --> comfort

Questionnaire

Interview excerpts	Notes
(As activities at stopovers) "having meals and snacks" is omitted.	The activity will be added to the current list of examples.
There is a twisting question. Rather than "no worries about my safety when I travel", I'd like a more direct expression.	The expression will be changed to "feeling safe while going to the place of the destination".

Interview 21: AA (6) (Garakbon, Songpa)

Name: XX, XXXX (Occupation: waitress at a local Korean restaurant)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 3	Automobiles: 0	Members: 4
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 6

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Costs	Because this neighborhood is close to Garak Agricultural Market, it's easy to walk there, and this neighborhood is convenient to shopping.	The interviewee states that living close to the destination facilitates walking, and this is consistent with the argument of this research.	
Instrumental benefits	And, the air's clean. (However) the public sewer should be cleaned. Families clean their houses once a week. The sewer is shared by those many families, but cleaned once a year. They (the government) don't care about the hygiene. I smell it when I walk by. But, that's even better than before.	Road conditions may affect travel behavior, but they are not the main focus of the analysis.	
	Also, they (the government) should mind monsoon flooding and landslides.	Natural hazards and related safety may affect travel behavior, but they are not the main focus of the analysis.	

Questionnaire

Interview excerpts	Notes
No suggestion	

Interview 22: AB (6) (Sinwol, Yangchon)

Name: XX, XXXX (Occupation: teleworking translator)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 2	Automobiles: 0	Members: 1
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 4

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Primary benefits	Other purposes that were not initially intended would be the main purpose at a later time, and you could consider such a possibility.	The survey is concerned with people's "typical" or "common" behavior of travel, so the possibility identified by the interviewee should not be an issue.	
	I would add benefits of various information that people can gather at destinations. They can check the starting time of a movie, traffic information to move to the next destination, and so on.	His remark shows that among affective benefits, "curiosity for information" (in the questionnaire, "a chance of meeting nice people or happening to know something") can be actually a primary benefit.	Primary benefits (factor) --> curiosity for information
On-the-way benefits	(Another example) can be "unusual activities" that unexpectedly happen. In case of congestion, especially when using a bus or private car, people (could take them off before the destination and) could walk for a while, and you can consider this sudden walk travel.	This remark is to add an example of on-the-way activities. Meanwhile, this research is concerned with "typical" or "common" behavior of travel, and unusual conditions are not analyzed.	
Symbolic benefits	(To be added) is sharing a certain hobby while living in a particular area. For example, joining the membership of XX golf club by living in an area in Gangnam is a symbolic benefit.	He confirms the existence of the symbolic benefits.	
Instrumental benefits	Safety matters. Because of institutional factors that are out of control, like something blocking the street, people might change the way of traveling to secure their safety.	Among instrumental benefits, he highlights safety.	

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Affective benefits	When people travel with significant others like a friend or a spouse, what can be considered important is "sharing feelings" by having conversations or doing something together.	The interviewee acknowledges the significance of the on-the-way benefits.	

Questionnaire

Interview excerpts	Notes
There's a question of ambiguity; a statement with one meaning was used again or in a different way, so I assume people could feel kind of confused and difficulty in giving an answer. Where "various" and "unique" are shown, from a layperson's view, this part is what people might feel confused of. I think it will be better if a word expressing the "degree" is used to express them in more detail.	This research will specify each of them as follows: "a wide variety of … in type" and "unique … that are not found elsewhere". (Additions are underlined.)

Interview 23: BA (6) (Gasan, Geumcheon)

Name: XX, XX-XX (Occupation: owner of a delivery food store)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 0	Members: 2
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 6

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
On-the-way benefits	In a subway, it is good to see how people are doing. People have different faces in the morning and the evening.	The interviewee confirms that "curiosity for information" is a significant benefit.	
Affective benefits	Through indirect experiences, it's possible to know how the world is going on. When taking cabs, because drivers meet people in various classes, I ask them, for example, "sir, which political party do you support?", "how is taxi business these days?", and "how are your customers?" No matter what I ask, they answer all, all about how it generally goes. So, I take taxies a lot on purpose—even though I have enough time—to hear about the recent trend from the drivers. They know well about it.	He acknowledges that on-the-way benefits are indeed significant, and further argues that such benefits affect the mode choice.	

Questionnaire

Interview excerpts	Notes
The survey is tedious. It idly asks similar questions by using different words. They would be fine if asked two or three times, but four or five are inefficient.	This research will check the full list of the items and combine analogous items.
I didn't understand some questions directly, and I gave answers after thinking a while.	This research will revise items by using clearer and fuller terms that are accessible to a wider public. Also, a hand-delivered survey, regular reminders, and financial incentives will be designed to provide sufficient time for response and to increase the response rate.

Interview 24: BB (6) (Banghwa 3, Gangseo)

Name: XX, XXXX (Occupation: retired banker, currently working as building superintendent)				
Neighborhood	(1) Type: high compact / unplanned / new town / low compact			
	(2) Distance to urban center (miles): ≤ 1.7 / ≤ 3.4 / ≤ 5.1 / ≤ 6.8 / ≤ 8.5 / ≤ 10.2			
Demographics	(1) Household	Monthly income (million won): 5	Automobiles: 2	Members: 5
	(2) Individual	Gender: male / female	Marriage: married / single	Age group (decades): 6

Utility

Categories (factors)	Interview excerpts	Notes	Possible reclassification
Instrumental benefits	You feel the joy of controlling the movement only if you drive. Then, why are you asking this for different modes? Well, it is a little bit possible when you ride a bicycle. Then, isn't it an instrumental benefit, not an affective benefit?	The interviewee argues that "control" should be classified into the instrumental benefits category.	Instrumental benefits (factor) --> control

Questionnaire

Interview excerpts	Notes
Maybe because the word "comfort" is not commonly used, it's hard to understand the question. I hope you ask questions in the language that people use in their daily lives. Please don't use such an academic term.	The expression will be changed to "pleasantness or comfort".

APPENDIX E:

RESULTS OF STRUCTURAL EQUATION MODELING

E.1 Variable and Factor Names

This appendix shows SEM output produced by Amos for a total of 20 individual models. The models used different factor and variable names as shown in Table E.1: Differences were made by travel purpose (commuting, shopping, leisure, and overall), data type (the sample of the 2006 MHTS, entire MHTS, and 2013 survey), model specification (with and without the utility factor), and measure of travel behavior (trip frequencies and mode shares).

Table E.1 Factor and Variable Names

Factors (factor names in SEM and CFA)			Variables (variable names in SEM and CFA)	Survey items
Urban compactness (UC)			Population density (c1)	
			Road connectivity (c2)	
			Transit availability (c3)	
			Land use mix (c4)	
Socio-demographics (SD)			Household—size (s1)	V. (1)
			Household—children (s2)	V. (2)
			Household—automobiles (s3)	V. (3)
			Household—income (s4)	V. (4)
			Individual—gender (s5)	V. (5)
			Individual—age (s6)	V. (6)
			Individual—license (s7)	V. (7)
Travel behavior (FC, SC, FS, SS, FL, SL, FM, and SM)*			Auto trips (yAC, mcA, yAS, msA, yAL, mlA, yA, and mA)**	VI.
			Transit trips (yTC, mcT, yTS, msT, yTL, mlT, yT, and mT)***	VI.
			Nonmotorized trips (yNC, mcN, yNS, msN, yNL, mlN, yN, and mN)****	VI.
Utility (UT)	Primary benefits (uC1, uS1, uL1, and u1)*****		Destination density (ddens)†	I. (1)
			Destination variety (dvari)†	I. (2)
			Destination quality (dqual)†	I. (3)
			Destination uniqueness (duniq)†	I. (4)
	Secondary benefits (uC2, uS2, uL2, and u2)******	On-the-way benefits (Synergy)	Anti-activity—relaxation (relax)†	II–IV. (3)
			Anti-activity—thinking (think)†	II–IV. (2)
			External activities—while traveling (acttv)†	II–IV. (4)
			External activities—at stopovers (actst)†	II–IV. (1)
		Symbolic benefits (Symbolic)	Status show-off (show)†	II–IV. (9)
			Lifestyle expression (style)†	II–IV. (10)
			Prestige symbolization (prstg)†	II–IV. (11)
		Instrumental benefits (Instrumental)	Convenience (cnvc)†	II–IV. (7)
			Comfort (cmfrt)†	II–IV. (5)
			Privacy (prvcy)†	II–IV. (6)
			Safety (safe)†	II–IV. (8)

Table E.1 (continued)

			Control (ctrl)†	II–IV. (18)
			Independence (indep)†	II–IV. (19)
			Environmental concerns (envrn)†	II–IV. (12)
			Physical exercise (exerc)†	II–IV. (21)
		Affective benefits (Affective)	Variety-seeking (diff)†	II–IV. (13)
			Curiosity for information (curis)†	II–IV. (14)
			Buffer (buffr)†	II–IV. (15)
			Amenities (amnt)†	II–IV. (16)
			Exposure to outdoors (outdr)†	II–IV. (17)
			Escape (escp)†	II–IV. (20)
			Mental therapy (thrpy)†	II–IV. (22)
	Costs (uC3, uS3, uL3, and u3)*******		Trip time (uC3, uS3, uL3, and u3)	VII.

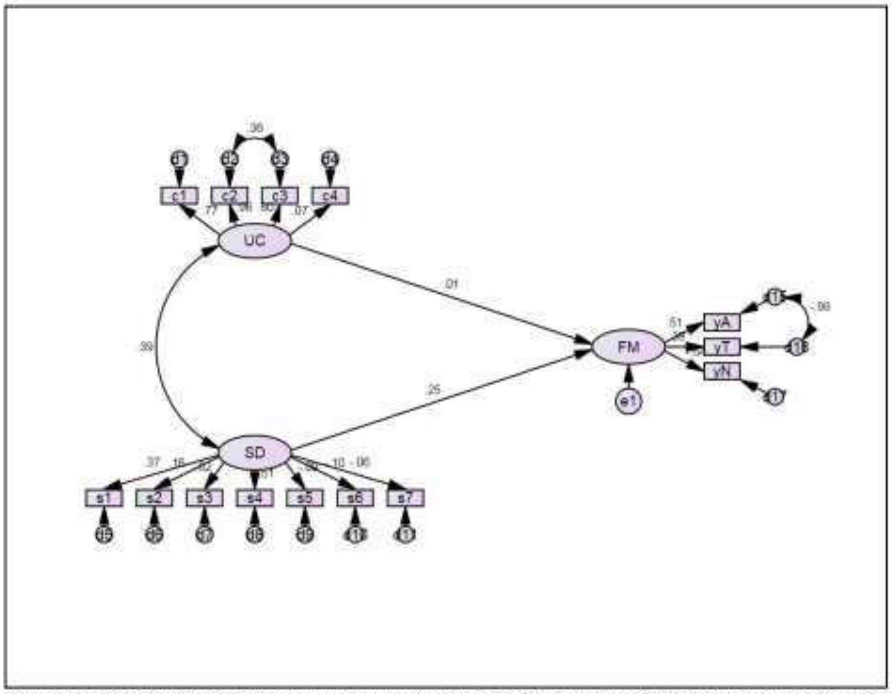
Table E.1 (continued)

* Trip frequencies (F) and mode shares (S) of the following trips: commuting trips (FC and SC), shopping trips (FS and SS), and leisure trips (FL and SL); those of overall trips (FM and SM) were calculated based on the mean of the three-time responses to the same survey item.
** Trip frequencies (y) and mode shares (m) of automobile trips (A) for the following purposes: commuting (yAC and mcA), shopping (yAS and msA), leisure (yAL and mlA), and overall, regardless of travel purpose (yA and mA)
*** Trip frequencies (y) and mode shares (m) of transit trips (T) for the following purposes: commuting (yTC and mcT), shopping (yTS and msT), leisure (yTL and mlT), and overall (yT and mT)
**** Trip frequencies (y) and mode shares (m) of nonmotorized trips (N) for the following purposes: commuting (yNC and mcN), shopping (yNS and msN), leisure (yNL and mlN), and overall (yN and mN)
***** Primary benefits (u1) of the following trips: commuting trips (uC1), shopping trips (uS1), and leisure trips (uL1); those of overall trips (u1) were calculated based on the mean of the three-time responses to the same survey item.
****** Secondary benefits (u2) of the following trips: commuting trips (uC2), shopping trips (uS2), and leisure trips (uL2); those of overall trips (u2) were calculated based on the mean of the three-time responses to the same survey item.
******* As represented by trip duration, travel costs (u3) of the following trips: commuting trips (uC3), shopping trips (uS3), and leisure trips (uL3); those of overall trips (u3) were calculated based on the mean for the three purposes of trips.
† Regarding psychometric items, four variables were made in confirmatory factor analysis (and higher-order confirmatory factor analysis), they differed by a prefix: for commuting (c_), for shopping (s_), for leisure (l_), and for the mean (mean_); for example, destination density for commuting was expressed as c_ddens.

The next section presents SEM results using figures and tables that were produced by Amos. The figures show standardized path coefficients (i.e., regression weights or correlations); they are the same as those coefficients in the "Standardized" column of the following tables: "Regression Weights" and "Covariances".

E.2 Output

E.2.1 Model A1: Frequencies of Overall Trips (Sample Data of the 2006 MHTS)



Note: In the initial SEM model, negative variances were present for d2 (-2.787) and d15 (-4.189), and to address this error, this research added correlation paths of d2 <--> d3 and d15 <--> d16.

Result (Default model)

Minimum was achieved
Chi-square = 172.872
Degrees of freedom = 72
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FM	<---	UC	.303	.051	5.901	***	.012
FM	<---	SD	.152	.028	5.413	***	.253
c1	<---	UC	5293206.386	1842870.151	2.872	.004	.599
c2	<---	UC	56372.880	19895.395	2.833	.005	.856
c3	<---	UC	1576.619	560.172	2.815	.005	.767
c4	<---	UC	1.000				.073
yA	<---	FM	1.000				.510
yT	<---	FM	1.015	.153	6.612	***	.389

			Unstandardized	S.E.	C.R.	p	Standardized
yN	<---	FM	-1.091	.177	-6.166	***	-.645
s1	<---	SD	1.000				.367
s2	<---	SD	.176	.038	4.596	***	.160
s3	<---	SD	.959	.103	9.302	***	.617
s4	<---	SD	2.046	.221	9.275	***	.509
s5	<---	SD	-.101	.039	-2.622	.009	-.086
s6	<---	SD	-3.038	1.017	-2.988	.003	-.099
s7	<---	SD	-.185	.103	-1.799	.072	-.059

*** p < 0.001

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	.002	.001	2.680	.007	.387
d2	<-->	d3	1265.298	640.748	1.975	.048	.365
d15	<-->	d16	-.257	.013	-19.459	***	-.983

*** p < 0.001

Squared Multiple Correlations

	Estimate
FM	.166
s7	.003
s6	.010
s5	.007
s4	.259
s3	.381
s2	.026
s1	.134
yN	.416
yT	.151
yA	.260
c4	.105
c3	.359
c2	.913
c1	.589

Total Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.152	.303	.000	.253	.012	.000
s7	-.185	.000	.000	-.059	.000	.000
s6	-3.038	.000	.000	-.099	.000	.000
s5	-.101	.000	.000	-.086	.000	.000
s4	2.046	.000	.000	.509	.000	.000
s3	.959	.000	.000	.617	.000	.000

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
s2	.176	.000	.000	.160	.000	.000
s1	1.000	.000	.000	.367	.000	.000
yN	-.166	-.331	-1.091	-.163	-.008	-.645
yT	.154	.308	1.015	.098	.005	.389
yA	.152	.303	1.000	.129	.006	.510
c4	.000	1.000	.000	.000	.073	.000
c3	.000	1576.619	.000	.000	.599	.000
c2	.000	56372.880	.000	.000	.956	.000
c1	.000	5293206.386	.000	.000	.767	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.152	.303	.000	.253	.012	.000
s7	-.185	.000	.000	-.059	.000	.000
s6	-3.038	.000	.000	-.099	.000	.000
s5	-.101	.000	.000	-.086	.000	.000
s4	2.046	.000	.000	.509	.000	.000
s3	.959	.000	.000	.617	.000	.000
s2	.176	.000	.000	.160	.000	.000
s1	1.000	.000	.000	.367	.000	.000
yN	.000	.000	-1.091	.000	.000	-.645
yT	.000	.000	1.015	.000	.000	.389
yA	.000	.000	1.000	.000	.000	.510
c4	.000	1.000	.000	.000	.073	.000
c3	.000	1576.619	.000	.000	.599	.000
c2	.000	56372.880	.000	.000	.956	.000
c1	.000	5293206.386	.000	.000	.767	.000

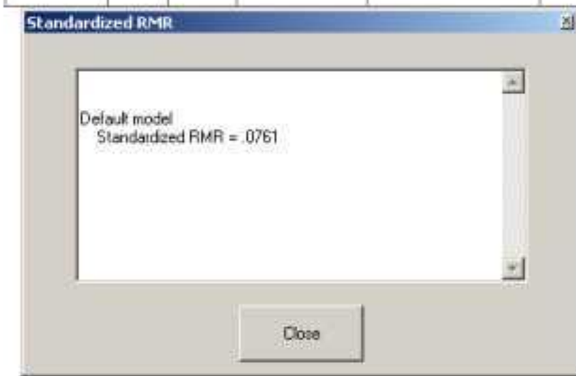
Indirect Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yN	-.166	-.331	.000	-.163	-.008	.000
yT	.154	.308	.000	.098	.005	.000
yA	.152	.303	.000	.129	.006	.000
c4	.000	.000	.000	.000	.000	.000

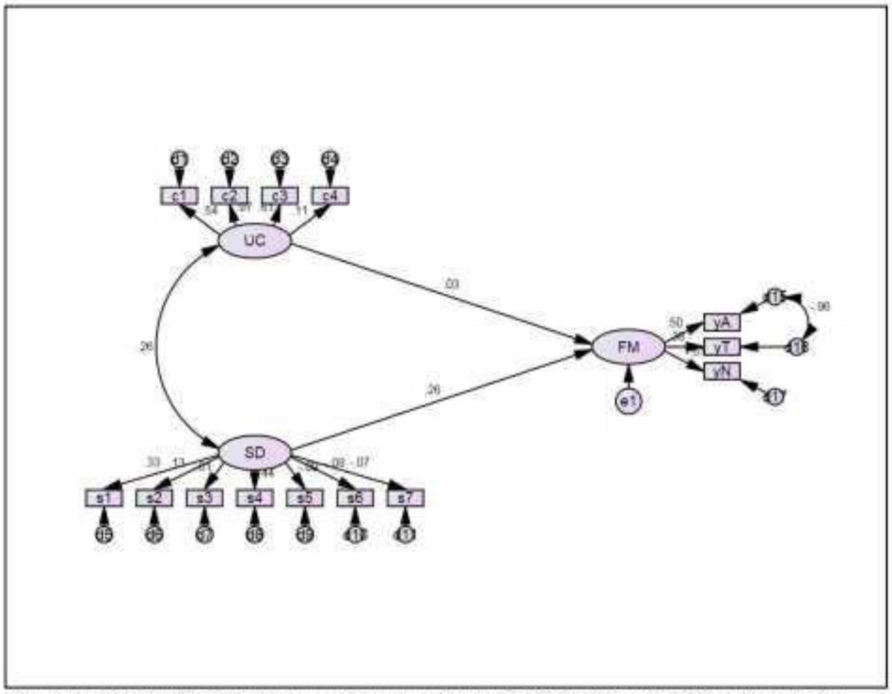
	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
172.872	72	.000	2.401	893	.029	.951	.934	.904	238.872	417.632



E.2.2 Model A2: Frequencies of Overall Trips (Entire Data of the 2006 MHTS)



Note: In the initial SEM model, negative variance was estimated for d15 (-5.484), and to address this error, this research added a correlation path of d15 <--> d16.

