Beyond Accessibility and Behavioral Outcomes: Re-conceptualizing Equity in Transportation through the Capabilities Approach

A Dissertation
SUBMITTED TO THE FACULTY OF THE
UNIVERSITY OF MINNESOTA

By

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF
THE DEGREE OF DOCTOR OF PHILOSOPHY

Advisor: Dr. Greg Lindsey

September 2020

Acknowledgements

I am indebted to many people for their consistent guidance, help, and support along the way to complete the thesis and my PhD program. First, I would like to express sincere thanks to my advisor, Dr. Greg Lindsey. Without his insightful feedback on the work and encouragement, I would not complete the dissertation. He has always provided me guidance when I encountered questions in my research and life. Having worked with him over the years, I am extremely grateful for the intellectual freedom he has given me and the patience he has shown me. It gives me a start as an independent researcher. Besides academic support, Dr. Lindsey has shared a lot of valuable experience and advice about being a good teacher and efficiently managing projects with me. This valuable experience would benefit my whole career.

I would like to thank Dr. Jason Cao, Dr. Yingling Fan, Dr. Ryan Allen and Dr. Ying Song for their insightful guidance and feedback through this research and my PhD study. Their guidance on linking the theoretical discussion to transportation practice has informed policy implications, which are a key part of this thesis. Having worked with Dr. Cao over several research projects, I really appreciate his guidance and mentorships on conducting empirical research and writing empirical research papers. The Neighborhood Environment, Daily Activities, and Well-Being Study led by Dr. Fan has provided a valuable data source for my empirical study in Chapter 4. I really appreciate her constant support and encouragement through the program. I am grateful for Dr. Allen for making me constantly thinking about policy-relevant implications and questions. I also really appreciate the aspects of spatial and geographic thinking Dr. Song brings into my research, which has become an integral part of what I would like to incorporate into my future study.

I am grateful for the support of my parents and friends around me, who have constantly encouraged me in all facets of my life.

Abstract

In the past decades, transportation equity has attracted increasing attention from transportation researchers and policymakers. Nonetheless, there is a lack of theoretical understanding of transportation equity. The dissertation engages the Capability Approach of Sen and Nussbaum as a theory of justice and well-being to conceptualize transportation equity as the process of the production of the equality of mobility capabilities, the substantial freedom people have to travel. Specifically, I propose an equity evaluative framework of five evaluation domains, including

1) Access to basic resources, services, and activities sites;
2) The freedom of physical movement around places;
3) Opportunities for active travel (walking and bicycling);
4) Opportunities to conduct safe and psychologically satisfied trips;
5) Access to political engagement activities.

The dissertation also applies the CA framework to two different empirical contexts. One assesses the inequalities of mobility outcomes and capabilities of traveling within low-car ownership households. The results reveal that low-car ownership people of different socio-economic groups achieve different mobility outcomes under the different levels of mobility capabilities. The analysis suggests the joint evaluation of mobility capability and outcomes in informing transportation inequity and disadvantage. The second examines the inequalities of travel mood among different socio-demographic groups and how mobility capabilities, measured as modal options and access destination opportunities, interact with travel mood. The results reveal the significant impacts of mobility capabilities on travel mood and the moderation effects of mobility capabilities on the relationship between mode and mood. The findings highlight the importance of explicit consideration of mobility capabilities– in policy debates and planning initiatives. The concluding chapter contextualizes these findings within the transportation literature and proposes several take-away for policy and future research directions.

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1. Chapter 1: Introduction

Transportation plays an important role in ensuring access to opportunities; researchers have revealed the importance of transportation on accessing jobs, healthcare, education, goods and services, and maintaining social connections with friends and families (Ong and Blumenberg, 1998; Lucas, 2006; Ettema et al., 2011; Lucas, 2012). These growing research efforts have also facilitated an increasing interest in social equity and transportation. Researchers have developed and used various measures to evaluate the relationship between transportation and social equity, such as infrastructure investment, accessibility, the number of trips, and personal miles traveled. However, these existing studies of relationships between social equity and transportation are mostly limited to studies of the disparities of access to infrastructure, behavioral outcomes, or accessibility among gender, ethnicities, age groups, and income class. How these disparities among individuals translate transportation equity is still unclear, and how transportation equity should be defined is still lack of consensus due to the difficulties involved in comprehensively comparing, measuring, and quantifying these social equities or inequities in transportation.

The social-political objective to promote well-being has been widely recognized both nationally and globally. The relationships between mobility and objective well-being, such as employment outcomes, earnings, and health outcomes, have received significant attention in the transportation fields, especially after the proposal of the Spatial Mismatch Hypothesis in 1969 (Kain, 1969). In recent years, researchers in transportation and mobility also have begun to examine the link between mobility and subjective well-being (e.g., Schwanen, 2015; Ettema et al., 2011; Ettema et al., 2012). Transportation studies could benefit from the conceptualization and theories of well-being. It is quite important to consider questions of equity and justice in transportation, along with well-being, as the policy objective is to improve the well-being.

In response to these research needs, I engage transportation and mobility literature with the Capability Approach (CA), which is a theory of well-being and social justice and

emphases that social arrangements should aim to expand people's capabilities, the substantial freedom people have to achieve valuable "functionings", to re-conceptualize transportation equity. In the process of re-conceptualization, notions such as opportunities, capabilities, functionings, well-being, and freedom of individuals are considered into the transportation setting. In the thesis, I argue that a more careful and systematic understanding of the relationship between transportation, and what transportation enables or produces is needed, to better recognize how transport and well-being are interconnected, and therefore deepens how notions of mobility and transportation equity are understood.

This thesis consists of five chapters. Chapters 2, 3, and 4 are three separate essays. Chapter 2 is a theoretical discussion that engages the CA with concepts in transportation to re-conceptualize transportation equity. In the following two chapters, I apply this theoretical work into two different empirical contexts. Chapter 3 is an empirical, analytical paper in which the theoretical work discussed in Chapter 2 is used to evaluate equity in low-car ownership households and inform planning practice and policy to promote equity in transportation. In Chapter 4, I apply the CA to investigate the interaction between daily travel and travel mood to justify the importance of considering the choice context of traveling, the freedom people have to travel or travel around. Chapter 5 is a synthesis chapter, summarizing the results and discussing the planning and policy implications of the results.

Specifically, in these chapters, I focus on the following research questions.

In Chapter 2, *the Capability Approach and Transportation*, I engage Sen's capability approach (Sen, 1979, 1999, and 2009) and Nussbaum's 10 central basic human capabilities (Nussbaum, 2011) into the transportation setting to inform transportation equity practices and develop an equity evaluation framework. In the chapter, I answer the following questions:

- Research Question 1: What should we value and assess for evaluating transportation equity?

- Research Question 2: What is transportation equity?

Chapter 3 is an empirical work. The work is built on the evaluation framework developed in the theoretical discussion of chapter 2 to assess transportation inequities among different social demographic groups. The chapter looks at a special transportation group, people living in low-car ownership households, who may need to share the only household vehicle with other household drivers, to reveal the disparities within the group of people. The assessment not only on people's actualized functioning outcomes (mobility outcomes), but also on the perceived travel opportunity sets, a core component of mobility capabilities, in the transportation context. It answers two following questions:

- Research Question 1: How do mobility capabilities, measured as alternative mode option availability for traveling from place to place, and functioning outcomes, measured as mobility behavior outcomes, vary among different socio-demographic groups?

- Research Question 2: How do mobility capabilities translate into functioning outcomes?

In Chapter 4, *Mobility Capabilities Matter: Mobility Capabilities, Daily Travel, and Travel Mood,* also is an empirical work. I examine the variation of emotions during travel among people with different socio-demographic characteristics and levels of mobility capabilities. Through the research, I examine the impacts of the context of traveling, i.e., the range of travel choices available to people, on their travel outcomes, mood during travel in the study. I am trying to justify that transportation equity evaluation should not only focus on the individual travel outcomes, for example mood during travel in the case, but also the range of travel choices available to people. In the chapter, I will answer the following key research questions:

- Research Question 1: how do modal options, destination accessibility, and travel mood vary among different socio-demographic groups?

- Research Question 2: how do modal options and destination accessibility correlate with emotions during travel?

- Research Question 3: how do mobility capabilities, measured as modal options and destination accessibility, moderate the relationship between moods and modes?

These three chapters answer these research questions in a stepwise sequence. They are logically interdependent and mutually supported, making the dissertation a comprehensive and cohesive whole. Chapter 2 develops a consistent theoretical framework to inform the empirical analyses in Chapter 3, and 4. Since the CA is not an explanatory theory that is used to explain empirical phenomena; instead, it is a tool and a framework to conceptualize and evaluate these phenomena. Applying the CA to the empirical contexts require the addition of explanatory theories (Robeyns, 2005). Thus, in each empirical chapter, I articulate the research questions, review the relevant literature to construct the conceptual framework, develop effective methods, and test hypotheses. Each chapter stands alone as a research paper with an independent structure.

2. Chapter 2: The Capability Approach and Transportation

2.1 Setting the Scene

In the past decades, researchers have paid increasing attention to justice and equity in transportation. Their studies have addressed a variety of questions, including the distribution of benefits of transportation investment or service provision (e.g., Wang & Lindsey, 2017); how policies, such as congestion pricing (e.g., Karlström & Franklin, 2009) disproportionally affect different social economic groups; and what social economic groups are in the disadvantaged population in transportation (Lucas et al., 2016a)? In recent years, a small but growing number of scholars (e.g., Lucas et al., 2016b; Martens, 2012; Marten et al., 2012; Marten & Golub, 2012; Van Wee & Roeser, 2013; Pereira et al., 2017) have engaged with different theories of social justice to conceptualize transportation equity. These studies are to theoretically argue the equity evaluation focus of accessibility and propose different moral principles such as sufficiency (Marten, 2012) to decide the distribution of accessibility. Conceptual clarity will be helpful to get the insights to inform policy decisions. Differing from these previous studies, this chapter specifically focuses on the Capability Approach, which is both a theory of social justice and a theory of well-being and incorporates notions such as opportunities, capabilities, functionings, well-being, and freedom of individuals into the transportation setting to conceptualize transportation equity.

The CA provides a general normative framework for the assessment of human development (Sen, 1979, 1999, 2005 and 2009). It also has been applied in the evaluation of specific areas of social policy, such as health and education. In this chapter, via engaging with the CA, I aim to answer the following key research questions and propose a framework for evaluating transportation equity.

- Research Question 1: What should we value and assess for evaluating transportation equity?

- Research Question 2: What is transportation equity?

The following discussion moves through a number of steps. I first introduce the Capabilities Approach of Sen and Nussbaum and discuss well-being, justice, and their interaction under the CA. Then I review different ways in which the relationships among transportation, well-being, and equity have been framed within academic analyses. I next engage the transportation context with the CA. I conclude by reviewing the implications of the capabilities-based framework for transportation

2.2 What is the Capability Approach

The CA was originally proposed by Amartya Sen (1979, 1999, 2005 and 2009) and further developed by a growing number of scholars for improving the theory and practice of human development. One of the most well-known followers is Martha Nussbaum (1993, 1995, and 2011), who further proposed ten central capabilities for human dignity and developed the CA as a theory of justice. The core idea of the CA is that human well-being should be understood and assessed in terms of what people are effectively able to be and to do, that is, on their capabilities. Specifically, Sen argues that:

> *"The objective of policies should focus on what people are able to be and do, on the quality of life, and on removing barriers so that they have more freedom to live the kind of life that, upon reflection, they have reason to value." (Robeyns 2005, 94)*

To ground his arguments, Sen proposed two core concepts: functionings and capabilities. Functionings refer to the achieved outcomes, the things that a person is doing or being, such as being healthy, having shelter, having enough nutrition, and using transit to commute. Capabilities represent the combinations of functionings that a person is able to do and has the "substantive freedom" to choose from. The distinction between functionings and capabilities is between the realized and the potential; functionings are the realized outcomes, while capabilities reflect people's freedom to choose from the realizable outcomes, i.e., the potential. Sen argues that the assessment of well-being should focus on the capabilities, the "real" opportunities, or the substantive freedom

people have to achieve "functionings," which have reasons to value. Each person, for instance, should have the opportunity to acquire enough nutrition. Suppose a person prefers to fast (functioning), in CA. In that case, he/she should also have the option of having enough nutrition available (capability) to not fast and have sufficient nutrition to maintain health.