Result (Default model)

Minimum was achieved
Chi-square = 264.260
Degrees of freedom = 73
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FM	<---	UC	.422	.106	3.970	***	.027
FM	<---	SD	.181	.008	21.862	***	.257
c1	<---	UC	1766060.394	98550.614	17.920	***	.543
c2	<---	UC	30116.305	1687.208	17.850	***	.870
c3	<---	UC	1059.717	58.899	17.992	***	.609
c4	<---	UC	1.000				.109
yA	<---	FM	1.000				.496
yT	<---	FM	1.074	.041	25.904	***	.382

			Unstandardized	S.E.	C.R.	p	Standardized
yN	<---	FM	-1.069	.046	-23.325	***	-.611
s1	<---	SD	1.000				.329
s2	<---	SD	.174	.012	14.862	***	.128
s3	<---	SD	1.043	.033	31.314	***	.606
s4	<---	SD	2.249	.070	32.208	***	.444
s5	<---	SD	-.137	.012	-11.345	***	-.095
s6	<---	SD	-3.064	.306	-10.012	***	-.083
s7	<---	SD	-.300	.036	-8.435	***	-.069

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	.001	.000	14.316	***	.257
d15	<-->	d16	-.272	.004	-77.720	***	-.958

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FM	.170
s7	.005
s6	.007
s5	.009
s4	.197
s3	.367
s2	.016
s1	.108
yN	.374
yT	.146
yA	.246
c4	.112
c3	.370
c2	.941
c1	.295

Total Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.181	.422	.000	.257	.027	.000
s7	-.300	.000	.000	-.069	.000	.000
s6	-3.064	.000	.000	-.083	.000	.000
s5	-.137	.000	.000	-.095	.000	.000
s4	2.249	.000	.000	.444	.000	.000
s3	1.043	.000	.000	.606	.000	.000
s2	.174	.000	.000	.128	.000	.000

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
s1	1.000	.000	.000	.329	.000	.000
yN	-.193	-.451	-1.069	-.157	-.017	-.611
yT	.194	.453	1.074	.098	.011	.382
yA	.181	.422	1.000	.128	.014	.496
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1059.717	.000	.000	.609	.000
c2	.000	30116.305	.000	.000	.970	.000
c1	.000	1766060.394	.000	.000	.543	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.181	.422	.000	.257	.027	.000
s7	-.300	.000	.000	-.069	.000	.000
s6	-3.064	.000	.000	-.083	.000	.000
s5	-.137	.000	.000	-.095	.000	.000
s4	2.249	.000	.000	.444	.000	.000
s3	1.043	.000	.000	.606	.000	.000
s2	.174	.000	.000	.128	.000	.000
s1	1.000	.000	.000	.329	.000	.000
yN	.000	.000	-1.069	.000	.000	-.611
yT	.000	.000	1.074	.000	.000	.382
yA	.000	.000	1.000	.000	.000	.496
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1059.717	.000	.000	.609	.000
c2	.000	30116.305	.000	.000	.970	.000
c1	.000	1766060.394	.000	.000	.543	.000

Indirect Effects

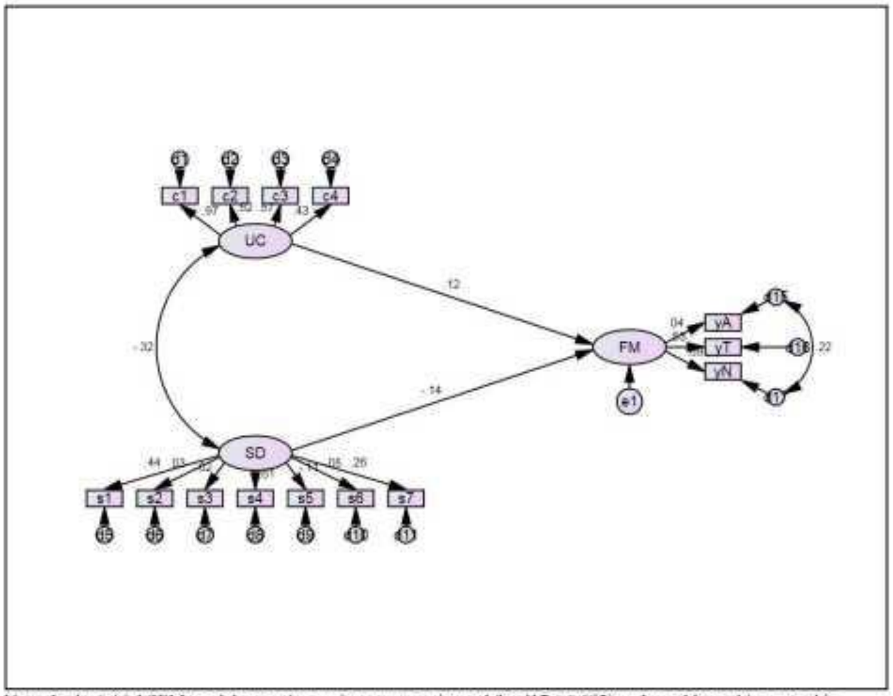
	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yN	-.193	-.451	.000	-.157	-.017	.000
yT	.194	.453	.000	.098	.011	.000
yA	.181	.422	.000	.128	.014	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
264.260	73	.000	3.620	10429	.009	.931	.949	.927	328.260	593.430

E.2.3 Model A3: Frequencies of Overall Trips (Data of the 2013 Survey) without Consideration of Utility



Note: In the initial SEM model, negative variance was estimated for d17 (-6.692) and to address this error, this research added a correlation path of d15 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 256.595
Degrees of freedom = 73
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FM	<---	UC	.558	.297	1.881	.060	.117
FM	<---	SD	-.060	.021	-2.843	.004	-.136
c1	<---	UC	649758.077	53286.798	12.194	***	.519
c2	<---	UC	2666.575	229.228	11.633	***	.869
c3	<---	UC	335.603	27.427	12.236	***	.575
c4	<---	UC	1.000				.428
yA	<---	FM	1.000				.042
yT	<---	FM	27.373	1.846	14.825	***	.535

			Unstandardized	S.E.	C.R.	p	Standardized
yN	<---	FM	50.161	3.556	14.106	***	.694
s1	<---	SD	1.000				.440
s2	<---	SD	.038	.048	.794	.427	.031
s3	<---	SD	.717	.079	9.026	***	.619
s4	<---	SD	2.970	.329	9.038	***	.605
s5	<---	SD	-.105	.039	-2.694	.007	-.109
s6	<---	SD	1.351	1.001	1.351	.177	.054
s7	<---	SD	.238	.041	5.862	***	.264

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.008	.001	-5.742	***	-.323
d15	<-->	d17	14.230	3.662	3.886	***	.223

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FM	.143
s7	.070
s6	.003
s5	.012
s4	.367
s3	.383
s2	.001
s1	.194
yN	.482
yT	.286
yA	.191
c4	.184
c3	.330
c2	.269
c1	.938

Total Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	-.060	.558	.000	-.136	.117	.000
s7	.238	.000	.000	.264	.000	.000
s6	1.351	.000	.000	.054	.000	.000
s5	-.105	.000	.000	-.109	.000	.000
s4	2.970	.000	.000	.605	.000	.000
s3	.717	.000	.000	.619	.000	.000
s2	.038	.000	.000	.031	.000	.000

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
s1	1.000	.000	.000	.440	.000	.000
yN	-3.026	28.006	50.161	-.095	.081	.694
yT	-1.651	15.283	27.373	-.073	.063	.535
yA	-.060	.558	1.000	-.006	.005	.042
c4	.000	1.000	.000	.000	.428	.000
c3	.000	335.603	.000	.000	.575	.000
c2	.000	2666.575	.000	.000	.519	.000
c1	.000	649758.077	.000	.000	.969	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	-.060	.558	.000	-.136	.117	.000
s7	.238	.000	.000	.264	.000	.000
s6	1.351	.000	.000	.054	.000	.000
s5	-.105	.000	.000	-.109	.000	.000
s4	2.970	.000	.000	.605	.000	.000
s3	.717	.000	.000	.619	.000	.000
s2	.038	.000	.000	.031	.000	.000
s1	1.000	.000	.000	.440	.000	.000
yN	.000	.000	50.161	.000	.000	.694
yT	.000	.000	27.373	.000	.000	.535
yA	.000	.000	1.000	.000	.000	.042
c4	.000	1.000	.000	.000	.428	.000
c3	.000	335.603	.000	.000	.575	.000
c2	.000	2666.575	.000	.000	.519	.000
c1	.000	649758.077	.000	.000	.969	.000

Indirect Effects

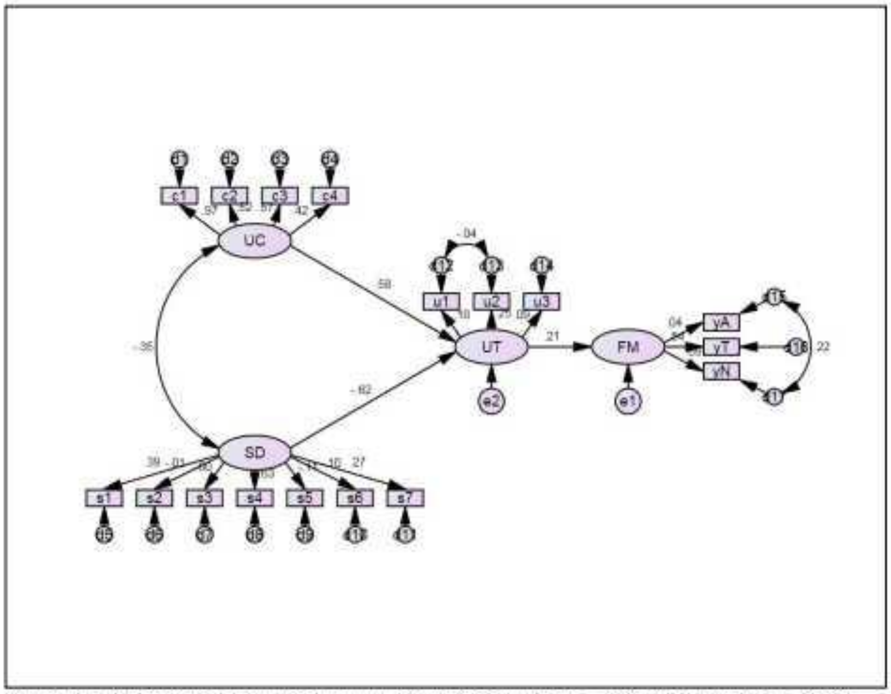
	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
FM	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yN	-3.026	28.006	.000	-.095	.081	.000
yT	-1.651	15.283	.000	-.073	.063	.000
yA	-.060	.558	.000	-.006	.005	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000

	Unstandardized			Standardized		
	SD	UC	FM	SD	UC	FM
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi2$	d.f.	p	Relative $\chi2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
256.595	73	.000	3.515	378	.049	.933	.925	.892	320.595	478.651

E.2.4 Model A4: Frequencies of Overall Trips (Data of the 2013 Survey) with Consideration of Utility



Note: In the initial SEM model, Heywood case was present for e2 (variance = -.016) and d17 (variance = -2.184), and this research addressed this error by adding correlation paths of d12 <--> d13 and d15 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 356.063
Degrees of freedom = 113
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	1.923	.473	4.061	***	.584
UT	<---	SD	-.210	.057	-3.656	***	-.620
FM	<---	UT	.311	.071	4.371	***	.214
c1	<---	UC	658776.191	53373.669	12.343	***	.518
c2	<---	UC	2689.092	232.266	11.578	***	.872
c3	<---	UC	338.080	27.794	12.164	***	.573
c4	<---	UC	1.000				.424
u1	<---	UT	1.000				.178

			Unstandardized	S.E.	C.R.	p	Standardized
u2	<---	UT	1.247	.295	4.221	***	.253
u3	<---	UT	4520.729	2011.553	2.247	.025	.086
yA	<---	FM	1.000				.042
yT	<---	FM	27.649	6.541	4.227	***	.538
yN	<---	FM	49.992	12.938	3.864	***	.690
s1	<---	SD	1.000				.394
s2	<---	SD	-.013	.053	-.250	.803	-.010
s3	<---	SD	.777	.091	8.522	***	.601
s4	<---	SD	3.454	.405	8.518	***	.630
s5	<---	SD	-.118	.044	-2.693	.007	-.109
s6	<---	SD	2.773	1.134	2.446	.014	.099
s7	<---	SD	.271	.047	5.796	***	.269

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.008	.001	-5.800	***	-.349
d12	<-->	d13	-.027	.026	-1.052	.293	-.042
d15	<-->	d17	14.256	3.617	3.941	***	.222

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.779
FM	.146
s7	.072
s6	.010
s5	.012
s4	.397
s3	.361
s2	.000
s1	.155
yN	.476
yT	.290
yA	.261
u3	.307
u2	.364
u1	.332
c4	.180
c3	.328
c2	.268
c1	.946

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	FM	SD	UC	UT	FM
UT	-.210	1.923	.000	.000	-.620	.584	.000	.000
FM	-.065	.598	.311	.000	-.132	.125	.214	.000
s7	.271	.000	.000	.000	.269	.000	.000	.000
s6	2.773	.000	.000	.000	.099	.000	.000	.000
s5	-.118	.000	.000	.000	-.109	.000	.000	.000
s4	3.454	.000	.000	.000	.630	.000	.000	.000
s3	.777	.000	.000	.000	.601	.000	.000	.000
s2	-.013	.000	.000	.000	-.010	.000	.000	.000
s1	1.000	.000	.000	.000	.394	.000	.000	.000
yN	-3.259	29.898	15.551	49.992	-.091	.086	.147	.690
yT	-1.802	16.536	8.601	27.649	-.071	.067	.115	.538
yA	-.065	.598	.311	1.000	-.006	.005	.009	.042
u3	-947.349	8691.378	4520.729	.000	-.053	.050	.086	.000
u2	-.261	2.398	1.247	.000	-.157	.148	.253	.000
u1	-.210	1.923	1.000	.000	-.110	.104	.178	.000
c4	.000	1.000	.000	.000	.000	.424	.000	.000
c3	.000	338.080	.000	.000	.000	.573	.000	.000
c2	.000	2689.092	.000	.000	.000	.518	.000	.000
c1	.000	658776.191	.000	.000	.000	.972	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	FM	SD	UC	UT	FM
UT	-.210	1.923	.000	.000	-.620	.584	.000	.000
FM	.000	.000	.311	.000	.000	.000	.214	.000
s7	.271	.000	.000	.000	.269	.000	.000	.000
s6	2.773	.000	.000	.000	.099	.000	.000	.000
s5	-.118	.000	.000	.000	-.109	.000	.000	.000
s4	3.454	.000	.000	.000	.630	.000	.000	.000
s3	.777	.000	.000	.000	.601	.000	.000	.000
s2	-.013	.000	.000	.000	-.010	.000	.000	.000
s1	1.000	.000	.000	.000	.394	.000	.000	.000
yN	.000	.000	.000	49.992	.000	.000	.000	.690
yT	.000	.000	.000	27.649	.000	.000	.000	.538
yA	.000	.000	.000	1.000	.000	.000	.000	.042
u3	.000	.000	4520.729	.000	.000	.000	.086	.000
u2	.000	.000	1.247	.000	.000	.000	.253	.000
u1	.000	.000	1.000	.000	.000	.000	.178	.000
c4	.000	1.000	.000	.000	.000	.424	.000	.000
c3	.000	338.080	.000	.000	.000	.573	.000	.000
c2	.000	2689.092	.000	.000	.000	.518	.000	.000
c1	.000	658776.191	.000	.000	.000	.972	.000	.000

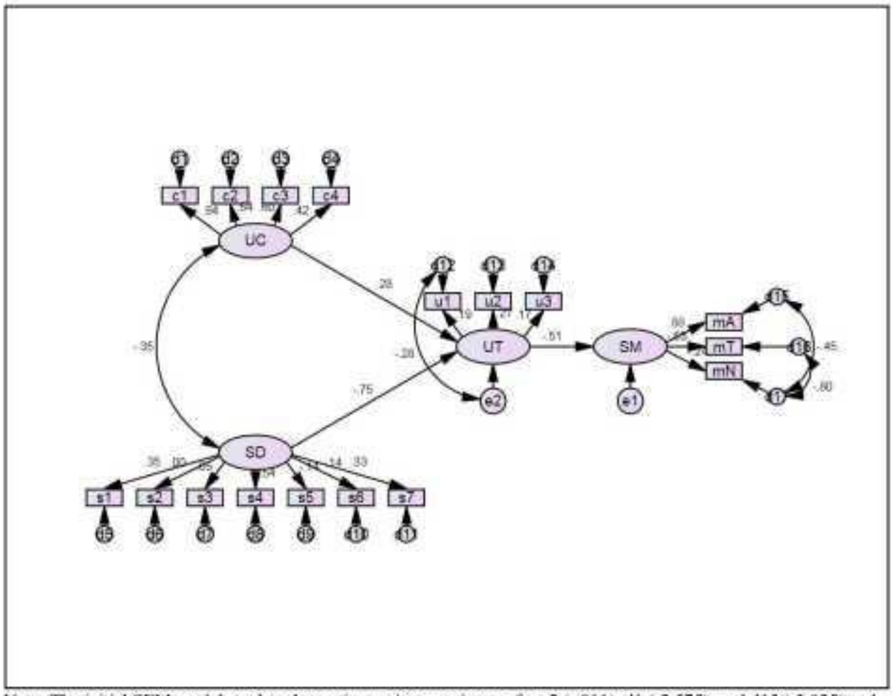
Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	FM	SD	UC	UT	FM
UT	.000	.000	.000	.000	.000	.000	.000	.000
FM	-.065	.598	.000	.000	-.132	.125	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
yN	-3.259	29.898	15.551	.000	-.091	.086	.147	.000
yT	-1.802	16.536	8.601	.000	-.071	.067	.115	.000
yA	-.065	.598	.311	.000	-.006	.005	.009	.000
u3	-947.349	8691.378	.000	.000	-.053	.050	.000	.000
u2	-.261	2.398	.000	.000	-.157	.148	.000	.000
u1	-.210	1.923	.000	.000	-.110	.104	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
356.063	113	.000	3.151	402	.046	.904	.924	.897	436.063	633.633