2.2.1 Freedom and agency

Capabilities, the real opportunities individuals have to achieve the life they value, have two important dimensions of freedom: opportunity freedom and agency freedom. Opportunity freedom is more likely a budget set of "functionings" individuals have to choose from. Agency freedom in the CA refers to a "process that allows freedom of actions and decisions, the actual opportunities that people have, given their personal and social circumstances" (Sen, 1999). The concept of agency freedom emphasizes the importance of empowering people to help themselves and focusing on individuals as the actors of their own development. Opportunity freedom focuses on the existence of a range of choices over valuable functionings while agency freedom moves further, emphasizing that the achievement of functionings is independent of others of favor or goodwill of other people or are independently guaranteed by one's own rights and power. Thus, improving capabilities under the CA is not only to increase the choices of functionings but to expand the freedom to shape one's own destiny.

2.2.2 Conversion factors

The CA makes a crucial distinction between resources or goods and functionings and capabilities (see. Figure 2-1). Goods and resources in the CA could be tangible such as transit and housing, or be intangible such as policies. Goods or resources themselves may not be of interest to people but often have some kind of characteristics that attract people's interest. For example, we may be interested in the bike share because it could take us to destinations we want to arrive or enable us to bicycle for fun or exercise. The characteristics of the good (bike share) enable functionings (traveling or destination arrival). However, the conversion process from the good to functionings is influenced by various conversion factors (Robeyns 2005). The conversion factors influence the degree

to which a person can transform resources/goods into capabilities and functionings and are often categorized into three groups (Robeyns 2005: 99). First, personal conversion factors are internal to the person, such as physical condition, sex, intelligence, or skills. For example, if a person has never learned to bicycle, and then the bike-share program will be limited in enabling the functioning of his/her mobility. Second, environmental conversion factors refer to the natural or built environment. If the roads are steep, cycling becomes more difficult, limiting the conversion process from resource to functionings. Thirdly, social conversion factors contain factors from the society where people live, such as social norms, public policies, practices, or power relations related to class, gender, and race. The three types of conversion factors are also interconnected and influencing each other. Overall, the availability of goods or resources is not sufficient for people to achieve what they want. The living circumstance plays an important role in determining the range of functionings and the freedom of choice, i.e., the capabilities. Thus, the socio-political goal to promote well-being is not exclusively about the provision of resources. But the evaluation of the circumstance to enable potential functioning (capability) expansion.

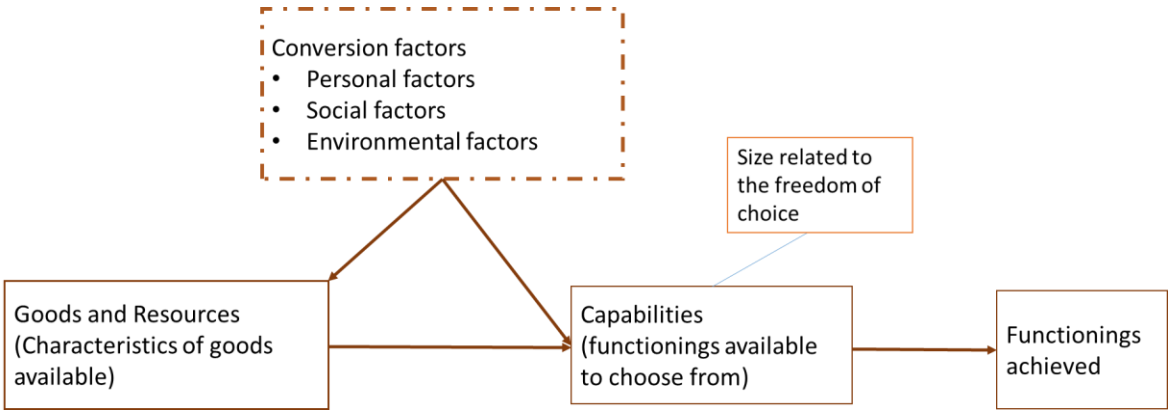


Figure 2-1: Simplified non-dynamic representation of the Capability Approach

Figure 2-2 illustrates a case when the CA is applied to measure the impacts of providing "free transit passes" for residents living in a deprived area. The functionings are various outcomes, including the direct functionings of mobility and destination accessibility, and indirect functioning of income and being healthy. The first key component of analysis are

the choice set. Do residents have other choices, such as a car? Would they use transit because of the lack of alternatives or by choice? The next key component is the ability and opportunity to convert a transit pass to real functionings, including the transit service availability, quality, connectivity, which are influenced by various conversion factors. In this context, people might have the opportunity to use transit but not to do it. The evaluative focus is on people's choice, ability, and opportunity to use the free transit pass to contribute the achievement of the various functionings, whether actually pursued or merely potential.

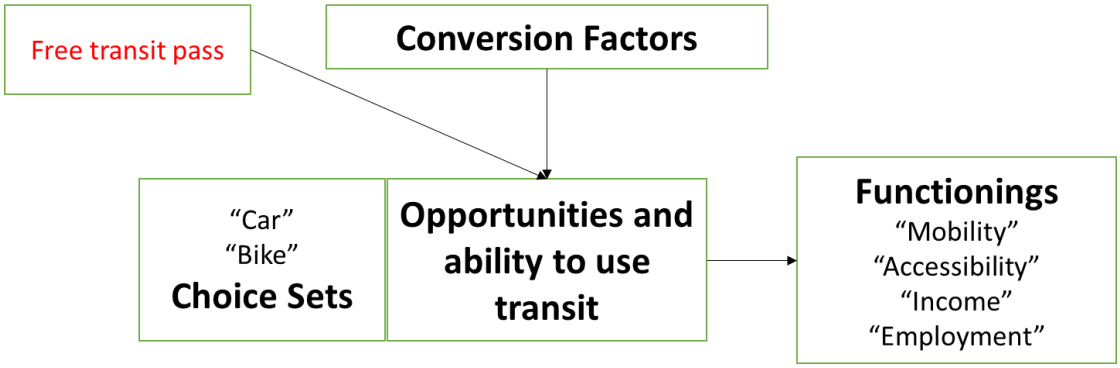


Figure 2-2: An illustrative example of the Capability Approach

2.3 The CA and Well-being

The Capability-based view of well-being stems from an Aristotelian view of humans as developmental beings with the potential to flourish in many different ways (Robeyns 2005). In the Aristotelian view, the possession of material goods and resources are only one component for assessing well-being, and it matters when the material goods and resources contribute to the diverse being and doings of human life. Sen, furthermore, argues that not only valuable human activities and achievements are relevant for assessing well-being but also how well people are able to do and be matters. A low-income woman without car access, for instance, may be forced to commute via transit at late night despite feeling unsecure during the late transit trip. In the case above, assessing well-being from the perspective of achieved outcomes (having the access to jobs and commuting) is not enough for better understanding the well-being of the low-income

woman. However, how well the low-income woman are able to commute via transit also matters in influencing the well-being (e.g.,, does she feel safe?).