E.2.5 Model A5: Mode Shares of Overall Trips (Data of the 2013 Survey) with Consideration of Utility



Note: The initial SEM model produced negative variance estimates for e2 (-.011), d1 (-2.575), and d15 (-3.035) and to address this error, this research modified the model for a multiple times. On the while, the issue was resolved by adding three correlation paths: d12 <--> e2, d15 <--> d17, and d16 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 251.440
Degrees of freedom = 112
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	1.006	.316	3.185	.001	.279
UT	<---	SD	-.303	.076	-3.982	***	-.749
SM	<---	UT	-.856	.201	-4.256	***	-.512
c1	<---	UC	646478.471	53482.482	12.088	***	.544
c2	<---	UC	2873.064	252.926	11.359	***	.839
c3	<---	UC	358.475	30.261	11.846	***	.598
c4	<---	UC	1.000				.417

			Unstandardized	S.E.	C.R.	p	Standardized
u1	<---	UT	1.000				.192
u2	<---	UT	1.252	.330	3.793	***	.274
u3	<---	UT	8291.197	2669.642	3.106	.002	.169
mA	<---	SM	1.000				.883
mT	<---	SM	-.664	.089	-7.452	***	-.533
mN	<---	SM	-.286	.089	-3.230	.001	-.239
s1	<---	SD	1.000				.354
s2	<---	SD	-.003	.059	-.060	.952	-.002
s3	<---	SD	.935	.115	8.124	***	.650
s4	<---	SD	3.309	.417	7.942	***	.543
s5	<---	SD	-.164	.049	-3.329	***	-.137
s6	<---	SD	4.426	1.294	3.420	***	.142
s7	<---	SD	.371	.058	6.447	***	.332

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.007	.001	-5.528	***	-.348
d12	<-->	e2	-.020	.012	-1.578	.115	-.282
d15	<-->	d17	-.022	.009	-2.375	.018	-.452
d16	<-->	d17	-.078	.006	-13.568	***	-.796

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.785
SM	.262
s7	.110
s6	.020
s5	.019
s4	.295
s3	.422
s2	.000
s1	.126
mN	.173
mT	.285
mA	.780
u3	.329
u2	.375
u1	.314
c4	.174
c3	.357
c2	.296
c1	.881

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	SM	SD	UC	UT	SM
UT	-.303	1.006	.000	.000	-.749	.279	.000	.000
SM	.260	-.861	-.856	.000	.383	-.143	-.512	.000
s7	.371	.000	.000	.000	.332	.000	.000	.000
s6	4.426	.000	.000	.000	.142	.000	.000	.000
s5	-.164	.000	.000	.000	-.137	.000	.000	.000
s4	3.309	.000	.000	.000	.543	.000	.000	.000
s3	.935	.000	.000	.000	.650	.000	.000	.000
s2	-.003	.000	.000	.000	-.002	.000	.000	.000
s1	1.000	.000	.000	.000	.354	.000	.000	.000
mN	-.074	.247	.245	-.286	-.091	.034	.122	-.239
mT	-.172	.572	.569	-.664	-.204	.076	.273	-.533
mA	.260	-.861	-.856	1.000	.338	-.126	-.452	.883
u3	-2514.606	8341.683	8291.197	.000	-.127	.047	.169	.000
u2	-.380	1.260	1.252	.000	-.205	.076	.274	.000
u1	-.303	1.006	1.000	.000	-.144	.054	.192	.000
c4	.000	1.000	.000	.000	.000	.417	.000	.000
c3	.000	358.475	.000	.000	.000	.598	.000	.000
c2	.000	2873.064	.000	.000	.000	.544	.000	.000
c1	.000	646478.471	.000	.000	.000	.939	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	SM	SD	UC	UT	SM
UT	-.303	1.006	.000	.000	-.749	.279	.000	.000
SM	.000	.000	-.856	.000	.000	.000	-.512	.000
s7	.371	.000	.000	.000	.332	.000	.000	.000
s6	4.426	.000	.000	.000	.142	.000	.000	.000
s5	-.164	.000	.000	.000	-.137	.000	.000	.000
s4	3.309	.000	.000	.000	.543	.000	.000	.000
s3	.935	.000	.000	.000	.650	.000	.000	.000
s2	-.003	.000	.000	.000	-.002	.000	.000	.000
s1	1.000	.000	.000	.000	.354	.000	.000	.000
mN	.000	.000	.000	-.286	.000	.000	.000	-.239
mT	.000	.000	.000	-.664	.000	.000	.000	-.533
mA	.000	.000	.000	1.000	.000	.000	.000	.883
u3	.000	.000	8291.197	.000	.000	.000	.169	.000
u2	.000	.000	1.252	.000	.000	.000	.274	.000
u1	.000	.000	1.000	.000	.000	.000	.192	.000
c4	.000	1.000	.000	.000	.000	.417	.000	.000
c3	.000	358.475	.000	.000	.000	.598	.000	.000
c2	.000	2873.064	.000	.000	.000	.544	.000	.000
c1	.000	646478.471	.000	.000	.000	.939	.000	.000

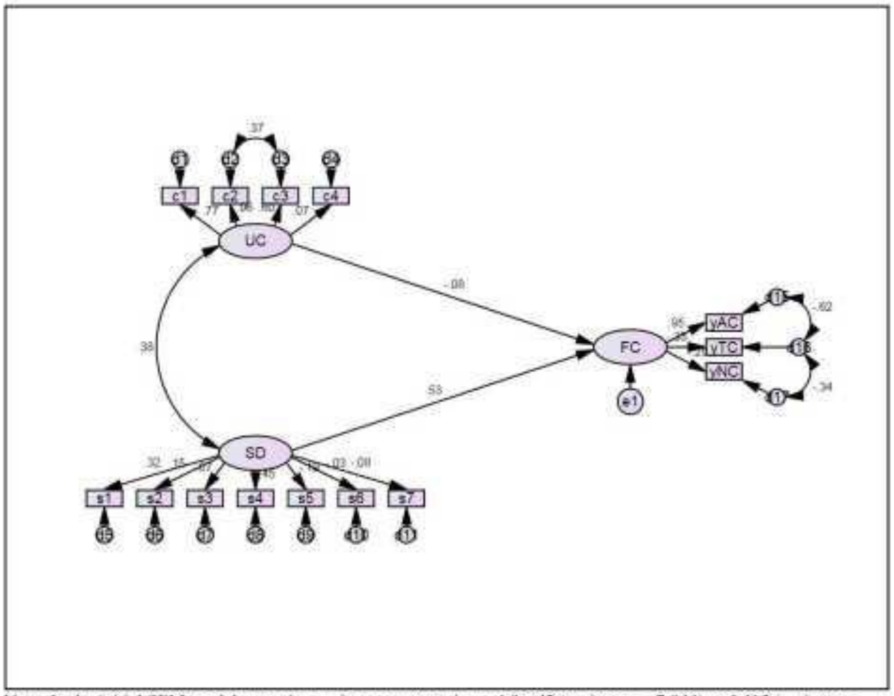
Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	SM	SD	UC	UT	SM
UT	.000	.000	.000	.000	.000	.000	.000	.000
SM	.260	-.861	.000	.000	.383	-.143	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
mN	-.074	.247	.245	.000	-.091	.034	.122	.000
mT	-.172	.572	.569	.000	-.204	.076	.273	.000
mA	.260	-.861	-.856	.000	.338	-.126	-.452	.000
u3	-2514.606	8341.683	.000	.000	-.127	.047	.000	.000
u2	-.380	1.260	.000	.000	-.205	.076	.000	.000
u1	-.303	1.006	.000	.000	-.144	.054	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
251.440	112	.000	2.245	565	.035	.954	.921	.892	333.440	535.949

E.2.6 Model C1: Frequencies of Commuting Trips (Sample Data of the 2006 MHTS)



Note: In the initial SEM model, negative variances were estimated for d2 (variance = -7.044) and d15 (variance = -1.544). This research resolved the former error with the path of d2 <--> d3 and for the second, it added two paths: d15 <--> d16 and d16 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 175.015
Degrees of freedom = 71
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FC	<---	UC	-3.361	1.783	-1.885	.059	-.078
FC	<---	SD	.610	.073	8.312	***	.525
c1	<---	UC	5254894.677	1816390.977	2.893	.004	.598
c2	<---	UC	55962.733	19628.106	2.851	.004	.956
c3	<---	UC	1561.720	551.514	2.832	.005	.767
c4	<---	UC	1.000				.074
yAC	<---	FC	1.000				.953

			Unstandardized	S.E.	C.R.	p	Standardized
yTC	<---	FC	-.496	.088	-5.648	***	-.331
yNC	<---	FC	-.221	.057	-3.837	***	-.248
s1	<---	SD	1.000				.315
s2	<---	SD	.196	.043	4.528	***	.154
s3	<---	SD	1.208	.132	9.128	***	.668
s4	<---	SD	2.091	.242	8.623	***	.447
s5	<---	SD	-.263	.049	-5.418	***	-.193
s6	<---	SD	-1.044	1.102	-.947	.343	-.029
s7	<---	SD	-.312	.117	-2.663	.008	-.085

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	.001	.001	2.676	.007	.379
d2	<-->	d3	1285.001	653.682	1.966	.049	.370
d15	<-->	d16	-.049	.030	-1.617	.106	-.620
d16	<-->	d17	-.074	.006	-11.971	***	-.342

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FC	.251
s7	.007
s6	.001
s5	.037
s4	.200
s3	.446
s2	.024
s1	.099
yNC	.161
yTC	.110
yAC	.908
c4	.105
c3	.357
c2	.913
c1	.588

Total Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.610	-3.361	.000	.525	-.078	.000
s7	-.312	.000	.000	-.085	.000	.000
s6	-1.044	.000	.000	-.029	.000	.000
s5	-.263	.000	.000	-.193	.000	.000

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
s4	2.091	.000	.000	.447	.000	.000
s3	1.208	.000	.000	.668	.000	.000
s2	.196	.000	.000	.154	.000	.000
s1	1.000	.000	.000	.315	.000	.000
yNC	-.134	.741	-.221	-.130	.019	-.248
yTC	-.302	1.667	-.496	-.174	.026	-.331
yAC	.610	-3.361	1.000	.500	-.075	.953
c4	.000	1.000	.000	.000	.074	.000
c3	.000	1561.720	.000	.000	.598	.000
c2	.000	55962.733	.000	.000	.956	.000
c1	.000	5254894.677	.000	.000	.767	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.610	-3.361	.000	.525	-.078	.000
s7	-.312	.000	.000	-.085	.000	.000
s6	-1.044	.000	.000	-.029	.000	.000
s5	-.263	.000	.000	-.193	.000	.000
s4	2.091	.000	.000	.447	.000	.000
s3	1.208	.000	.000	.668	.000	.000
s2	.196	.000	.000	.154	.000	.000
s1	1.000	.000	.000	.315	.000	.000
yNC	.000	.000	-.221	.000	.000	-.248
yTC	.000	.000	-.496	.000	.000	-.331
yAC	.000	.000	1.000	.000	.000	.953
c4	.000	1.000	.000	.000	.074	.000
c3	.000	1561.720	.000	.000	.598	.000
c2	.000	55962.733	.000	.000	.956	.000
c1	.000	5254894.677	.000	.000	.767	.000

Indirect Effects

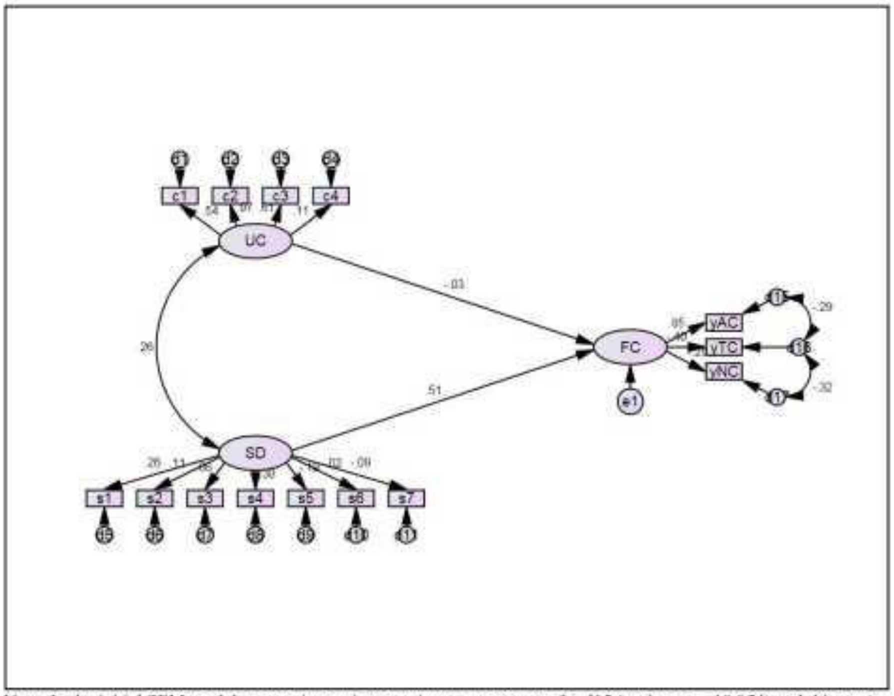
	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNC	-.134	.741	.000	-.130	.019	.000
yTC	-.302	1.667	.000	-.174	.026	.000

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
yAC	.610	-3.361	.000	.500	-.075	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
175.015	71	.000	2.465	872	.030	.921	.931	.898	243.015	427.192

E.2.7 Model C2: Frequencies of Commuting Trips (Entire Data of the 2006 MHTS)



Note: In the initial SEM model, a negative variance estimate was present for d15 (variance = -10.054) and this error was resolved by two additional paths: d15 <--> d16 and d16 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 226.152
Degrees of freedom = 72
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FC	<---	UC	-.610	.184	-3.307	***	-.026
FC	<---	SD	.692	.024	28.892	***	.514
c1	<---	UC	1769020.774	98842.597	17.897	***	.544
c2	<---	UC	30062.567	1686.085	17.830	***	.968
c3	<---	UC	1061.267	59.063	17.969	***	.610
c4	<---	UC	1.000				.109
yAC	<---	FC	1.000				.855
yTC	<---	FC	-.710	.024	-29.074	***	-.403

			Unstandardized	S.E.	C.R.	p	Standardized
yNC	<---	FC	-.238	.015	-16.395	***	-.255
s1	<---	SD	1.000				.262
s2	<---	SD	.190	.014	13.469	***	.112
s3	<---	SD	1.432	.048	29.610	***	.663
s4	<---	SD	2.425	.085	28.586	***	.381
s5	<---	SD	-.343	.017	-20.283	***	-.190
s6	<---	SD	.871	.355	2.451	.014	.019
s7	<---	SD	-.475	.044	-10.845	***	-.087

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	.001	.000	14.008	***	.259
d15	<-->	d16	-.042	.008	-5.336	***	-.295
d16	<-->	d17	-.068	.001	-46.149	***	-.321

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FC	.258
s7	.008
s6	.000
s5	.036
s4	.145
s3	.439
s2	.012
s1	.069
yNC	.165
yTC	.163
yAC	.731
c4	.112
c3	.372
c2	.937
c1	.296

Total Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.692	-.610	.000	.514	-.026	.000
s7	-.475	.000	.000	-.087	.000	.000
s6	.871	.000	.000	.019	.000	.000
s5	-.343	.000	.000	-.190	.000	.000
s4	2.425	.000	.000	.381	.000	.000
s3	1.432	.000	.000	.663	.000	.000

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
s2	.190	.000	.000	.112	.000	.000
s1	1.000	.000	.000	.262	.000	.000
yNC	-.165	.145	-.238	-.131	.007	-.255
yTC	-.492	.433	-.710	-.207	.011	-.403
yAC	.692	-.610	1.000	.440	-.022	.855
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1061.267	.000	.000	.610	.000
c2	.000	30062.567	.000	.000	.968	.000
c1	.000	1769020.774	.000	.000	.544	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.692	-.610	.000	.514	-.026	.000
s7	-.475	.000	.000	-.087	.000	.000
s6	.871	.000	.000	.019	.000	.000
s5	-.343	.000	.000	-.190	.000	.000
s4	2.425	.000	.000	.381	.000	.000
s3	1.432	.000	.000	.663	.000	.000
s2	.190	.000	.000	.112	.000	.000
s1	1.000	.000	.000	.262	.000	.000
yNC	.000	.000	-.238	.000	.000	-.255
yTC	.000	.000	-.710	.000	.000	-.403
yAC	.000	.000	1.000	.000	.000	.855
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1061.267	.000	.000	.610	.000
c2	.000	30062.567	.000	.000	.968	.000
c1	.000	1769020.774	.000	.000	.544	.000

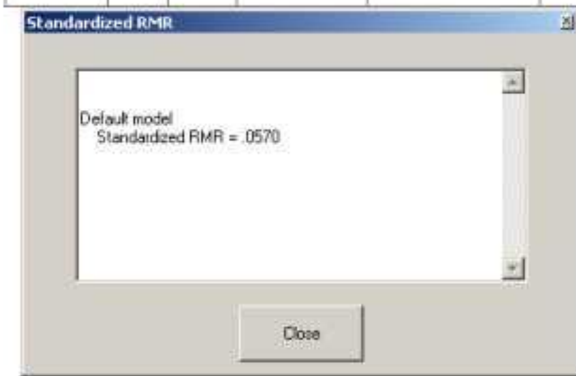
Indirect Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNC	-.165	.145	.000	-.131	.007	.000
yTC	-.492	.433	.000	-.207	.011	.000
yAC	.692	-.610	.000	.440	-.022	.000
c4	.000	.000	.000	.000	.000	.000

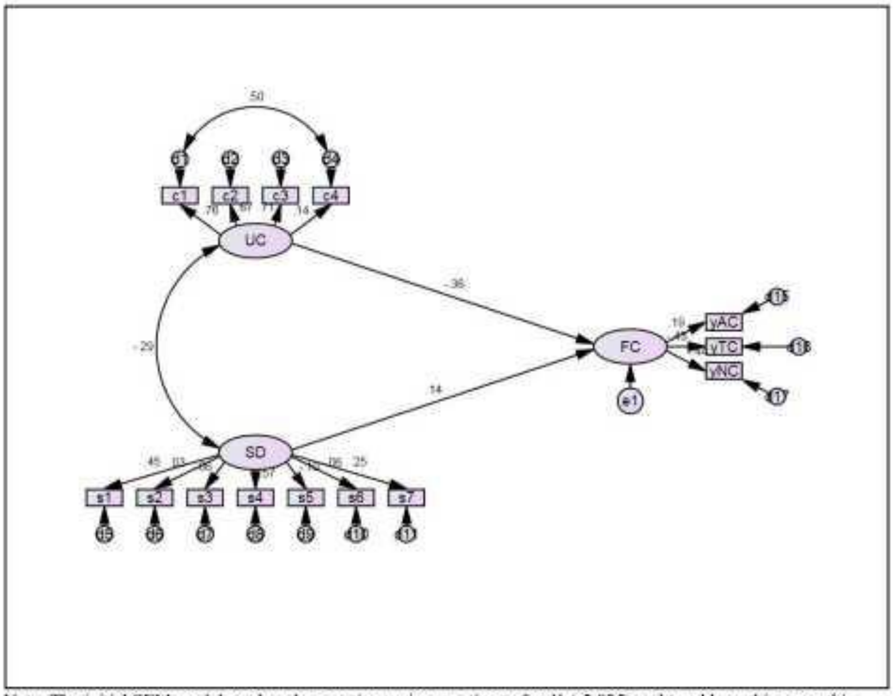
	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi2$	d.f.	p	Relative $\chi2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
226.152	72	.000	3.141	12039	.009	.882	.945	.920	292.152	565.609



E.2.8 Model C3: Frequencies of Commuting Trips (Data of the 2013 Survey) without Consideration of Utility



Note: The initial SEM model produced a negative variance estimate for d1 (-2.035) and to address this error, this research added a correlation path of d1 <--> d4.

Result (Default model)

Minimum was achieved
Chi-square = 220.460
Degrees of freedom = 73
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FC	<---	UC	-11.192	4.688	-2.387	.017	-.356
FC	<---	SD	.127	.076	1.675	.094	.136
c1	<---	UC	1552365.108	393489.409	3.945	***	.669
c2	<---	UC	10440.859	2847.358	3.667	***	.763
c3	<---	UC	1265.694	344.821	3.671	***	.715
c4	<---	UC	1.000				.141
yAC	<---	FC	1.000				.186
yTC	<---	FC	-6.097	1.877	-3.248	.001	-.433

	Unstandardized	S.E.	C.R.	p	Standardized
yNC <--- FC	-6.576	2.027	-3.244	.001	-.440
s1 <--- SD	1.000				.451
s2 <--- SD	.037	.047	.794	.427	.031
s3 <--- SD	.745	.083	8.990	***	.659
s4 <--- SD	2.736	.299	9.159	***	.572
s5 <--- SD	-.093	.038	-2.448	.014	-.098
s6 <--- SD	1.449	.975	1.486	.137	.059
s7 <--- SD	.217	.039	5.609	***	.247

*** $p < 0.001$

Covariances

	Estimate	S.E.	C.R.	p	Correlations
UC <--> SD	-.002	.001	-3.100	.002	-.286
d1 <--> d4	1162.168	104.061	11.168	***	.503

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FC	.173
s7	.061
s6	.003
s5	.010
s4	.327
s3	.435
s2	.001
s1	.203
yNC	.193
yTC	.187
yAC	.135
c4	.020
c3	.511
c2	.448
c1	.582

Total Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.127	-11.192	.000	.136	-.356	.000
s7	.217	.000	.000	.247	.000	.000
s6	1.449	.000	.000	.059	.000	.000
s5	-.093	.000	.000	-.098	.000	.000
s4	2.736	.000	.000	.572	.000	.000
s3	.745	.000	.000	.659	.000	.000
s2	.037	.000	.000	.031	.000	.000

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
s1	1.000	.000	.000	.451	.000	.000
yNC	-.838	73.594	-6.576	-.060	.157	-.440
yTC	-.777	68.236	-6.097	-.059	.154	-.433
yAC	.127	-11.192	1.000	.025	-.066	.186
c4	.000	1.000	.000	.000	.141	.000
c3	.000	1265.694	.000	.000	.715	.000
c2	.000	10440.859	.000	.000	.669	.000
c1	.000	1552365.108	.000	.000	.763	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.127	-11.192	.000	.136	-.356	.000
s7	.217	.000	.000	.247	.000	.000
s6	1.449	.000	.000	.059	.000	.000
s5	-.093	.000	.000	-.098	.000	.000
s4	2.736	.000	.000	.572	.000	.000
s3	.745	.000	.000	.659	.000	.000
s2	.037	.000	.000	.031	.000	.000
s1	1.000	.000	.000	.451	.000	.000
yNC	.000	.000	-6.576	.000	.000	-.440
yTC	.000	.000	-6.097	.000	.000	-.433
yAC	.000	.000	1.000	.000	.000	.186
c4	.000	1.000	.000	.000	.141	.000
c3	.000	1265.694	.000	.000	.715	.000
c2	.000	10440.859	.000	.000	.669	.000
c1	.000	1552365.108	.000	.000	.763	.000

Indirect Effects

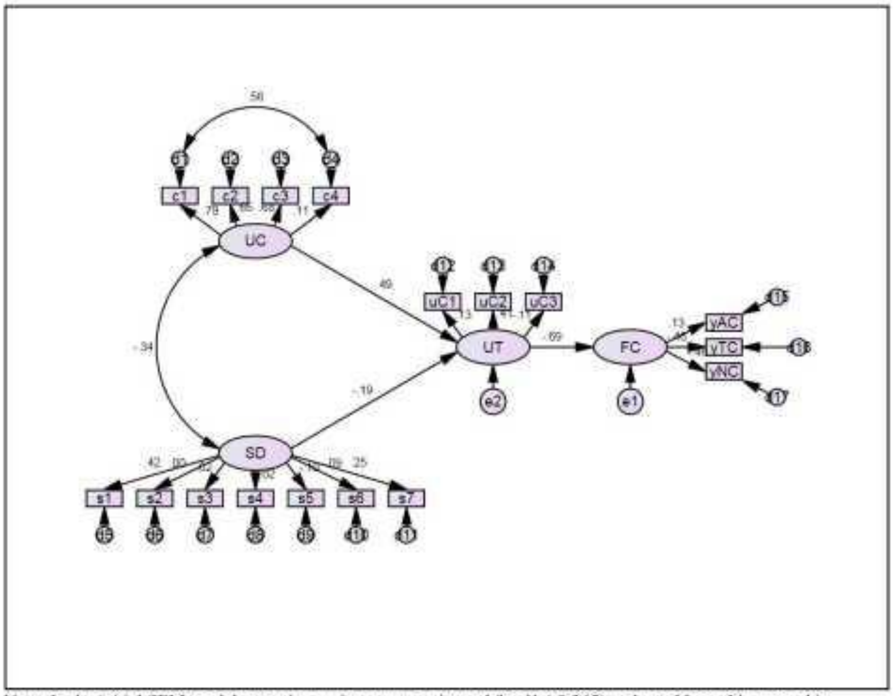
	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
FC	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNC	-.838	73.594	.000	-.060	.157	.000
yTC	-.777	68.236	.000	-.059	.154	.000
yAC	.127	-11.192	.000	.025	-.066	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000

	Unstandardized			Standardized		
	SD	UC	FC	SD	UC	FC
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
220.460	73	.000	3.020	440	.044	.942	.943	.918	284.460	442.516

E.2.9 Model C4: Frequencies of Commuting Trips (Data of the 2013 Survey) with Consideration of Utility



Note: In the initial SEM model, negative variance was estimated for d1 (-9.365) and to address this error, this research added a correlation path of d1 <--> d4.

Result (Default model)

Minimum was achieved
Chi-square = 272.118
Degrees of freedom = 114
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	5.935	3.056	1.942	.052	.488
UT	<---	SD	-.058	.032	-1.804	.071	-.187
FC	<---	UT	-1.586	.833	-1.904	.057	-.691
c1	<---	UC	1999058.842	650260.680	3.074	.002	.653
c2	<---	UC	12692.095	4380.193	2.898	.004	.788
c3	<---	UC	1507.761	520.022	2.899	.004	.683
c4	<---	UC	1.000				.113
uC1	<---	UT	1.000				.129

			Unstandardized	S.E.	C.R.	p	Standardized
uC2	<---	UT	2.608	1.005	2.596	.009	.409
uC3	<---	UT	-623.073	348.086	-1.790	.073	-.110
yAC	<---	FC	1.000				.133
yTC	<---	FC	-9.010	3.443	-2.617	.009	-.456
yNC	<---	FC	-9.578	3.660	-2.617	.009	-.456
s1	<---	SD	1.000				.420
s2	<---	SD	-.005	.050	-.099	.921	-.004
s3	<---	SD	.753	.086	8.758	***	.620
s4	<---	SD	3.174	.362	8.762	***	.617
s5	<---	SD	-.098	.041	-2.412	.016	-.097
s6	<---	SD	2.341	1.062	2.205	.027	.089
s7	<---	SD	.233	.042	5.497	***	.246

*** p < 0.001

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.002	.001	-2.651	.008	-.339
d1	<-->	d4	1228.892	105.531	11.645	***	.557

*** p < 0.001

Squared Multiple Correlations

	Estimate
UT	.335
FC	.478
s7	.061
s6	.008
s5	.009
s4	.381
s3	.384
s2	.000
s1	.176
yNC	.208
yTC	.208
yAC	.118
uC3	.312
uC2	.467
uC1	.317
c4	.113
c3	.466
c2	.426
c1	.621

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	FC	SD	UC	UT	FC
UT	-.058	5.935	.000	.000	-.187	.488	.000	.000
FC	.093	-9.410	-1.586	.000	.129	-.337	-.691	.000
s7	.233	.000	.000	.000	.246	.000	.000	.000
s6	2.341	.000	.000	.000	.089	.000	.000	.000
s5	-.098	.000	.000	.000	-.097	.000	.000	.000
s4	3.174	.000	.000	.000	.617	.000	.000	.000
s3	.753	.000	.000	.000	.620	.000	.000	.000
s2	-.005	.000	.000	.000	-.004	.000	.000	.000
s1	1.000	.000	.000	.000	.420	.000	.000	.000
yNC	-.888	90.134	15.188	-9.578	-.059	.154	.315	-.456
yTC	-.836	84.789	14.287	-9.010	-.059	.154	.315	-.456
yAC	.093	-9.410	-1.586	1.000	.017	-.045	-.092	.133
uC3	36.437	-3697.679	-623.073	.000	.021	-.054	-.110	.000
uC2	-.153	15.479	2.608	.000	-.076	.199	.409	.000
uC1	-.058	5.935	1.000	.000	-.024	.063	.129	.000
c4	.000	1.000	.000	.000	.000	.113	.000	.000
c3	.000	1507.761	.000	.000	.000	.683	.000	.000
c2	.000	12692.095	.000	.000	.000	.653	.000	.000
c1	.000	1999058.842	.000	.000	.000	.788	.000	.000

Direct Effects

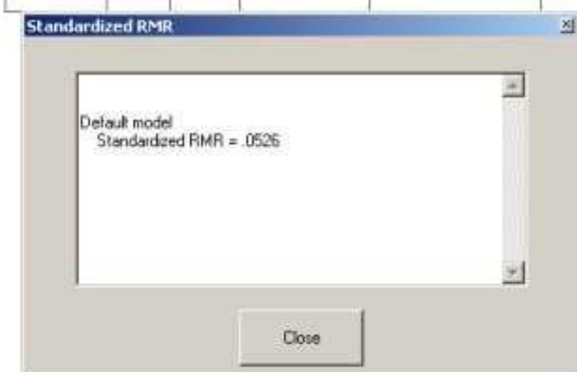
	Unstandardized				Standardized			
	SD	UC	UT	FC	SD	UC	UT	FC
UT	-.058	5.935	.000	.000	-.187	.488	.000	.000
FC	.000	.000	-1.586	.000	.000	.000	-.691	.000
s7	.233	.000	.000	.000	.246	.000	.000	.000
s6	2.341	.000	.000	.000	.089	.000	.000	.000
s5	-.098	.000	.000	.000	-.097	.000	.000	.000
s4	3.174	.000	.000	.000	.617	.000	.000	.000
s3	.753	.000	.000	.000	.620	.000	.000	.000
s2	-.005	.000	.000	.000	-.004	.000	.000	.000
s1	1.000	.000	.000	.000	.420	.000	.000	.000
yNC	.000	.000	.000	-9.578	.000	.000	.000	-.456
yTC	.000	.000	.000	-9.010	.000	.000	.000	-.456
yAC	.000	.000	.000	1.000	.000	.000	.000	.133
uC3	.000	.000	-623.073	.000	.000	.000	-.110	.000
uC2	.000	.000	2.608	.000	.000	.000	.409	.000
uC1	.000	.000	1.000	.000	.000	.000	.129	.000
c4	.000	1.000	.000	.000	.000	.113	.000	.000
c3	.000	1507.761	.000	.000	.000	.683	.000	.000
c2	.000	12692.095	.000	.000	.000	.653	.000	.000
c1	.000	1999058.842	.000	.000	.000	.788	.000	.000

Indirect Effects

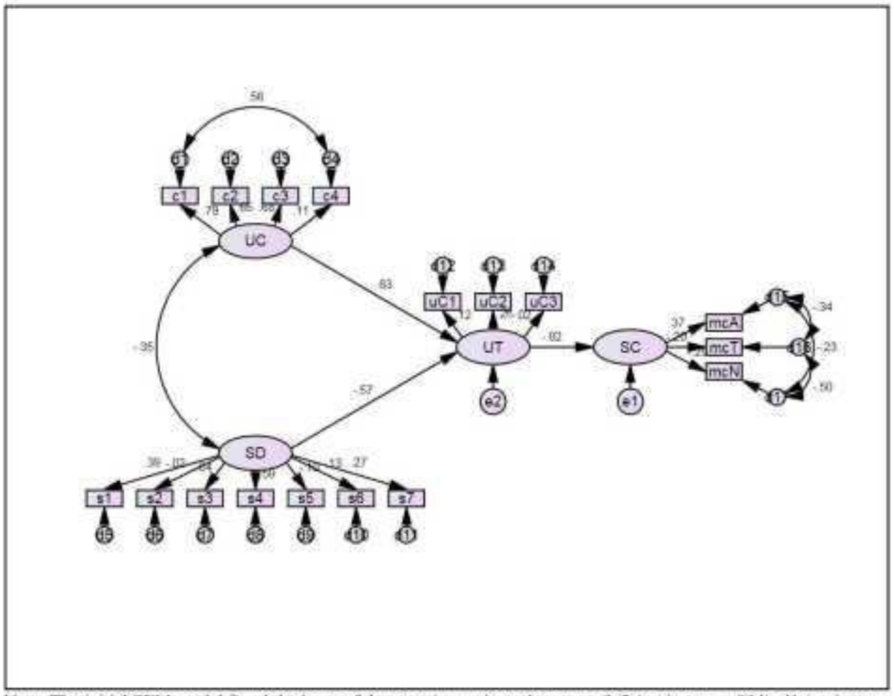
	Unstandardized				Standardized			
	SD	UC	UT	FC	SD	UC	UT	FC
UT	.000	.000	.000	.000	.000	.000	.000	.000
FC	.093	-9.410	.000	.000	.129	-.337	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
yNC	-.888	90.134	15.188	.000	-.059	.154	.315	.000
yTC	-.836	84.789	14.287	.000	-.059	.154	.315	.000
yAC	.093	-9.410	-1.586	.000	.017	-.045	-.092	.000
uC3	36.437	-3697.679	.000	.000	.021	-.054	.000	.000
uC2	-.153	15.479	.000	.000	-.076	.199	.000	.000
uC1	-.058	5.935	.000	.000	-.024	.063	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
272.118	114	.000	2.387	531	0.037	.921	.954	.938	350.118	542.749



E.2.10 Model C5: Mode Shares of Commuting Trips (Data of the 2013 Survey) with Consideration of Utility



Note: The initial SEM model faced the issue of the negative variance because of e2 (variance = -.004), d1 (variance = -4.949), and d15 (variance = -2.770). This issue brought about multiple modifications: This research added a correlation path for each negative variance and if it introduced another negative variance issue in other parts of the model, then an alternative path was considered. The final model included the following paths: d1 <--> d4, d15 <--> d16, d16 <--> d17, and d15 <--> d17. (In this model, the variance of e2 was not negative and no modification was necessary for this error term.)