The Capability-based view of well-being offers a critique of the evaluative focuses of well-being from resource-based theories. The central critique of the resource-based theories from the CA is that the same amount of goods and resources would not have the same implications for people, given individuals' heterogeneities in capabilities (Sen 1979 and 1999). Different people need different amounts and kinds of goods to reach the same level of well-being. For example, the same bus service without the provision of assistance facilities for the disabled would be very challenging for people without the necessary physical capacities. The inquiry of well-being in CA is what would make people more equal in consideration of their inherent diversity. The distinction between resource and capabilities also represents the same distinction between "goods" and "what goods do to human beings". In CA, "what goods do to human beings" should be the focus of well-being evaluations. However, I would argue that the focus on goods and "what goods do to human beings" are not mutually exclusive. "What goods do human beings" also establishes relational condition between goods and capabilities, accounting for human diversity to achieve equal capabilities.

The CA also offers a critique of the exclusive focus on utility in the welfare theories as the core of well-being concerns (Sen, 1979). Utility is often a latent construct, summing up the benefits and costs in an activity, and economists, for example, seek to maximize the utilities in aggregation. The utilitarian theories of well-being are widely recognized in the transportation setting and are also the foundation of the Cost-Benefit Analysis (CBA). Traveling itself is seen as negative utility while time-saving is treated as the core evaluative focus of transportation projects or policy. The predominant focus of utility often excludes the non-utility information in the evaluation. Also, it predominantly focuses on maximizing utility in aggregation while ignores the important distributional issues in society.

The CA also rejects the exclusive focus of subjective values, such as happiness, to measure well-being. Living in a deprived situation, people often habituate to their circumstance and adapt their preferences. Sen (2009) stated "*Happiness is not all that matters, but first of all, it does matter (and that is important), and second, it can often provide useful evidence on whether or not we are achieving our* objectives *in general*". This subjective information such as life satisfaction and happiness can provide some information of people's present values with respect to each element of a vector of functions (Veehoven, 2010). Furthermore, the subjective values could be treated as discrete and general functionings, to be measured alongside with other important functionings such as being healthy, being well nourished, and working.

Under the CA framework, Sen moves beyond the primary focus of discussion on well-being on the possession of resources and achievements. The substantive freedom people have to achieve the achievements matters for evaluating well-being. Specifically, Sen distinguished four types of well-being in related to capabilities and functionings, *well-being achievement; well-being freedom; agency achievement and agency freedom* (Alikire, 2005, 6-8). Well-being achievement is derived from the behavioral outcomes such as using transit to access jobs. The achievement also secures the other capabilities to being nutrition and better health care. Agency achievement means exercising individual agency of choosing to use transit to commute as a part of an informed consideration. Well-being freedom concerns the conditions enabling or deterring commuting via transit. For example, assume two people both use transit to commute. One person uses transit for commuting because transit is the only choice available for her, and she must use transit even though she feels very insecure. The other uses transit for commuting because a new express service recently opened as another alternative option. These two people would experience well-being freedom differently. Agency freedom is having the condition to exercise agency; these include access to information, the chance for discussion and evaluation, and the freedom to make up one' mind without violence or shame.

2.4 The CA, Social Justice and Equity

The core argument of the CA that well-being should be assessed in the evaluation space of a person's capability is directly engaged with liberal theories of justice. However, as an economist, Sen strongly criticized theories that offer up standards of a just society. Instead of being a transcendent theory of justice inquiring how society ought to be, for Sen, the CA emphasizes the realization-based comparisons, focuses on the advancement or retreat of justice, and seeks to advance justice in the concrete realm of society (Basta, 2015). Thus, in the CA, equity is to promote a process to advance justice, such as via removing barriers instead of a static status. Sen was also reluctant to provide a list of capabilities to prescribe how just society should be. In this work, however, I am interested in a theory of justice that can provide references for evaluating transportation equity. I introduce the context of Nussbaum's list of Central Human Capabilities to deal with the complexity and challenges involved in defining the Capabilities from the original CA and in an attempt to redefine the evaluative focus of transportation equity. Nussbaum's list of central capabilities is(Nussbaum, 2000., p. 78 – 80):

1. ***Life.*** *Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living.*
2. ***Bodily Health****. Being able to have good health, including reproductive health; to be adequately nourished, to have adequate shelter.*
3. ***Bodily Integrity****. Being able to move freely from place to place; having one's bodily boundaries treated as sovereign, i.e. being able to be secure against assault, including sexual assault, child sexual abuse, and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction.*
4. ***Senses****,* ***Imagination, and Thought****. Being able to use the senses, to imagine, think, and reason—and to do these things in a "truly human" way, a way informed and cultivated by an adequate education, including, but by no means limited to, literacy and basic mathematical and scientific training. Being able to use imagination and thought in connection with experiencing and producing self-expressive works and events of one's own choice, religious, literary, musical, and*

so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression with respect to both political and artistic speech, and freedom of religious exercise. Being able to search for the ultimate meaning of life in one's own way. Being able to have pleasurable experiences, and to avoid non-necessary pain.

5. ***Emotions**. Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve at their absence; in general, to love, to grieve, to experience longing, (p.74) gratitude, and justified anger. Not having one's emotional development blighted by overwhelming fear and anxiety, or by traumatic events of abuse or neglect. (Supporting this capability means supporting forms of human association that can be shown to be crucial in their development.)*
6. ***Practical Reason**. Being able to form a conception of the good and to engage in critical reflection about the planning of one's life. (This entails protection for the liberty of conscience.)*
7. ***Affiliation**.*

   A. Being able to live with and toward others, to recognize and show concern for other human beings, to engage in various forms of social interaction; to be able to imagine the situation of another and to have compassion for that situation; to have the capability for both justice and friendship. (Protecting this capability means protecting institutions that constitute and nourish such forms of affiliation, and also protecting the freedom of assembly and political speech.)

   B. Having the social bases of self-respect and non-humiliation; being able to be treated as a dignified being whose worth is equal to that of others. This entails at a minimum, protections against discrimination on the basis of race, sex, sexual orientation, religion, caste, ethnicity, or national origin. In work, being able to work as a human being, exercising practical reason and entering into meaningful relationships of mutual recognition with other workers.
8. ***Other Species**. Being able to live with concern for and in relation to animals, plants, and the world of nature.*
9. ***Play**. Being able to laugh, to play, to enjoy recreational activities.*

10. ***Control over One's Environment***.