Result (Default model)

Minimum was achieved
Chi-square = 228.105
Degrees of freedom = 111
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	6.846	3.189	2.147	.032	.629
UT	<---	SD	-.175	.061	-2.855	.004	-.570
SC	<---	UT	-.727	.235	-3.097	.002	-.822
e1	<---	UC	1977195.089	632545.105	3.126	.002	.651

			Unstandardized	S.E.	C.R.	p	Standardized
c2	<---	UC	12489.996	4241.560	2.945	.003	.790
c3	<---	UC	1491.456	506.111	2.947	.003	.684
c4	<---	UC	1.000				.115
uC1	<---	UT	1.000				.117
uC2	<---	UT	1.859	.612	3.036	.002	.264
uC3	<---	UT	-110.406	61.817	-1.786	.074	-.018
mcA	<---	SC	1.000				.371
mcT	<---	SC	-.655	.135	-4.863	***	-.199
mcN	<---	SC	-.755	.134	-5.633	***	-.253
s1	<---	SD	1.000				.387
s2	<---	SD	-.028	.054	-.520	.603	-.020
s3	<---	SD	.838	.099	8.438	***	.636
s4	<---	SD	3.296	.391	8.432	***	.592
s5	<---	SD	-.112	.044	-2.527	.012	-.102
s6	<---	SD	3.738	1.176	3.180	.001	.131
s7	<---	SD	.278	.048	5.800	***	.271

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.002	.001	-2.686	.007	-.354
d1	<-->	d4	1224.241	104.976	11.662	***	.556
d15	<-->	d16	-.043	.004	-9.570	***	-.342
d16	<-->	d17	-.071	.005	-14.066	***	-.499
d15	<-->	d17	-.025	.004	-6.484	***	-.228

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.775
SC	.675
s7	.073
s6	.017
s5	.010
s4	.350
s3	.405
s2	.000
s1	.150
mcN	.164
mcT	.140
mcA	.237
uC3	.300
uC2	.370
uC1	.314
c4	.113

	Estimate
c3	.468
c2	.423
c1	.624

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	SC	SD	UC	UT	SC
UT	-.175	6.846	.000	.000	-.570	.629	.000	.000
SC	.128	-4.980	-.727	.000	.469	-.517	-.822	.000
s7	.278	.000	.000	.000	.271	.000	.000	.000
s6	3.738	.000	.000	.000	.131	.000	.000	.000
s5	-.112	.000	.000	.000	-.102	.000	.000	.000
s4	3.296	.000	.000	.000	.592	.000	.000	.000
s3	.838	.000	.000	.000	.636	.000	.000	.000
s2	-.028	.000	.000	.000	-.020	.000	.000	.000
s1	1.000	.000	.000	.000	.387	.000	.000	.000
mcN	-.096	3.758	.549	-.755	-.119	.131	.208	-.253
mcT	-.084	3.263	.477	-.655	-.093	.103	.163	-.199
mcA	.128	-4.980	-.727	1.000	.174	-.191	-.304	.371
uC3	19.371	-755.812	-110.406	.000	.010	-.011	-.018	.000
uC2	-.326	12.725	1.859	.000	-.151	.166	.264	.000
uC1	-.175	6.846	1.000	.000	-.067	.074	.117	.000
c4	.000	1.000	.000	.000	.000	.115	.000	.000
c3	.000	1491.456	.000	.000	.000	.684	.000	.000
c2	.000	12489.996	.000	.000	.000	.651	.000	.000
c1	.000	1977195.089	.000	.000	.000	.790	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	SC	SD	UC	UT	SC
UT	-.175	6.846	.000	.000	-.570	.629	.000	.000
SC	.000	.000	-.727	.000	.000	.000	-.822	.000
s7	.278	.000	.000	.000	.271	.000	.000	.000
s6	3.738	.000	.000	.000	.131	.000	.000	.000
s5	-.112	.000	.000	.000	-.102	.000	.000	.000
s4	3.296	.000	.000	.000	.592	.000	.000	.000
s3	.838	.000	.000	.000	.636	.000	.000	.000
s2	-.028	.000	.000	.000	-.020	.000	.000	.000
s1	1.000	.000	.000	.000	.387	.000	.000	.000
mcN	.000	.000	.000	-.755	.000	.000	.000	-.253
mcT	.000	.000	.000	-.655	.000	.000	.000	-.199
mcA	.000	.000	.000	1.000	.000	.000	.000	.371
uC3	.000	.000	-110.406	.000	.000	.000	-.018	.000
uC2	.000	.000	1.859	.000	.000	.000	.264	.000
uC1	.000	.000	1.000	.000	.000	.000	.117	.000

	Unstandardized				Standardized			
	SD	UC	UT	SC	SD	UC	UT	SC
c4	.000	1.000	.000	.000	.000	.115	.000	.000
c3	.000	1491.456	.000	.000	.000	.684	.000	.000
c2	.000	12489.996	.000	.000	.000	.651	.000	.000
c1	.000	1977195.089	.000	.000	.000	.790	.000	.000

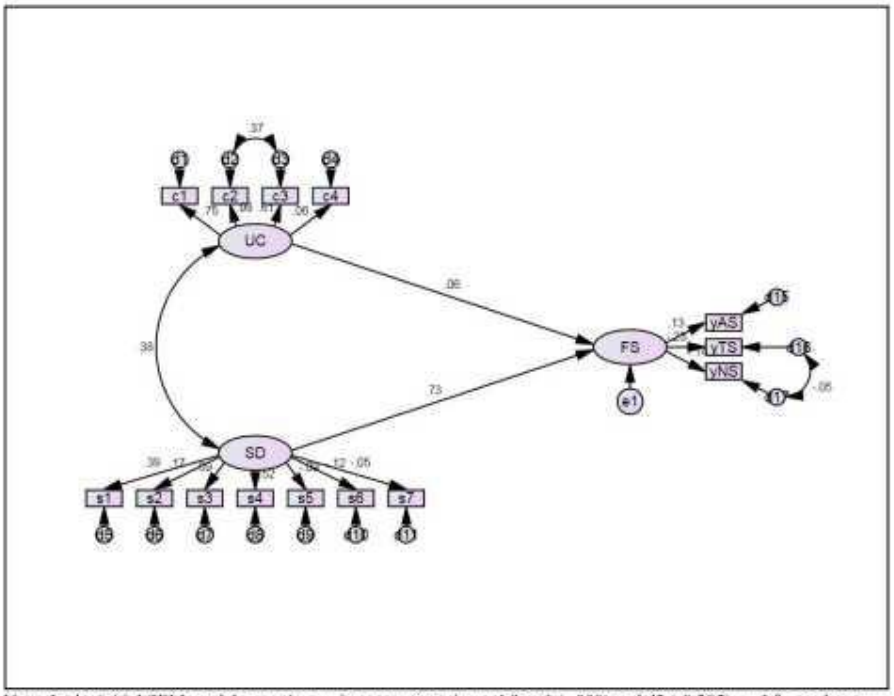
Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	SC	SD	UC	UT	SC
UT	.000	.000	.000	.000	.000	.000	.000	.000
SC	.128	-4.980	.000	.000	.469	-.517	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
mcN	-.096	3.758	.549	.000	-.119	.131	.208	.000
mcT	-.084	3.263	.477	.000	-.093	.103	.163	.000
mcA	.128	-4.980	-.727	.000	.174	-.191	-.304	.000
uC3	19.371	-755.812	.000	.000	.010	-.011	.000	.000
uC2	-.326	12.725	.000	.000	-.151	.166	.000	.000
uC1	-.175	6.846	.000	.000	-.067	.074	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ^2	d.f.	p	Relative χ^2	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
228.105	111	.000	2.055	618	.032	.943	.927	.899	312.105	519.554

E.2.11 Model S1: Frequencies of Shopping Trips (Sample Data of the 2006 MHTS)



Note: In the initial SEM model, negative variances were estimated for e1 (-.000) and d2 (-0.285), and for each case, this research added the following paths: d16 <--> d17 and d2 <--> d3.

Result (Default model)

Minimum was achieved
Chi-square = 135.504
Degrees of freedom = 72
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FS	<---	UC	.162	.065	2.511	.012	.061
FS	<---	SD	.035	.012	2.900	.004	.728
c1	<---	UC	6269413.961	2596877.633	2.414	.016	.613
c2	<---	UC	70216.255	29465.181	2.383	.017	.980
c3	<---	UC	1958.118	825.635	2.372	.018	.748
c4	<---	UC	1.000				.060
yAS	<---	FS	1.000				.133
yTS	<---	FS	-2.181	.794	-2.748	.006	-.230

	Unstandardized	S.E.	C.R.	p	Standardized
yNS <--- FS	-1.033	.445	-2.319	.020	-.142
s1 <--- SD	1.000				.387
s2 <--- SD	.180	.037	4.891	***	.173
s3 <--- SD	.862	.091	9.485	***	.585
s4 <--- SD	1.982	.210	9.448	***	.520
s5 <--- SD	-.098	.037	-2.653	.008	-.088
s6 <--- SD	-3.455	.983	-3.516	***	-.119
s7 <--- SD	-.160	.098	-1.634	.102	-.053

*** $p < 0.001$

Covariances

	Estimate	S.E.	C.R.	p	Correlations
UC <--> SD	.001	.001	2.290	.022	.379
d2 <--> d3	856.635	704.640	1.216	.224	.370
d16 <--> d17	-.001	.001	-1.353	.176	-.047

Squared Multiple Correlations

	Estimate
FS	.167
s7	.003
s6	.014
s5	.008
s4	.270
s3	.342
s2	.030
s1	.150
yNS	.120
yTS	.153
yAS	.118
c4	.104
c3	.375
c2	.960
c1	.560

Total Effects

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.035	.162	.000	.728	.061	.000
s7	-.160	.000	.000	-.053	.000	.000
s6	-3.455	.000	.000	-.119	.000	.000
s5	-.098	.000	.000	-.088	.000	.000
s4	1.982	.000	.000	.520	.000	.000
s3	.862	.000	.000	.585	.000	.000
s2	.180	.000	.000	.173	.000	.000

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
s1	1.000	.000	.000	.387	.000	.000
yNS	-.036	-.167	-1.033	-.104	-.009	-.142
yTS	-.076	-.352	-2.181	-.167	-.014	-.230
yAS	.035	.162	1.000	.097	.008	.133
c4	.000	1.000	.000	.000	.060	.000
c3	.000	1958.118	.000	.000	.613	.000
c2	.000	70216.255	.000	.000	.980	.000
c1	.000	6269413.961	.000	.000	.748	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.035	.162	.000	.728	.061	.000
s7	-.160	.000	.000	-.053	.000	.000
s6	-3.455	.000	.000	-.119	.000	.000
s5	-.098	.000	.000	-.088	.000	.000
s4	1.982	.000	.000	.520	.000	.000
s3	.862	.000	.000	.585	.000	.000
s2	.180	.000	.000	.173	.000	.000
s1	1.000	.000	.000	.387	.000	.000
yNS	.000	.000	-1.033	.000	.000	-.142
yTS	.000	.000	-2.181	.000	.000	-.230
yAS	.000	.000	1.000	.000	.000	.133
c4	.000	1.000	.000	.000	.060	.000
c3	.000	1958.118	.000	.000	.613	.000
c2	.000	70216.255	.000	.000	.980	.000
c1	.000	6269413.961	.000	.000	.748	.000

Indirect Effects

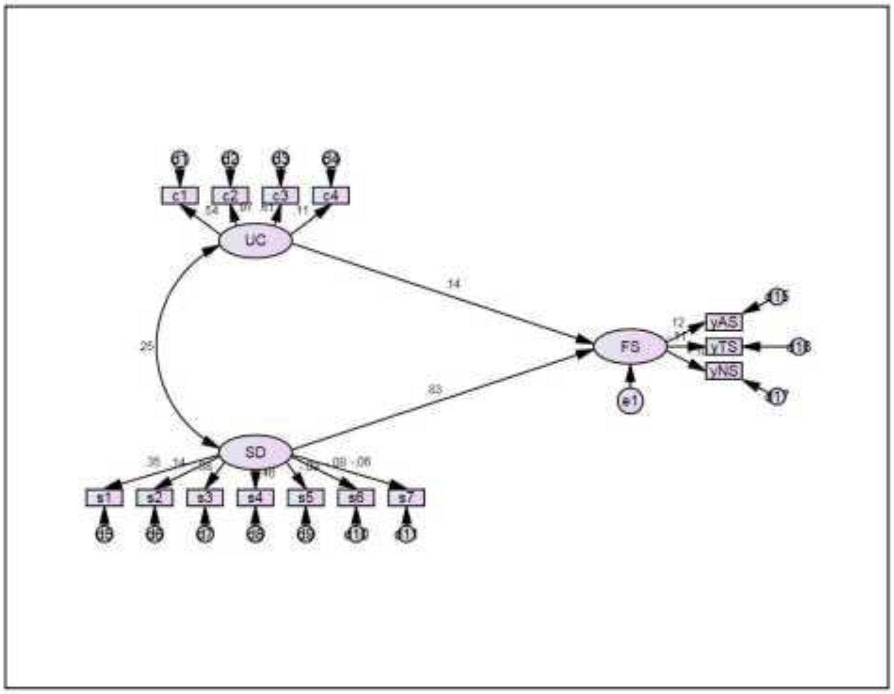
	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNS	-.036	-.167	.000	-.104	-.009	.000
yTS	-.076	-.352	.000	-.167	-.014	.000
yAS	.035	.162	.000	.097	.008	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
135.504	72	.000	1.882	1140	.023	.937	.952	.930	201.504	380.264

E.2.12 Model S2: Frequencies of Shopping Trips (Entire Data of the 2006 MHTS)



Result (Default model)

Minimum was achieved
Chi-square = 265.660
Degrees of freedom = 74
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FS	<---	UC	.171	.044	3.905	***	.139
FS	<---	SD	.044	.004	12.047	***	.828
c1	<---	UC	1768191.949	98761.454	17.904	***	.544
c2	<---	UC	30071.386	1686.301	17.833	***	.969
c3	<---	UC	1060.862	59.019	17.975	***	.609
c4	<---	UC	1.000				.109
yAS	<---	FS	1.000				.122
yTS	<---	FS	-1.294	.138	-9.359	***	-.115
yNS	<---	FS	-.871	.102	-8.521	***	-.097
s1	<---	SD	1.000				.348

			Unstandardized	S.E.	C.R.	p	Standardized
s2	<---	SD	.181	.011	15.914	***	.141
s3	<---	SD	.942	.030	31.289	***	.578
s4	<---	SD	2.206	.068	32.367	***	.459
s5	<---	SD	-.120	.012	-10.434	***	-.088
s6	<---	SD	-2.909	.294	-9.882	***	-.083
s7	<---	SD	-.263	.034	-7.701	***	-.064

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlation
UC	<-->	SD	.002	.000	14.315	***	.254

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FS	.162
s7	.004
s6	.007
s5	.008
s4	.211
s3	.334
s2	.020
s1	.121
yNS	.009
yTS	.013
yAS	.015
c4	.012
c3	.371
c2	.938
c1	.296

Total Effects

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.044	.171	.000	.828	.139	.000
s7	-.263	.000	.000	-.064	.000	.000
s6	-2.909	.000	.000	-.083	.000	.000
s5	-.120	.000	.000	-.088	.000	.000
s4	2.206	.000	.000	.459	.000	.000
s3	.942	.000	.000	.578	.000	.000
s2	.181	.000	.000	.141	.000	.000
s1	1.000	.000	.000	.348	.000	.000
yNS	-.039	-.149	-.871	-.081	-.013	-.097
yTS	-.057	-.221	-1.294	-.095	-.016	-.115

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
yAS	.044	.171	1.000	.101	.017	.122
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1060.862	.000	.000	.609	.000
c2	.000	30071.386	.000	.000	.969	.000
c1	.000	1768191.949	.000	.000	.544	.000

Direct Effects

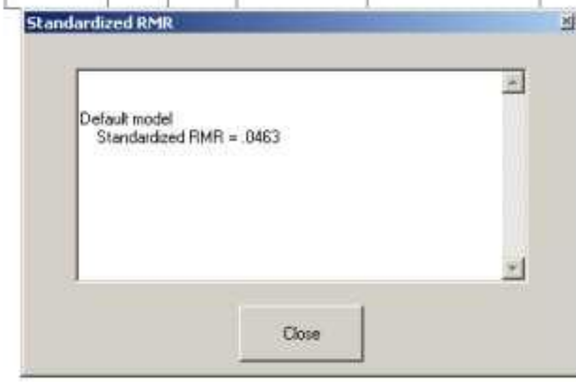
	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.044	.171	.000	.828	.139	.000
s7	-.263	.000	.000	-.064	.000	.000
s6	-2.909	.000	.000	-.083	.000	.000
s5	-.120	.000	.000	-.088	.000	.000
s4	2.206	.000	.000	.459	.000	.000
s3	.942	.000	.000	.578	.000	.000
s2	.181	.000	.000	.141	.000	.000
s1	1.000	.000	.000	.348	.000	.000
yNS	.000	.000	-.871	.000	.000	-.097
yTS	.000	.000	-1.294	.000	.000	-.115
yAS	.000	.000	1.000	.000	.000	.122
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1060.862	.000	.000	.609	.000
c2	.000	30071.386	.000	.000	.969	.000
c1	.000	1768191.949	.000	.000	.544	.000

Indirect Effects

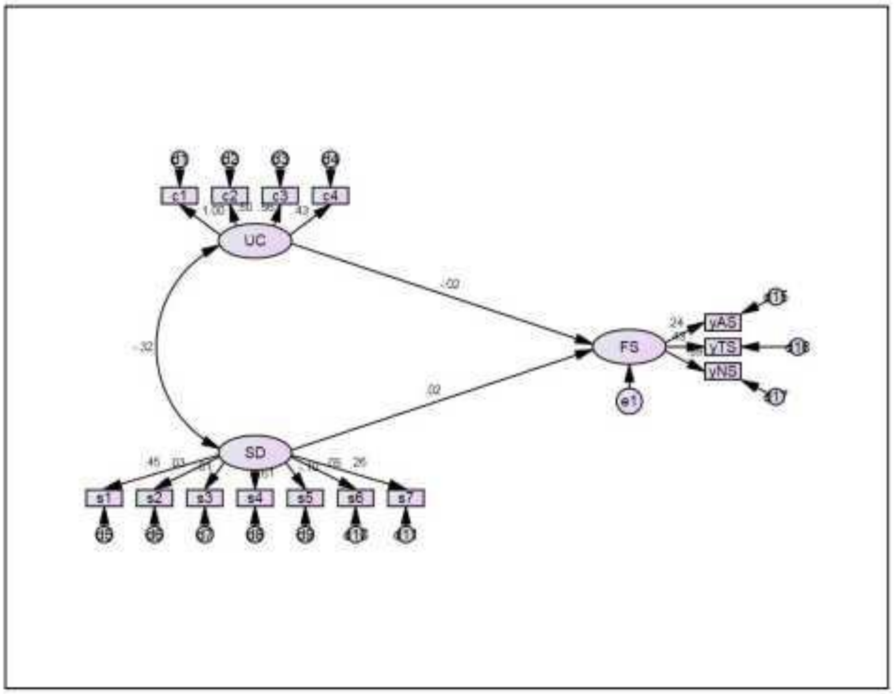
	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNS	-.039	-.149	.000	-.081	-.013	.000
yTS	-.057	-.221	.000	-.095	-.016	.000
yAS	.044	.171	.000	.101	.017	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
265.660	74	.000	3.590	10500	.009	.884	.965	.951	327.660	584.544



E.2.13 Model S3: Frequencies of Shopping Trips (Data of the 2013 Survey) without Consideration of Utility



Result (Default model)

Minimum was achieved
Chi-square = 224.072
Degrees of freedom = 74
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FS	<---	UC	-.158	-.078	2.034	.042	-.019
FS	<---	SD	.018	.009	1.953	.051	.023
c1	<---	UC	666727.803	55042.896	12.113	***	.497
c2	<---	UC	2547.840	217.576	11.710	***	.897
c3	<---	UC	323.585	26.087	12.404	***	.556
c4	<---	UC	1.000				.430
yAS	<---	FS	1.000				.240
yTS	<---	FS	4.466	.716	6.239	***	.426
yNS	<---	FS	15.501	4.582	3.383	***	.888
s1	<---	SD	1.000				.450

			Unstandardized	S.E.	C.R.	p	Standardized
s2	<---	SD	.041	.047	.865	.387	.034
s3	<---	SD	.693	.076	9.137	***	.611
s4	<---	SD	2.934	.321	9.136	***	.611
s5	<---	SD	-.099	.038	-2.601	.009	-.105
s6	<---	SD	1.147	.978	1.174	.240	.047
s7	<---	SD	.225	.039	5.744	***	.255

*** p < 0.001

Covariances

			Estimate	S.E.	C.R.	p	Correlation
UC	<-->	SD	-.008	.001	-5.785	***	-.320

*** p < 0.001

Squared Multiple Correlations

	Estimate
FS	.101
s7	.065
s6	.002
s5	.011
s4	.374
s3	.373
s2	.001
s1	.202
yNS	.788
yTS	.182
yAS	.158
c4	.185
c3	.309
c2	.247
c1	.993

Total Effects

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.018	-.158	.000	.023	-.019	.000
s7	.225	.000	.000	.255	.000	.000
s6	1.147	.000	.000	.047	.000	.000
s5	-.099	.000	.000	-.105	.000	.000
s4	2.934	.000	.000	.611	.000	.000
s3	.693	.000	.000	.611	.000	.000
s2	.041	.000	.000	.034	.000	.000
s1	1.000	.000	.000	.450	.000	.000
yNS	.272	-2.452	15.501	.021	-.017	.888
yTS	.078	-.706	4.466	.010	-.008	.426

	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
yAS	.018	-.158	1.000	.006	-.005	.240
c4	.000	1.000	.000	.000	.430	.000
c3	.000	323.585	.000	.000	.556	.000
c2	.000	2547.840	.000	.000	.497	.000
c1	.000	666727.803	.000	.000	.997	.000

Direct Effects

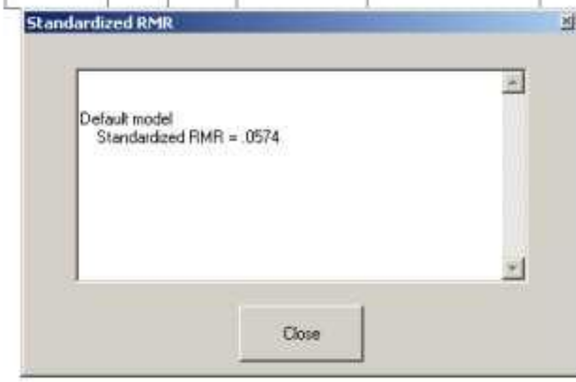
	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.018	-.158	.000	.023	-.019	.000
s7	.225	.000	.000	.255	.000	.000
s6	1.147	.000	.000	.047	.000	.000
s5	-.099	.000	.000	-.105	.000	.000
s4	2.934	.000	.000	.611	.000	.000
s3	.693	.000	.000	.611	.000	.000
s2	.041	.000	.000	.034	.000	.000
s1	1.000	.000	.000	.450	.000	.000
yNS	.000	.000	15.501	.000	.000	.888
yTS	.000	.000	4.466	.000	.000	.426
yAS	.000	.000	1.000	.000	.000	.240
c4	.000	1.000	.000	.000	.430	.000
c3	.000	323.585	.000	.000	.556	.000
c2	.000	2547.840	.000	.000	.497	.000
c1	.000	666727.803	.000	.000	.997	.000

Indirect Effects

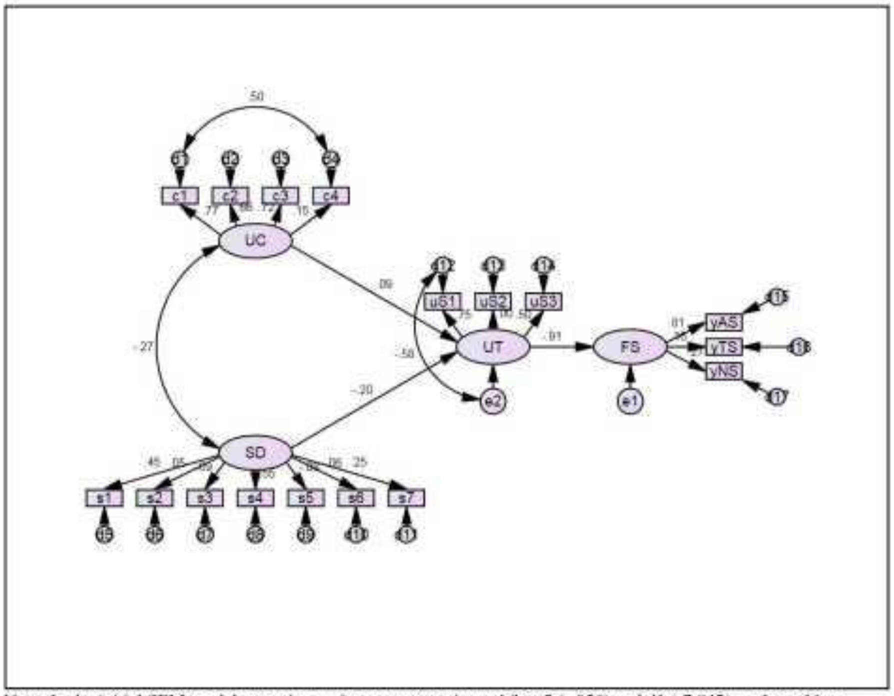
	Unstandardized			Standardized		
	SD	UC	FS	SD	UC	FS
FS	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNS	.272	-2.452	.000	.021	-.017	.000
yTS	.078	-.706	.000	.010	-.008	.000
yAS	.018	-.158	.000	.006	-.005	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
224.072	74	.000	3.028	438	.044	.921	.932	.904	286.072	439.189



E.2.14 Model S4: Frequencies of Shopping Trips (Data of the 2013 Survey) with Consideration of Utility



Note: In the initial SEM model, negative variances were estimated for e2 (-.056) and d1 (-7.842), and to address each of the cases, this research added the paths of d12 <--> e2 and d1 <--> d4.

Result (Default model)

Minimum was achieved
Chi-square = 216.169
Degrees of freedom = 113
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	3.995	1.955	2.044	.041	.089
UT	<---	SD	-.282	.073	-3.854	***	-.197
FS	<---	UT	-1.622	.469	-3.457	***	-.912
c1	<---	UC	1470789.374	350607.117	4.195	***	.656
c2	<---	UC	9599.003	2473.417	3.881	***	.771
c3	<---	UC	1196.872	307.928	3.887	***	.720
c4	<---	UC	1.000				.151
uS1	<---	UT	1.000				.746

			Unstandardized	S.E.	C.R.	p	Standardized
uS2	<---	UT	.005	.003	1.749	.080	.004
uS3	<---	UT	5372.496	1974.144	2.721	.006	.504
yAS	<---	FS	1.000				.814
yTS	<---	FS	.503	.139	3.610	***	.163
yNS	<---	FS	1.393	.294	4.734	***	.270
s1	<---	SD	1.000				.449
s2	<---	SD	.061	.047	1.318	.187	.052
s3	<---	SD	.781	.086	9.095	***	.689
s4	<---	SD	2.618	.283	9.262	***	.545
s5	<---	SD	-.073	.037	-1.960	.050	-.077
s6	<---	SD	1.392	.967	1.439	.150	.056
s7	<---	SD	.223	.039	5.791	***	.253

*** p < 0.001

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.002	.001	-3.190	.001	-.272
d12	<-->	e2	-.524	.322	-1.627	.104	-.583
d1	<-->	d4	1132.279	104.286	10.857	***	.498

*** p < 0.001

Squared Multiple Correlations

	Estimate
UT	.656
FS	.232
s7	.064
s6	.003
s5	.006
s4	.297
s3	.474
s2	.003
s1	.202
yNS	.173
yTS	.127
yAS	.662
uS3	.254
uS2	.200
uS1	.466
c4	.123
c3	.519
c2	.430
c1	.594

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	FS	SD	UC	UT	FS
UT	-.282	3.995	.000	.000	-.197	.089	.000	.000
FS	.457	-6.479	-1.622	.000	.180	-.081	-.912	.000
s7	.223	.000	.000	.000	.253	.000	.000	.000
s6	1.392	.000	.000	.000	.056	.000	.000	.000
s5	-.073	.000	.000	.000	-.077	.000	.000	.000
s4	2.618	.000	.000	.000	.545	.000	.000	.000
s3	.781	.000	.000	.000	.689	.000	.000	.000
s2	.061	.000	.000	.000	.052	.000	.000	.000
s1	1.000	.000	.000	.000	.449	.000	.000	.000
yNS	.637	-9.025	-2.259	1.393	.049	-.022	-.247	.270
yTS	.230	-3.261	-.816	.503	.029	-.013	-.149	.163
yAS	.457	-6.479	-1.622	1.000	.146	-.066	-.742	.814
uS3	-1515.305	21465.423	5372.496	.000	-.099	.045	.504	.000
uS2	-.001	.020	.005	.000	-.001	.000	.004	.000
uS1	-.282	3.995	1.000	.000	-.147	.067	.746	.000
c4	.000	1.000	.000	.000	.000	.151	.000	.000
c3	.000	1196.872	.000	.000	.000	.720	.000	.000
c2	.000	9599.003	.000	.000	.000	.656	.000	.000
c1	.000	1470789.374	.000	.000	.000	.771	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	FS	SD	UC	UT	FS
UT	-.282	3.995	.000	.000	-.197	.089	.000	.000
FS	.000	.000	-1.622	.000	.000	.000	-.912	.000
s7	.223	.000	.000	.000	.253	.000	.000	.000
s6	1.392	.000	.000	.000	.056	.000	.000	.000
s5	-.073	.000	.000	.000	-.077	.000	.000	.000
s4	2.618	.000	.000	.000	.545	.000	.000	.000
s3	.781	.000	.000	.000	.689	.000	.000	.000
s2	.061	.000	.000	.000	.052	.000	.000	.000
s1	1.000	.000	.000	.000	.449	.000	.000	.000
yNS	.000	.000	.000	1.393	.000	.000	.000	.270
yTS	.000	.000	.000	.503	.000	.000	.000	.163
yAS	.000	.000	.000	1.000	.000	.000	.000	.814
uS3	.000	.000	5372.496	.000	.000	.000	.504	.000
uS2	.000	.000	.005	.000	.000	.000	.004	.000
uS1	.000	.000	1.000	.000	.000	.000	.746	.000
c4	.000	1.000	.000	.000	.000	.151	.000	.000
c3	.000	1196.872	.000	.000	.000	.720	.000	.000
c2	.000	9599.003	.000	.000	.000	.656	.000	.000
c1	.000	1470789.374	.000	.000	.000	.771	.000	.000

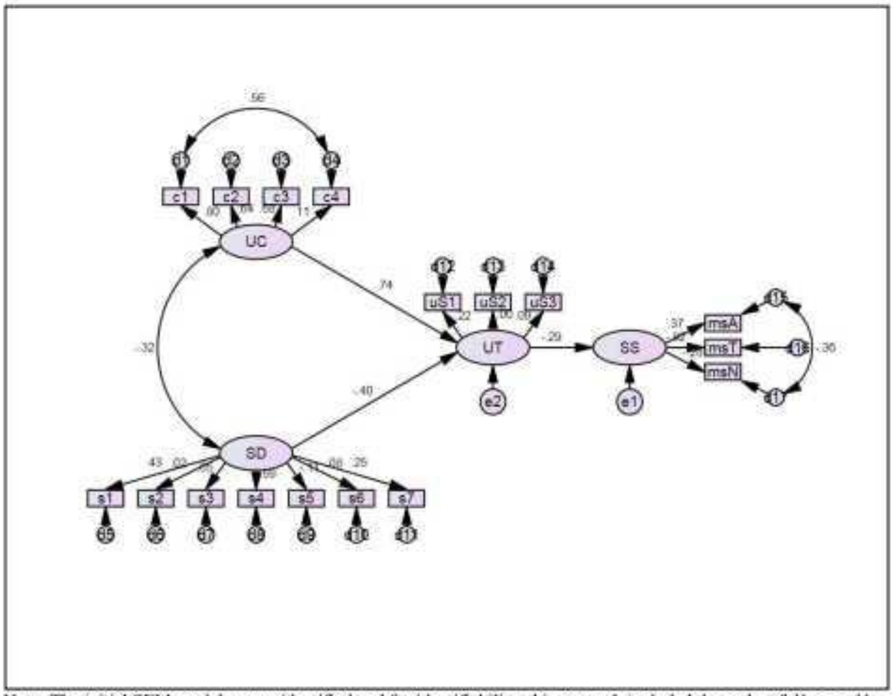
Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	FS	SD	UC	UT	FS
UT	.000	.000	.000	.000	.000	.000	.000	.000
FS	.457	-6.479	.000	.000	.180	-.081	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
yNS	.637	-9.025	-2.259	.000	.049	-.022	-.247	.000
yTS	.230	-3.261	-.816	.000	.029	-.013	-.149	.000
yAS	.457	-6.479	-1.622	.000	.146	-.066	-.742	.000
uS3	-1515.305	21465.423	.000	.000	-.099	.045	.000	.000
uS2	-.001	.020	.000	.000	-.001	.000	.000	.000
uS1	-.282	3.995	.000	.000	-.147	.067	.000	.000
e4	.000	.000	.000	.000	.000	.000	.000	.000
e3	.000	.000	.000	.000	.000	.000	.000	.000
e2	.000	.000	.000	.000	.000	.000	.000	.000
e1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ^2	d.f.	p	Relative χ^2	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
216.169	113	.000	1.913	663	.030	.919	.943	.923	296.169	493.739

E.2.15 Model S5: Mode Shares of Shopping Trips (Data of the 2013 Survey) with Consideration of Utility



Note: The initial SEM model was unidentified and for identifiability, this research included the paths of d1 <--> d4 and d15 <--> d17.

Result (Default model)

Minimum was achieved
Chi-square = 215.039
Degrees of freedom = 113
Probability level = ,000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	12.842	4.988	2.574	,010	,736
UT	<---	SD	-,177	,051	-3.443	***	-,404
SS	<---	UT	-,159	,047	-3.360	***	-,291
c1	<---	UC	2018902.240	657094.474	3.072	,002	,639
c2	<---	UC	12426.337	4290.248	2.896	,004	,796
c3	<---	UC	1512.178	521.539	2.899	,004	,685
c4	<---	UC	1.000				,113
uS1	<---	UT	1.000				,219

			Unstandardized	S.E.	C.R.	p	Standardized
uS2	<---	UT	1.125	.226	4.984	***	.004
uS3	<---	UT	3290.512	1425.378	2.309	.021	.091
msA	<---	SS	1.000				.370
msT	<---	SS	-2.628	.617	-4.259	***	-.823
msN	<---	SS	-.822	.153	-5.376	***	-.279
s1	<---	SD	1.000				.431
s2	<---	SD	.028	.049	.573	.567	.023
s3	<---	SD	.764	.085	8.962	***	.646
s4	<---	SD	2.934	.326	9.007	***	.586
s5	<---	SD	-.107	.040	-2.695	.007	-.109
s6	<---	SD	2.172	1.027	2.115	.034	.084
s7	<---	SD	.235	.041	5.708	***	.255

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.002	.001	-2.642	.008	-.324
d1	<-->	d4	1225.592	105.214	11.649	***	.564
d15	<-->	d17	-.038	.004	-8.568	***	-.358

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.698
SS	.285
s7	.065
s6	.007
s5	.012
s4	.343
s3	.417
s2	.001
s1	.186
msN	.178
msT	.677
msA	.137
uS3	.308
uS2	.390
uS1	.348
c4	.113
c3	.469
c2	.409
c1	.634

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	SS	SD	UC	UT	SS
UT	-.177	12.842	.000	.000	-.404	.736	.000	.000
SS	.028	-2.047	-.159	.000	.117	-.214	-.291	.000
s7	.235	.000	.000	.000	.255	.000	.000	.000
s6	2.172	.000	.000	.000	.084	.000	.000	.000
s5	-.107	.000	.000	.000	-.109	.000	.000	.000
s4	2.934	.000	.000	.000	.586	.000	.000	.000
s3	.764	.000	.000	.000	.646	.000	.000	.000
s2	.028	.000	.000	.000	.023	.000	.000	.000
s1	1.000	.000	.000	.000	.431	.000	.000	.000
msN	-.023	1.683	.131	-.822	-.033	.060	.081	-.279
msT	-.074	5.380	.419	-2.628	-.097	.176	.239	-.823
msA	.028	-2.047	-.159	1.000	.043	-.079	-.108	.370
uS3	-581.416	42256.203	3290.512	.000	-.037	.067	.091	.000
uS2	-.199	14.445	1.125	.000	-.121	.000	.004	.000
uS1	-.177	12.842	1.000	.000	-.088	.161	.219	.000
c4	.000	1.000	.000	.000	.000	.113	.000	.000
c3	.000	1512.178	.000	.000	.000	.685	.000	.000
c2	.000	12426.337	.000	.000	.000	.639	.000	.000
c1	.000	2018902.240	.000	.000	.000	.796	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	SS	SD	UC	UT	SS
UT	-.177	12.842	.000	.000	-.404	.736	.000	.000
SS	.000	.000	-.159	.000	.000	.000	-.291	.000
s7	.235	.000	.000	.000	.255	.000	.000	.000
s6	2.172	.000	.000	.000	.084	.000	.000	.000
s5	-.107	.000	.000	.000	-.109	.000	.000	.000
s4	2.934	.000	.000	.000	.586	.000	.000	.000
s3	.764	.000	.000	.000	.646	.000	.000	.000
s2	.028	.000	.000	.000	.023	.000	.000	.000
s1	1.000	.000	.000	.000	.431	.000	.000	.000
msN	.000	.000	.000	-.822	.000	.000	.000	-.279
msT	.000	.000	.000	-2.628	.000	.000	.000	-.823
msA	.000	.000	.000	1.000	.000	.000	.000	.370
uS3	.000	.000	3290.512	.000	.000	.000	.091	.000
uS2	.000	.000	1.125	.000	.000	.000	.004	.000
uS1	.000	.000	1.000	.000	.000	.000	.219	.000
c4	.000	1.000	.000	.000	.000	.113	.000	.000
c3	.000	1512.178	.000	.000	.000	.685	.000	.000
c2	.000	12426.337	.000	.000	.000	.639	.000	.000
c1	.000	2018902.240	.000	.000	.000	.796	.000	.000