A. Political. *Being able to participate effectively in political choices that govern one's life; having the right of political participation, protections of free speech and association.*

B. Material. *Being able to hold property (both land and moveable goods), not just formally but in terms of real opportunity; and having property rights on an equal basis with others; having the right to seek employment on an equal basis with others; having the freedom from unwarranted search and seizure.*

For Nussbaum, having these ten Central Human Capabilities is required for human dignity, and all constitutions should endorse these capabilities. Nussbaum argues that a life lacking in any of these, whether from external deprivation or individual choice, does not mean that it is a less than human life. However, choice and deprivation are different. If someone lacks access to these capabilities, for example, to be well-nourished (bodily health), that reflects a failure of our society to respect her human dignity. If someone chooses not to actualize her opportunities to certain capabilities, for example, to adopt an ascetic life-style and fast for religious reasons at the expense of her bodily health, having that choice is also an important aspect of respecting her/his dignity. Having the central human capabilities also are the conditions of enablement that allow people to pursue their own defined good lives.

2.5 Transportation and Social Justice

The idea of social justice has been addressed from a variety of different theoretical approaches (Young, 1990). It involves distributive justice, justice as recognition (Fraser, 1995) and justice as participation and procedure (Young, 1990). In urban planning literature, Susan Feinstein (2010) developed the idea of a "just city" to accommodate the three ideas of justice, which encompasses three aspects: democracy, diversity, and distributive justice. Democracy focuses on the ideal decision-making process in which each opinion could be heard to shape the built environment. Diversity refers to the recognition of differences and identities, and the promotion of diversity in the decision-making process to flight injustices caused by marginalization (Young, 1990). Distributive

justice addresses how the institutions and rules that govern society shape social and economic inequalities among the members.

These three components of justice are analytically separable but complementary for a just city (Fainstein, 2010). Many empirical studies (e.g., Welch & Mishra, 2010; Wang & Greg, 2017) have focused on the distributive justice while critical theorists comment on justice from the perspective of democracy and diversity (Harvey, 2009, Soja, 2010). Distributive justice theories are focused on the distributional outcomes, as a manifestation of "the most basic and obvious oppression of spatial injustice" while justice from the perspective of democracy explores the root causes of such distribution.

2.5.1 Previous studies on transportation equity

Transportation equity has gained attention since 1960. Similarly, scholars have investigated transportation equity from different perspectives, including participatory planning in transportation (e.g., Booth & Richardson, 2001), the recognition justice (e.g., Cresswell 2006), and the role of transport in promoting the right to the city (e.g., Attoh, 2012). This section focuses on empirical studies of distributive justice, especially on social inequalities and transport-related social exclusion.

Transport-related social exclusion and social inequalities have gained increasing attention in transportation (Lucas 2012; Delbosc & Currie., 2011) and mobility literature (Uteng and Cresswell 2008). One stream of research is to focus on the imbalance in the distributional effects of transport-related resources (Wang & Lindsey, 2017). The unit of analysis varies among studies from the level of the individual, group to neighborhoods. Researchers often have adopted GIS-based methods to measure the spatial distribution of transportation services (e.g., Delbosc & Currie., 2011). They then often used different statistical indices, such as GINI coefficients (Delbosc and Currie, 2011), to identify spatial inequalities between transportation service and social needs. Among various studies, transportation services are often measured in different ways, including infrastructure-proximity measures compared with the spatial distribution of different socio-economic groups. These studies are capable of revealing the existence of inequality

in transportation when inequity remained in its initially narrow conception of proximity. Underlying these studies, possession of resources or goods is people's well-being, and equalizing the distribution of resource is equity.

The critique CA offers to the resource-based theories of justice could also apply here. People differ in their capabilities to convert transport services to satisfy their needs. Thus, the provision of transportation service solely is not a good indicator to reveal inequality. Using the methodologies of "one size fit all" will result in failing to recognize that bodies of different age, race, gender, possess different capabilities to convert transport service into use. For example, the limited scope of transportation equity on the quantity and quality of transit will fail to inform the inequity aroused from the fact that females may feel unsafe to walk access to transit service. Furthermore, these studies fall short in understanding the process through which inequity is produced and thus are limited to informing policy changes of alleviating inequity.

Another stream of research examines the disparities in travel behavioral outcomes among different socio-demographic groups to reveal and inform transportation inequality. Measures of these behavioral outcomes often include trip frequency, travel distance, and travel time (e.g., Karlstrom and Franklin, 2009). One type of the relevant work is to examine the relationship between race, behavioral outcomes, and labor market outcomes, which is highly influenced by the Spatial Mismatch Hypothesis proposed by John Kain (1969) and further developed in the later five decades (Fan, 2012; Qi et al., 2017)

Another important type of work examines the gender differences in traveling. It usually engages with feminism theories to investigate the mobility constraints from social norms, psychological reasons, and home-work relationships females' experience (Fan, 2017; Blumenberg, 2004; Schwanen, 2011). There are also a growing number of works examining travel behavioral outcomes of the low income (Lucas et al., 2012; Blumenberg, 2001; Blumenberg & Pierce, 2012) and the elderly (Kim & Ulfarsson, 2004) to reveal the mobility constraints. The observed behavioral outcomes are primarily a matter of both contextual constraints (e.g., no bike lanes) and personal preferences (not

wanting to). The sole focus on behavioral outcomes cannot tease out the disparities in observed behavioral outcomes resulting from individuals' preferences and contextual constraints. The differentiation between contextual constraints and individual preferences is important as the information could offer insights for addressing constraints and promoting transport equity.

A growing number of studies argue that the evaluative focus of transportation equity should be on accessibility (Martens & Golub, 2012; Pereira et al., 2017). From a justice perspective, accessibility can be conceptualized as the number of destination opportunities people could reach from a given location (usually home) with a given time limit. The evaluative focus on accessibility is consistent with the goal of transportation policy on promoting access to places and accessibility (Marten et al., 2012). Many studies have adopted sophisticated analytical techniques to better measure accessibility provided by different types of transportation services. For example, Welch (2013) calculated transit connectivity and accessibility as measures of the transportation service, compared with the spatially distribution of subsidized housing in Baltimore, and revealed transit inequity. Wang and Lindsey (2017) calculated an index of job penalty, as the loss of job opportunities as the result of choosing low-stress bike routes rather than the shortest routes. They then examined the disparities of job penalty of different social-demographics to reveal inequality. Scholars from studying the time-spatial behavior (e.g., Chen & Akar, 2017) calculated the size of personal activity space and compared the destination opportunity accessibility shaped by personal activity space. The actual personal activity space calculated based on actualized travel behavior suffers the same critique on the evaluative focus of travel behavior outcomes as the travel behavior is the observed outcomes of choices and constraints, which could not reflect the "potential" (Martens & Golub, 2012). Marten & Golub (2012) have discussed various measures of accessibility and CA. Thus, the chapter will not elaborate a lot about accessibility and CA.