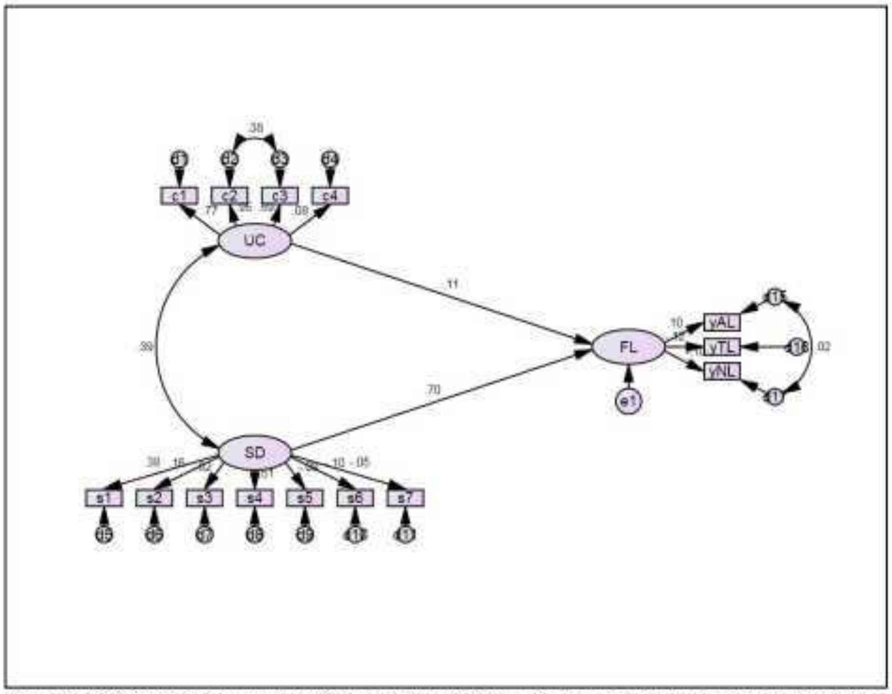
Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	SS	SD	UC	UT	SS
UT	.000	.000	.000	.000	.000	.000	.000	.000
SS	.028	-2.047	.000	.000	.117	-.214	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
msN	-.023	1.683	.131	.000	-.033	.060	.081	.000
msT	-.074	5.380	.419	.000	-.097	.176	.239	.000
msA	.028	-2.047	-.159	.000	.043	-.079	-.108	.000
uS3	-581.416	42256.203	.000	.000	-.037	.067	.000	.000
uS2	-.199	14.445	.000	.000	-.121	.000	.000	.000
uS1	-.177	12.842	.000	.000	-.088	.161	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
215.039	113	.000	1.903	666	.030	.933	.941	.920	295.039	492.609

E.2.16 Model L1: Frequencies of Leisure Trips (Sample Data of the 2006 MHTS)



Note: The initial SEM model was unidentified and for identifiability, this research included the correlation path of d15 <---> d17.

Result (Default model)

Minimum was achieved
Chi-square = 133.848
Degrees of freedom = 72
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FL	<---	UC	.195	.057	3.398	***	.107
FL	<---	SD	.030	.014	2.209	.027	.704
c1	<---	UC	5066577.299	1685528.847	3.006	.003	.593
c2	<---	UC	53243.184	17964.385	2.964	.003	.949
c3	<---	UC	1484.254	504.523	2.942	.003	.772
c4	<---	UC	1.000				.077
yAL	<---	FL	1.000				.102
yTL	<---	FL	-1.874	.989	-1.894	.058	-.121

			Unstandardized	S.E.	C.R.	p	Standardized
yNL	<---	FL	-.921	.529	-1.741	.082	-.102
s1	<---	SD	1.000				.377
s2	<---	SD	.174	.038	4.638	***	.163
s3	<---	SD	.931	.101	9.217	***	.616
s4	<---	SD	1.980	.213	9.276	***	.506
s5	<---	SD	-.086	.038	-2.295	.022	-.076
s6	<---	SD	-2.892	.994	-2.908	.004	-.097
s7	<---	SD	-.143	.100	-1.428	.153	-.047

*** p < 0.001

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	.002	.001	2.792	.005	.387
d2	<-->	d3	1405.309	631.543	2.225	.026	.377
d15	<-->	d17	.001	.001	.851	.395	.024

Squared Multiple Correlations

	Estimate
FL	.165
s7	.002
s6	.009
s5	.006
s4	.256
s3	.379
s2	.026
s1	.142
yNL	.110
yTL	.115
yAL	.110
c4	.106
c3	.352
c2	.901
c1	.596

Total Effects

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.030	.195	.000	.704	.107	.000
s7	-.143	.000	.000	-.047	.000	.000
s6	-2.892	.000	.000	-.097	.000	.000
s5	-.086	.000	.000	-.076	.000	.000
s4	1.980	.000	.000	.506	.000	.000
s3	.931	.000	.000	.616	.000	.000
s2	.174	.000	.000	.163	.000	.000

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
s1	1.000	.000	.000	.377	.000	.000
yNL	-.028	-.180	-.921	-.072	-.011	-.102
yTL	-.057	-.366	-1.874	-.085	-.013	-.121
yAL	.030	.195	1.000	.072	.011	.102
c4	.000	1.000	.000	.000	.077	.000
c3	.000	1484.254	.000	.000	.593	.000
c2	.000	53243.184	.000	.000	.949	.000
c1	.000	5066577.299	.000	.000	.772	.000

Direct Effects

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.030	.195	.000	.704	.107	.000
s7	-.143	.000	.000	-.047	.000	.000
s6	-2.892	.000	.000	-.097	.000	.000
s5	-.086	.000	.000	-.076	.000	.000
s4	1.980	.000	.000	.506	.000	.000
s3	.931	.000	.000	.616	.000	.000
s2	.174	.000	.000	.163	.000	.000
s1	1.000	.000	.000	.377	.000	.000
yNL	.000	.000	-.921	.000	.000	-.102
yTL	.000	.000	-1.874	.000	.000	-.121
yAL	.000	.000	1.000	.000	.000	.102
c4	.000	1.000	.000	.000	.077	.000
c3	.000	1484.254	.000	.000	.593	.000
c2	.000	53243.184	.000	.000	.949	.000
c1	.000	5066577.299	.000	.000	.772	.000

Indirect Effects

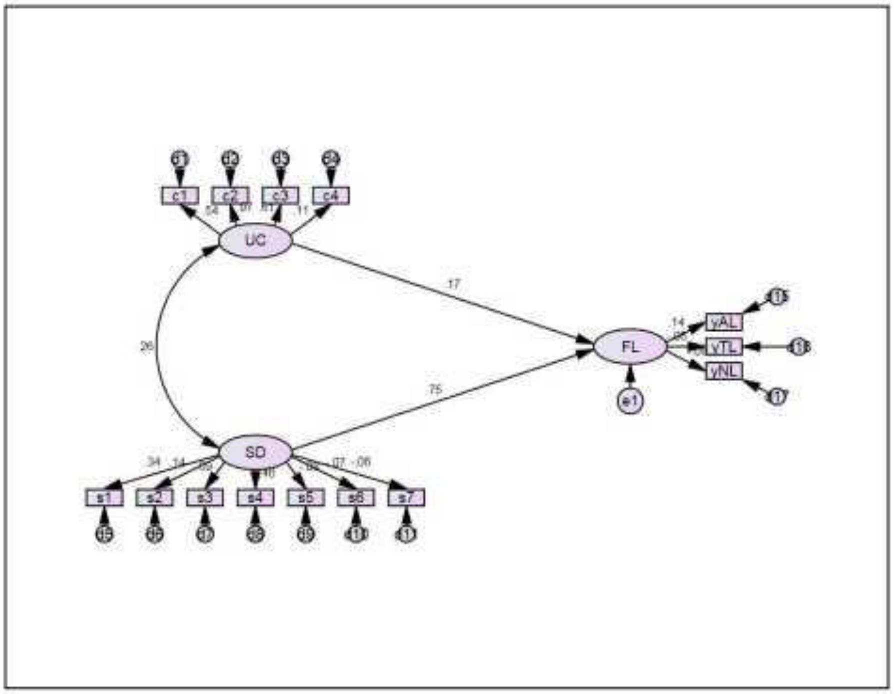
	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNL	-.028	-.180	.000	-.072	-.011	.000
yTL	-.057	-.366	.000	-.085	-.013	.000
yAL	.030	.195	.000	.072	.011	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
133.848	72	.000	1.859	1154	.023	.945	.955	.934	199.848	378.608

E.2.17 Model L2: Frequencies of Leisure Trips (Entire Data of the 2006 MHTS)



Result (Default model)

Minimum was achieved
Chi-square = 255.152
Degrees of freedom = 74
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FL	<---	UC	.282	.067	4.221	***	.169
FL	<---	SD	.055	.004	12.273	***	.750
c1	<---	UC	1762777.623	98190.425	17.953	***	.543
c2	<---	UC	30068.997	1681.826	17.879	***	.970
c3	<---	UC	1057.718	58.682	18.025	***	.608
c4	<---	UC	1.000				.109
yAL	<---	FL	1.000				.143
yTL	<---	FL	-.637	.102	-6.224	***	-.065
yNL	<---	FL	-.426	.073	-5.855	***	-.060
s1	<---	SD	1.000				.344

			Unstandardized	S.E.	C.R.	p	Standardized
s2	<---	SD	.178	.011	15.560	***	.137
s3	<---	SD	.968	.031	30.778	***	.589
s4	<---	SD	2.209	.068	32.259	***	.456
s5	<---	SD	-.103	.012	-8.974	***	-.075
s6	<---	SD	-2.558	.295	-8.684	***	-.073
s7	<---	SD	-.264	.034	-7.668	***	-.064

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Label	Correlation
UC	<-->	SD	.002	.000	14.334	***		.255

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FL	.156
s7	.004
s6	.005
s5	.006
s4	.208
s3	.347
s2	.019
s1	.119
yNL	.104
yTL	.104
yAL	.120
c4	.112
c3	.370
c2	.941
c1	.295

Total Effects

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.055	.282	.000	.750	.169	.000
s7	-.264	.000	.000	-.064	.000	.000
s6	-2.558	.000	.000	-.073	.000	.000
s5	-.103	.000	.000	-.075	.000	.000
s4	2.209	.000	.000	.456	.000	.000
s3	.968	.000	.000	.589	.000	.000
s2	.178	.000	.000	.137	.000	.000
s1	1.000	.000	.000	.344	.000	.000
yNL	-.023	-.120	-.426	-.045	-.010	-.060
yTL	-.035	-.180	-.637	-.048	-.011	-.065

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
yAL	.055	.282	1.000	.107	.024	.143
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1057.718	.000	.000	.608	.000
c2	.000	30068.997	.000	.000	.970	.000
c1	.000	1762777.623	.000	.000	.543	.000

Direct Effects

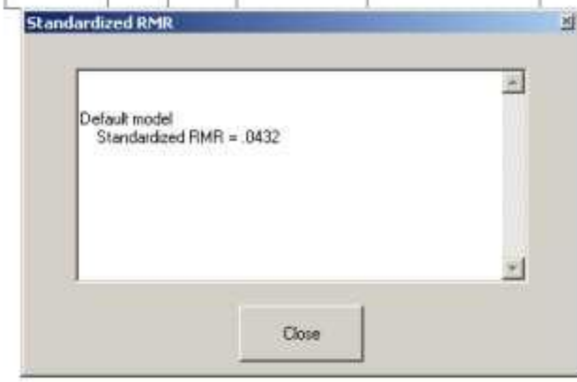
	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.055	.282	.000	.750	.169	.000
s7	-.264	.000	.000	-.064	.000	.000
s6	-2.558	.000	.000	-.073	.000	.000
s5	-.103	.000	.000	-.075	.000	.000
s4	2.209	.000	.000	.456	.000	.000
s3	.968	.000	.000	.589	.000	.000
s2	.178	.000	.000	.137	.000	.000
s1	1.000	.000	.000	.344	.000	.000
yNL	.000	.000	-.426	.000	.000	-.060
yTL	.000	.000	-.637	.000	.000	-.065
yAL	.000	.000	1.000	.000	.000	.143
c4	.000	1.000	.000	.000	.109	.000
c3	.000	1057.718	.000	.000	.608	.000
c2	.000	30068.997	.000	.000	.970	.000
c1	.000	1762777.623	.000	.000	.543	.000

Indirect Effects

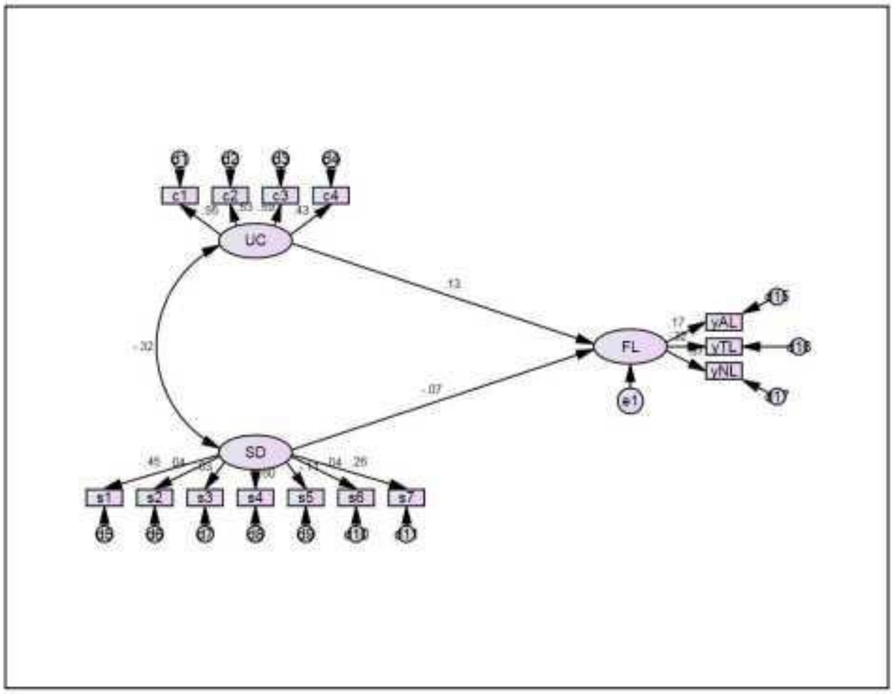
	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNL	-.023	-.120	.000	-.045	-.010	.000
yTL	-.035	-.180	.000	-.048	-.011	.000
yAL	.055	.282	.000	.107	.024	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
255.152	74	.000	3.448	10932	0.009	.912	.969	.956	317.152	574.036



E.2.18 Model L3: Frequencies of Leisure Trips (Data of the 2013 Survey) without Consideration of Utility



Result (Default model)

Minimum was achieved
Chi-square = 217.042
Degrees of freedom = 74
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
FL	<---	UC	1.385	.728	1.903	.057	.125
FL	<---	SD	-.072	.032	-2.241	.025	-.072
c1	<---	UC	639989.612	52547.271	12.179	***	.531
c2	<---	UC	2733.967	236.199	11.575	***	.852
c3	<---	UC	342.935	28.253	12.138	***	.586
c4	<---	UC	1.000				.428
yAL	<---	FL	1.000				.170
yTL	<---	FL	1.958	.456	4.289	***	.324
yNL	<---	FL	9.932	4.217	2.355	.019	.867
s1	<---	SD	1.000				.451

			Unstandardized	S.E.	C.R.	p	Standardized
s2	<---	SD	.047	.047	1.003	.316	.040
s3	<---	SD	.706	.078	9.112	***	.625
s4	<---	SD	2.852	.312	9.143	***	.596
s5	<---	SD	-.101	.038	-2.667	.008	-.108
s6	<---	SD	1.030	.974	1.058	.290	.042
s7	<---	SD	.230	.039	5.854	***	.262

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlation
UC	<-->	SD	-.008	.001	-5.670	***	-.315

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
FL	.126
s7	.068
s6	.002
s5	.012
s4	.355
s3	.391
s2	.002
s1	.204
yNL	.751
yTL	.105
yAL	.129
c4	.183
c3	.343
c2	.282
c1	.907

Total Effects

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	-.072	1.385	.000	-.072	.125	.000
s7	.230	.000	.000	.262	.000	.000
s6	1.030	.000	.000	.042	.000	.000
s5	-.101	.000	.000	-.108	.000	.000
s4	2.852	.000	.000	.596	.000	.000
s3	.706	.000	.000	.625	.000	.000
s2	.047	.000	.000	.040	.000	.000
s1	1.000	.000	.000	.451	.000	.000
yNL	-.714	13.754	9.932	-.062	.108	.867
yTL	-.141	2.711	1.958	-.023	.040	.324

	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
yAL	-.072	1.385	1.000	-.012	.021	.170
c4	.000	1.000	.000	.000	.428	.000
c3	.000	342.935	.000	.000	.586	.000
c2	.000	2733.967	.000	.000	.531	.000
c1	.000	639989.612	.000	.000	.952	.000

Direct Effects

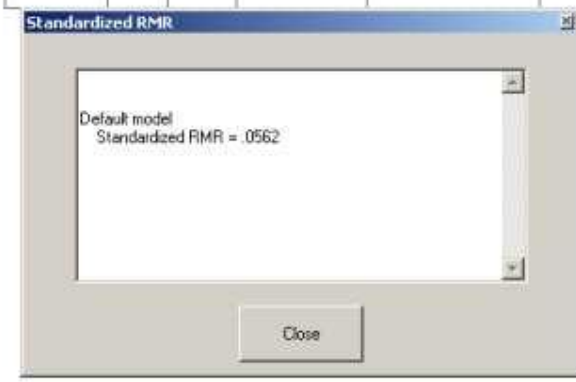
	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	-.072	1.385	.000	-.072	.125	.000
s7	.230	.000	.000	.262	.000	.000
s6	1.030	.000	.000	.042	.000	.000
s5	-.101	.000	.000	-.108	.000	.000
s4	2.852	.000	.000	.596	.000	.000
s3	.706	.000	.000	.625	.000	.000
s2	.047	.000	.000	.040	.000	.000
s1	1.000	.000	.000	.451	.000	.000
yNL	.000	.000	9.932	.000	.000	.867
yTL	.000	.000	1.958	.000	.000	.324
yAL	.000	.000	1.000	.000	.000	.170
c4	.000	1.000	.000	.000	.428	.000
c3	.000	342.935	.000	.000	.586	.000
c2	.000	2733.967	.000	.000	.531	.000
c1	.000	639989.612	.000	.000	.952	.000