Most empirical studies have considered the observed inequalities in transport-related resources, behavioral outcomes, and accessibility levels as unfair without offering any

moral guide toward a fair distribution. A few studies have raised some principles to guide transportation policies toward transportation equity. Litman (2002) defines vertical equity and horizontal equity. Horizontal equity concerns the equal distribution of benefits and costs between people with equal abilities and equal needs, while vertical equity attempts to compensate for the inequalities between groups via offering benefits to those groups in disadvantaged positions. According to the conceptualization, transportation equity aims to facilitate the redistribution of opportunities to those who most need it (Litman, 2002). Marten (2012) introduced Walzer's sphere of justice and Rawls' theory of justice to conceptualize transportation equity and argued that transportation should provide the minimum standard accessibility to goods and services. Pereira et al. (2017) argued that distributive justice in transportation should focus on accessibility and consider minimum standards of accessibility to key destinations.

Table 2-1: Evaluation focuses in transportation literature and CA

Evaluation focuses in Transportation	**Underlying assumption about well-being**	**Critiques from the CA**
Resources and Service Provision	Possession of and access to resources and goods is directly relevant to human well-being	Does not consider human diversity
Mobility behavior outcomes	The behavioral outcomes are relevant to well-being	Does not differentiate choice vs constraints
Accessibility	Potential destination accessibility is relevant to well-being	It is only one component of capabilities

2.6 Transportation Equity and the Capabilities Approach

2.6.1 Existing application of the CA in transportation

The CA has been widely applied in the discipline of education, health, sustainable development, employment, gender issues, and poverty as an evaluative framework. Scholars in urban planning and transportation planning also have begun to apply the CA (Beyazit, 2011; Ryan et al., 2015; Smith et al., 2012; Pereira et al., 2017; Martens, 2012).

Beyazit (2011) discussed the relationship between transport research and the CA, evaluated the strengths and weaknesses of the CA for transportation research via a SWOT analysis, and explored the potential to incorporate the CA with the CBA method in measuring distributional issues of transportation projects. Specifically, in response to the critiques for the traditional CBA, Beyazit (2011) argued that the CA furthers the discussion of benefits in CBA to inclusive bottom-up participatory identified benefits. Besides, the CA, as a realization-based comparison theory of justice, asks for the comparison of different dimensions of a certain project to facilitate the understanding of whether the development generated from transportation is socially just.

Martens and Golub (2012) discussed various measures of accessibility with theories of social justices and critically evaluated the usefulness of existing measures of accessibility in the distributional analysis of transportation projects over population groups or geographic areas. Specifically, Martens and Golub (2012) reviewed theories of social justice, including equality of welfare, equality of resources, the capability approach, and equality of mid-fare. They linked these theories with existing accessibility measures, including infrastructure-based, space-time, contour measures, and utility-based measures. They argued that accessibility drawn from the actual behavior of individuals is not suitable as performance indicators as it could not differentiate choices from constraints.

Smith et al., (2012) used the CA as the framework to identify the income needed by rural households in the UK to be capable of achieving a minimum living standard within given accessibility levels. Personal characteristics, accessibility to services, and income jointly determine the capabilities: income requirement is calculated given certain personal characteristics and accessibility.

Ryan et al. (2015) used the CA as a guiding framework to explore the capability of using public transportation measured as the potential to use public transportation among older persons. The study examined the relationship between socio-demographics, the built environment, and the potential to use public transit to complete the majority of trips and

the actual use of public transit. The results showed that increasing population density, being females, living alone and a lower ratio of car household members all have positive relationships with both the potential and real use of public transport.

Hananel and Berechman (2016) proposed a transportation decision-making framework with the consideration of justice under the CA that includes three separable but complementary measures: maximum allowable travel time, maximum allowable travel distances, and maximum allowable travel expense to make the decision about transport service provision.

Pereira et al., (2017) reviewed several theories of social justice, including the CA, and argued that distributive justice in transportation should focus on accessibility as human capability and a transport policy/project is fair if it distributes transport investments and services in ways that reduces inequality of accessibility opportunities.

These existing studies have made significant progress in understanding transportation equity. Built on the existing studies, the following section engages transportation with the CA systematically to help understand transportation equity. Differing from previous studies, the study not only addresses Sen's work on Capabilities Approaches to inform transportation conceptualization and practice, but also incorporates the discussion of Nussbaum's 10 central capabilities to link transportation and 10 central capabilities and thereby to re-conceptualize transportation equity.

2.6.2 Equality of what?

The key question in evaluating transportation equity is what we should value and assess. To better answer the question, a good understanding of the question concerns what dimensions of human well-being we should consider when we value transportation's role in making a person's life go well. Under the CA, well-being is both valuable human activities and achievements and how well people are able to do and be. Thus, in the following section, I will answer how transportation is relevant to valuable human activities and achievement and how well people are able to do and be.

Sen did not prescribe a list of capabilities for social justice. Thus, I linked the Nussbaum's list of central capabilities with transportation to answer how transportation contributes to the various capabilities that enable people to make choices of living a good life. In Nussbaum's list of central capability for human dignity, the freedom of movement is identified as one of the basic human capabilities, which corresponds with the intrinsic value of travel as the representation of autonomy and freedom. Mobility or travel is also a key enabler for the central capabilities listed in the Nussbaum's list, representing the diversified instrumental value of travel (Table 2-2).