Indirect Effects

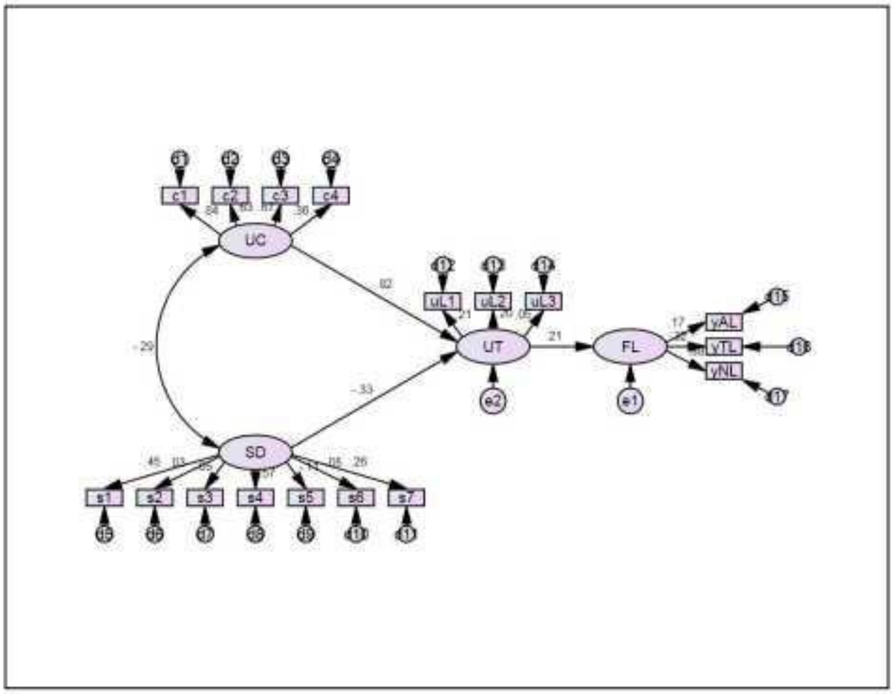
	Unstandardized			Standardized		
	SD	UC	FL	SD	UC	FL
FL	.000	.000	.000	.000	.000	.000
s7	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000
yNL	-.714	13.754	.000	-.062	.108	.000
yTL	-.141	2.711	.000	-.023	.040	.000
yAL	-.072	1.385	.000	-.012	.021	.000
c4	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000

Model Fit Summary

χ2	d.f.	p	Relative χ2	Hoelter's critical N (α = 0.05)	RMSEA	CFI	GFI	AGFI	AIC	BIC
217.042	74	.000	2.933	452	0.043	.938	.934	.906	279.042	432.159



E.2.19 Model L4: Frequencies of Leisure Trips (Data of the 2013 Survey) with Consideration of Utility



Result (Default model)

Minimum was achieved
Chi-square = 255.300
Degrees of freedom = 115
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	5.510	1.138	4.843	***	.816
UT	<---	SD	-.173	.070	-2.483	.013	-.332
FL	<---	UT	.396	.184	2.148	.032	.205
c1	<---	UC	668580.597	65030.176	10.281	***	.627
c2	<---	UC	3828.530	386.615	9.903	***	.839
c3	<---	UC	465.478	46.160	10.084	***	.671
c4	<---	UC	1.000				.361
uL1	<---	UT	1.000				.212
uL2	<---	UT	.577	.141	4.091	***	.196
uL3	<---	UT	133.580	74.793	1.786	.074	.146

			Unstandardized	S.E.	C.R.	p	Standardized
yAL	<---	FL	1.000				.168
yTL	<---	FL	1.947	.452	4.304	***	.319
yNL	<---	FL	10.141	4.079	2.486	.013	.878
s1	<---	SD	1.000				.446
s2	<---	SD	.034	.047	.719	.472	.028
s3	<---	SD	.748	.083	8.989	***	.655
s4	<---	SD	2.770	.304	9.108	***	.573
s5	<---	SD	-.106	.038	-2.753	.006	-.111
s6	<---	SD	1.181	.983	1.201	.230	.048
s7	<---	SD	.231	.040	5.832	***	.260

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlation
UC	<-->	SD	-.006	.001	-5.047	***	-.290

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.733
FL	.242
s7	.068
s6	.002
s5	.012
s4	.328
s3	.429
s2	.001
s1	.199
yNL	.771
yTL	.102
yAL	.028
uL3	.002
uL2	.038
uL1	.045
c4	.130
c3	.450
c2	.393
c1	.704

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	FL	SD	UC	UT	FL
UT	-.173	5.510	.000	.000	-.332	.816	.000	.000
FL	-.068	2.182	.396	.000	-.068	.168	.205	.000

	Unstandardized				Standardized			
	SD	UC	UT	FL	SD	UC	UT	FL
s7	.231	.000	.000	.000	.260	.000	.000	.000
s6	1.181	.000	.000	.000	.048	.000	.000	.000
s5	-.106	.000	.000	.000	-.111	.000	.000	.000
s4	2.770	.000	.000	.000	.573	.000	.000	.000
s3	.748	.000	.000	.000	.655	.000	.000	.000
s2	.034	.000	.000	.000	.028	.000	.000	.000
s1	1.000	.000	.000	.000	.446	.000	.000	.000
yNL	-.694	22.127	4.016	10.141	-.060	.147	.180	.878
yTL	-.133	4.248	.771	1.947	-.022	.054	.066	.319
yAL	-.068	2.182	.396	1.000	-.011	.028	.035	.168
uL3	-23.098	736.018	133.580	.000	-.015	.037	.046	.000
uL2	-.100	3.179	.577	.000	-.065	.160	.196	.000
uL1	-.173	5.510	1.000	.000	-.071	.173	.212	.000
c4	.000	1.000	.000	.000	.000	.361	.000	.000
c3	.000	465.478	.000	.000	.000	.671	.000	.000
c2	.000	3828.530	.000	.000	.000	.627	.000	.000
c1	.000	668580.597	.000	.000	.000	.839	.000	.000

Direct Effects

	Unstandardized				Standardized			
	SD	UC	UT	FL	SD	UC	UT	FL
UT	-.173	5.510	.000	.000	-.332	.816	.000	.000
FL	.000	.000	.396	.000	.000	.000	.205	.000
s7	.231	.000	.000	.000	.260	.000	.000	.000
s6	1.181	.000	.000	.000	.048	.000	.000	.000
s5	-.106	.000	.000	.000	-.111	.000	.000	.000
s4	2.770	.000	.000	.000	.573	.000	.000	.000
s3	.748	.000	.000	.000	.655	.000	.000	.000
s2	.034	.000	.000	.000	.028	.000	.000	.000
s1	1.000	.000	.000	.000	.446	.000	.000	.000
yNL	.000	.000	.000	10.141	.000	.000	.000	.878
yTL	.000	.000	.000	1.947	.000	.000	.000	.319
yAL	.000	.000	.000	1.000	.000	.000	.000	.168
uL3	.000	.000	133.580	.000	.000	.000	.046	.000
uL2	.000	.000	.577	.000	.000	.000	.196	.000
uL1	.000	.000	1.000	.000	.000	.000	.212	.000
c4	.000	1.000	.000	.000	.000	.361	.000	.000
c3	.000	465.478	.000	.000	.000	.671	.000	.000
c2	.000	3828.530	.000	.000	.000	.627	.000	.000
c1	.000	668580.597	.000	.000	.000	.839	.000	.000

Indirect Effects

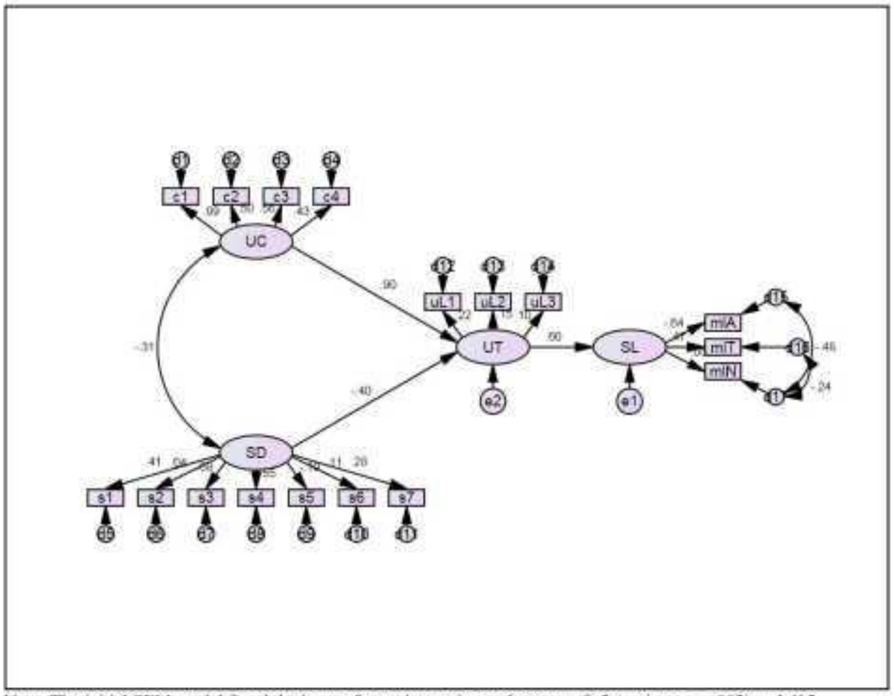
	Unstandardized				Standardized			
	SD	UC	UT	FL	SD	UC	UT	FL

	Unstandardized				Standardized			
	SD	UC	UT	FL	SD	UC	UT	FL
UT	.000	.000	.000	.000	.000	.000	.000	.000
FL	-.068	2.182	.000	.000	-.068	.168	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
yNL	-.694	22.127	4.016	.000	-.060	.147	.180	.000
yTL	-.133	4.248	.771	.000	-.022	.054	.066	.000
yAL	-.068	2.182	.396	.000	-.011	.028	.035	.000
uL3	-23.098	736.018	.000	.000	-.015	.037	.000	.000
uL2	-.100	3.179	.000	.000	-.065	.160	.000	.000
uL1	-.173	5.510	.000	.000	-.071	.173	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
255.300	115	.000	2.220	570	.034	.914	.943	.924	331.300	518.992

E.2.20 Model L5: Mode Shares of Leisure Trips (Data of the 2013 Survey) with Consideration of Utility



Note: The initial SEM model faced the issue of negative variances because of e2 (variance = -.002) and d15 (variance = -3.514). This issue led to multiple modifications: A correlation path was introduced for each case and if it resulted in another issue in different parts of the model, an alternative path was considered. The final model included the following paths: d15 <--> d17 and d16 <--> d17. That is, in this final model, variance of e2 became positive and no modification was necessary.

Result (Default model)

Minimum was achieved
Chi-square = 241.029
Degrees of freedom = 113
Probability level = .000

Regression Weights

			Unstandardized	S.E.	C.R.	p	Standardized
UT	<---	UC	.380	.058	6.606	***	.900
UT	<---	SD	-.262	.101	-2.601	.009	-.396
SL	<---	UT	.706	.280	2.524	.012	.605
c1	<---	UC	662638.958	54722.595	12.109	***	.501
c2	<---	UC	2569.805	219.672	11.698	***	.891

			Unstandardized	S.E.	C.R.	p	Standardized
c3	<---	UC	325.887	26.331	12.377	***	.560
c4	<---	UC	1.000				.430
uL1	<---	UT	1.000				.219
uL2	<---	UT	.876	.378	2.316	.021	.154
uL3	<---	UT	579.300	307.589	1.883	.060	.103
mlA	<---	SL	-1.410	.239	-5.906	***	-.636
mlT	<---	SL	1.000				.468
mlN	<---	SL	.115	.046	2.506	.012	.049
s1	<---	SD	1.000				.411
s2	<---	SD	.053	.050	1.050	.294	.040
s3	<---	SD	.846	.092	9.244	***	.681
s4	<---	SD	2.888	.320	9.026	***	.549
s5	<---	SD	-.106	.041	-2.607	.009	-.103
s6	<---	SD	2.858	1.064	2.687	.007	.106
s7	<---	SD	.273	.044	6.266	***	.283

*** $p < 0.001$

Covariances

			Estimate	S.E.	C.R.	p	Correlations
UC	<-->	SD	-.007	.001	-5.599	***	-.309
d15	<-->	d17	-.052	.007	-7.372	***	-.480
d16	<-->	d17	-.029	.006	-4.789	***	-.239

*** $p < 0.001$

Squared Multiple Correlations

	Estimate
UT	.748
SL	.366
s7	.080
s6	.011
s5	.011
s4	.302
s3	.464
s2	.002
s1	.169
mlN	.102
mlT	.219
mlA	.404
uL3	.311
uL2	.324
uL1	.312
c4	.185
c3	.313
c2	.251
c1	.982

Total Effects

	Unstandardized				Standardized			
	SD	UC	UT	SL	SD	UC	UT	SL
UT	-.262	.380	.000	.000	-.396	.900	.000	.000
SL	-.185	.268	.706	.000	-.240	.545	.605	.000
s7	.273	.000	.000	.000	.283	.000	.000	.000
s6	2.858	.000	.000	.000	.106	.000	.000	.000
s5	-.106	.000	.000	.000	-.103	.000	.000	.000
s4	2.888	.000	.000	.000	.549	.000	.000	.000
s3	.846	.000	.000	.000	.681	.000	.000	.000
s2	.053	.000	.000	.000	.040	.000	.000	.000
s1	1.000	.000	.000	.000	.411	.000	.000	.000
mlN	-.021	.031	.081	.115	-.012	.027	.030	.049
mlT	-.185	.268	.706	1.000	-.112	.255	.283	.468
mlA	.261	-.378	-.996	-1.410	.153	-.347	-.385	-.636
uL3	-151.693	219.919	579.300	.000	-.041	.093	.103	.000
uL2	-.229	.333	.876	.000	-.061	.139	.154	.000
uL1	-.262	.380	1.000	.000	-.087	.197	.219	.000
c4	.000	1.000	.000	.000	.000	.430	.000	.000
c3	.000	325.887	.000	.000	.000	.560	.000	.000
c2	.000	2569.805	.000	.000	.000	.501	.000	.000
c1	.000	662638.958	.000	.000	.000	.991	.000	.000

Direct Effects

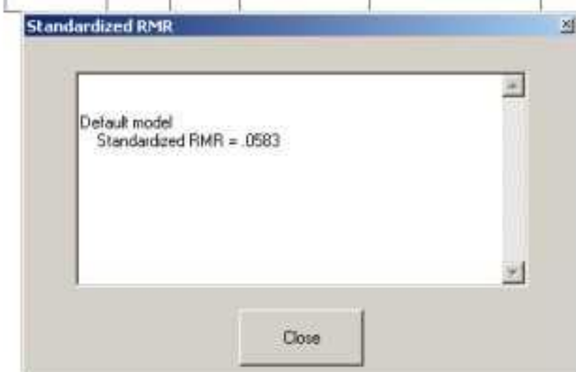
	Unstandardized				Standardized			
	SD	UC	UT	SL	SD	UC	UT	SL
UT	-.262	.380	.000	.000	-.396	.900	.000	.000
SL	.000	.000	.706	.000	.000	.000	.605	.000
s7	.273	.000	.000	.000	.283	.000	.000	.000
s6	2.858	.000	.000	.000	.106	.000	.000	.000
s5	-.106	.000	.000	.000	-.103	.000	.000	.000
s4	2.888	.000	.000	.000	.549	.000	.000	.000
s3	.846	.000	.000	.000	.681	.000	.000	.000
s2	.053	.000	.000	.000	.040	.000	.000	.000
s1	1.000	.000	.000	.000	.411	.000	.000	.000
mlN	.000	.000	.000	.115	.000	.000	.000	.049
mlT	.000	.000	.000	1.000	.000	.000	.000	.468
mlA	.000	.000	.000	-1.410	.000	.000	.000	-.636
uL3	.000	.000	579.300	.000	.000	.000	.103	.000
uL2	.000	.000	.876	.000	.000	.000	.154	.000
uL1	.000	.000	1.000	.000	.000	.000	.219	.000
c4	.000	1.000	.000	.000	.000	.430	.000	.000
c3	.000	325.887	.000	.000	.000	.560	.000	.000
c2	.000	2569.805	.000	.000	.000	.501	.000	.000
c1	.000	662638.958	.000	.000	.000	.991	.000	.000

Indirect Effects

	Unstandardized				Standardized			
	SD	UC	UT	SL	SD	UC	UT	SL
UT	.000	.000	.000	.000	.000	.000	.000	.000
SL	-.185	.268	.000	.000	-.240	.545	.000	.000
s7	.000	.000	.000	.000	.000	.000	.000	.000
s6	.000	.000	.000	.000	.000	.000	.000	.000
s5	.000	.000	.000	.000	.000	.000	.000	.000
s4	.000	.000	.000	.000	.000	.000	.000	.000
s3	.000	.000	.000	.000	.000	.000	.000	.000
s2	.000	.000	.000	.000	.000	.000	.000	.000
s1	.000	.000	.000	.000	.000	.000	.000	.000
mIN	-.021	.031	.081	.000	-.012	.027	.030	.000
mIT	-.185	.268	.706	.000	-.112	.255	.283	.000
mIA	.261	-.378	-.996	.000	.153	-.347	-.385	.000
uL3	-151.693	219.919	.000	.000	-.041	.093	.000	.000
uL2	-.229	.333	.000	.000	-.061	.139	.000	.000
uL1	-.262	.380	.000	.000	-.087	.197	.000	.000
c4	.000	.000	.000	.000	.000	.000	.000	.000
c3	.000	.000	.000	.000	.000	.000	.000	.000
c2	.000	.000	.000	.000	.000	.000	.000	.000
c1	.000	.000	.000	.000	.000	.000	.000	.000

Model Fit Summary

$\chi 2$	d.f.	p	Relative $\chi 2$	Hoelter's critical N ($\alpha = 0.05$)	RMSEA	CFI	GFI	AGFI	AIC	BIC
241.029	113	.000	2.133	594	.033	.920	.918	.889	321.029	518.599



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