Table 2-2: Engaging Nussbaum's list of central human capabilities with transportation

Central Capabilities	**Definitions**	**Application in Transportation**
Life	Being able to live to the end of a human life of normal length, not dying prematurely, or before one's life is so reduced as to be not worth living.	Access to basic goods such as food, shelter, and economic and social activities Travel safely at all ages
Bodily Health	Being able to have good health, including reproductive health; to be adequately nourished, to have adequate shelter	Access to health facilities, healthy food, economic and social activity; having the opportunities of active travel
Bodily integrity	Being able to move freely from place to place; having one's bodily boundaries treated as sovereign, i.e. being able to be secure against assault, including sexual assault, child sexual abuse, and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction	Able to travel or not travel when wanted; Able to feel secure when traveling.
Sense, imagination and thoughts	Being able to use imagination and thought in connection with experiencing and producing self-expressive works and events of one's own choice, religious, literary, musical, and so forth. Being able to use one's mind in ways protected by guarantees of freedom of expression with respect to both political and artistic speech, and freedom of religious exercise. Being able to search for the ultimate meaning of life in one's own way. Being able to have pleasurable experiences, and to avoid non-necessary pain.	Able to choose to travel or not when wanted, Access to schools, education opportunities, and religious opportunities; Able to have pleased travel experience
Emotion	Being able to have attachments to things and people outside ourselves; to love those who love and care for us, to grieve at their absence; in general, to love, to grieve, to experience longing, (p.74) gratitude, and justified anger. Not having one's emotional	Able to have pleasant travel experience Access to social interactions and activities Able to travel securely and safely

	development blighted by overwhelming fear and anxiety, or by traumatic events of abuse or neglect	
Practical reasons	Being able to form a conception of the good and to engage in critical reflection about the planning of one's life.	Access to schools, information, and participation in public discussion Having opportunities to learn individuals and society's benefits and costs of alternative modes
Affiliation	Being able to live with and toward others, to recognize and show concern for other human beings, to engage in various forms of social interaction; to be able to imagine the situation of another and to have compassion for that situation; to have the capability for both justice and friendship.	Being able to participate in transport planning process Use any mode without any discrimination Access to cultural activities and social interaction
Other species	Being able to live with concern for and in relation to animals, plants, and the world of nature	Able to choose transportation without harming others and environment
Play	Being able to laugh, to play, to enjoy recreational activities.	Opportunities for active travel Access to the recreational facilities
Control over one's environment	A. Political. Being able to participate effectively in political choices that govern one's life; having the right of political participation, protections of free speech and association. B. Material. Being able to hold property (both land and moveable goods), not just formally but in terms of real opportunity; and having property rights on an equal basis with others; having the right to seek employment on an equal basis with others; having the freedom from unwarranted search and seizure.	Able to travel or not as wanted; Being able to participate in political engagement

To summarize the application of the CA with transportation (Table 2-1, column 3), I re-categorized the evaluation focuses into five important domains:

1) Access to basic resources, services and activities sites;
2) The freedom of physical movement around places;
3) Opportunities for active travel (walking and bicycling);
4) Opportunities to conduct safe and psychologically satisfied trips;
5) Access to political engagement activities.

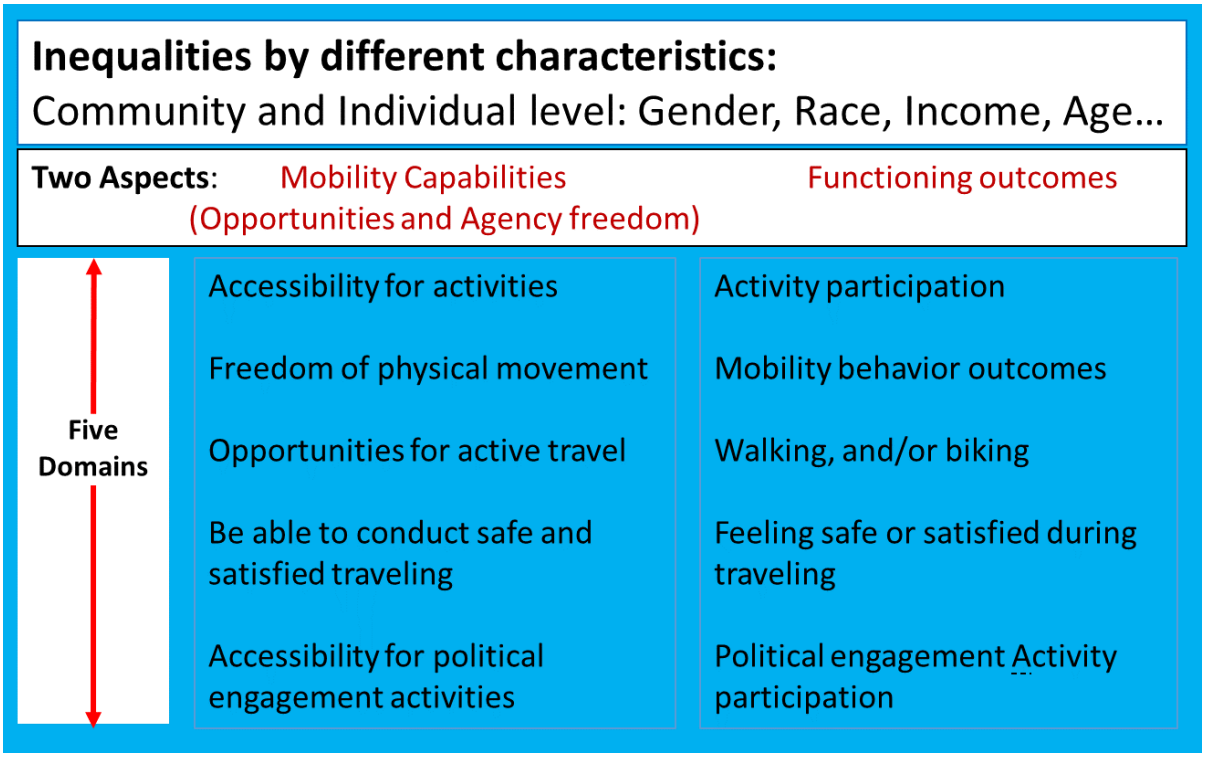


Figure 2-3: Equity evaluation framework in transportation

The five important domains could be evaluated via capabilities (potential) and functionings (observed outcomes) (Figure 2-3). Functionings, as actual outcomes, are often measured via relying on observed data in empirical studies. Capabilities reflect the potential, the substantial freedom people have to achieve the five domains of functionings, which could be seen as the opportunity freedom and agency freedom. It is important to examine capabilities when investigating the disparities of functioning

outcomes. Opportunity freedom in the transportation context could represent the budget lists of opportunities or functionings available for people, such as potential destinations and modal options available for people to travel while agency freedom refers to the freedom of exercising their agency to make the decisions about traveling.

2.6.3 Five domains of evaluative focuses, mobility and accessibility

However, most previous studies have examined the realized travel or unrealized travel (unmet needs) to assess inequity (.Delbosc & Currie, 2011; Dargay, 2001). Travel is multiple facets, which could be measured in different ways. Analyzing specific aspects of travel in isolation leaves many questions unanswered. The realized travel is often measured as travel time, trip patterns, number of trips, miles traveled, and the unrealized travel often are evaluated through qualitative studies to examine the unmet needs of people.

In recent years, a growing number of studies have re-conceptualized mobility as "motility", both actual embodied movement and the potential to realize such movements (e.g., Kronilid 2008; Kaufmann et al. 2004). Both the embodied movements and the potential to realize such movements were then conceptualized as derivatives of the resources available to the individual (e.g., Cresswell, 2010; Nordbakke and Schwanen 2014). Motility pays more attention to the impacts of social structure on the potential mobility while the "freedom of physical movement across space" under CA pays more attention to the process and the production of the potential mobility and how people adapt or achieve mobility outcomes when faced with limited mobility.

The concept of accessibility is based on the notion that travel is a derived demand. Accessibility is often conceptualized as the extent to which individuals could reach activity opportunities given the interaction between the individual resources and the transport and land-use system. Accessibility has several central elements, including travel cost, destination opportunities, and mode options. Accessibility varies along with the type of activity, modal options, time of day, the individual, or individual involves. The less time and money spent on travel, the more places can be reached within a certain budget.

The more destinations, the higher the level of accessibility. The accessibility is also determined by what mode individuals use to reach activity opportunities.

Different definitions and applications have been widely used in transport research and practice (Boisjoly & El-Geneidy, 2017; van wee & Roeser 2013). Generally, there are two types of measurements: placed-based measure and person-based measure. The most commonly used definition in the planning practice is a place-based measurement, proposed by Hansen (1959), as the potential opportunities to reach within a certain threshold of travel time or distance to evaluate the performance of land use and transportation systems. The individual-level accessibility often involves the interactions of three components, individual, spatial, and transportation components. Time geographers proposed a spatial-time prism to measure the accessibility (Hägerstrand, 1966). Personal circumstances interacting with spatial and temporal conditions are considered to measure the extent of opportunities to be reached.

The domain, access to activities (capabilities), and activity participation (funcitionings), is directly related to the concept of "accessibility". Several scholars (Marten et al., 2012) have argued that individual accessibility, as a measure of potential opportunities, is an appropriate indicator to measure equity of transportation. For this interpretation, Sen's term's capability is the accessibility in transportation, more precisely, individual-level accessibility, in which personal circumstances to reach activity opportunities are constrained or enabled by the spatial and temporal factors. More research on developing accessibility measures to reflect the potential opportunities is needed.

In the framework, access to political engagement activities is independently stated as a core domain because of the importance of access to political engagement activities on procedural justice and then further on advancing equity.

2.6.4 What is transportation equity?

After discussing the evaluative focuses of equity, the section moves to discuss what transportation equity is. The principle of equity in the CA encompasses the fair distribution and re-distribution of "real" capabilities. However, instead of being a transcendent justice theory inquiring how society ought to be justice, the CA focuses more on the process how equality of real opportunities or capabilities could be achieved. Thus, transportation equity under the CA should be assessed in the process of production of equality of mobility capabilities for individuals and the comparison of the environmental and social contexts where mobility capabilities of individuals are shaped. Based on the conceptualization, advancing equity in transportation is to expand the freedom to choose among functionings and appropriate functionings they have reason to value and means removing unwanted options or offering the freedom not to appropriate unwanted mobility.

2.7 Summary and Discussion

A number of studies have addressed equity issues in the transportation, and these studies have predominantly focused on what people actually receive or achieve in terms of service, accessibility and outcome. However, the CA argues that what can one do with the resources to improve well-being is more crucial. Thus, as a response to the limitations of assessments that measure resources, accessibility and outcomes, the CA expand the evaluative focus on the range of real choices that have been available to people; whether have the "real" freedom (opportunity and agency freedom) to achieve a valued functioning. What transportation enables people to make a good choice of life matters for the evaluation for transportation equity.

Because of the reluctance of Sen to define a list of central capabilities, the chapter also engages the work of Nussbaum's list of 10 central capabilities to propose a new evaluative framework for incorporating the CA into transportation decision-making. In the evaluative framework, five important domains of evaluative focuses have been summarized, including

1) Access to basic resources, services and activities sites;
2) The freedom of physical movement around places;
3) Opportunities for active travel (walking and bicycling);
4) Opportunities to conduct safe and psychologically satisfied trips;
5) Access to political engagement activities.

Furthermore, the CA pays much attention to the production of equality of mobility capabilities for individuals and compares the environmental and social contexts where individuals' mobility capabilities are shaped. Thus, CA could be used to analyze the distribution of circumstances among a group and how individuals in the group shape their actions given the circumstance.

Operationalizing the CA in practice faces several challenges in the empirical transportation context. The first challenge involves the measurement of mobility capabilities. Even in the original work of CA, Sen admitted the difficulty in measuring capability. Mobility capabilities here represent the potential people have to travel or travel from place to place, with five separate and interrelated domains. Most data used in transportation literature are observed outcome data without considering the potential and thus, empirical studies have predominantly looked at inequities observed in the outcomes. In addition, most studies have focused on a single indicator about the observed mobility and activity participation, such as vehicle miles of travel or personal miles of travel (Guiliano 2006). No studies have taken into account for the evaluation of the outcome aspects of the five domains, and future relevant research is needed.

The difficulty in measuring the five domains brings additional challenges to apply the evaluative framework and evaluate the equity of transportation policy and project investments. Several questions need to be answered. For example, how should each domain should be measured? Is it possible to compare each domain across a range of individuals? One project could bring more benefits for access while another project could bring more benefits for opportunities for active travel. How could the two projects be compared? The following questions require value judgements, which, in the context of

planning, typically require some type of public participation process to reason through and discuss these judgements and inform the policymakers who must prioritize projects. In other words, the CA establishes what should be prioritized (e.g., mobility capabilities) but it is silent on procedures planners and policy-makers should follow when resource shortages require prioritization among options to increase mobility capabilities.

Despite the challenges involving in the operationalization in practice, however, policymakers and planners should bear in mind that transportation service provision is not sufficient to guarantee people could convert the resource into real mobility capabilities. Efforts are needed to identify the barriers and limitations in the conversion process to facilitate the potential possible for all urban residents. For example, several planning agencies such as Southern California Association of Governments have expanded the evaluation of mobility outcomes such as savings in travel time to accessibility improvement. Multiple detailed evaluation metrics, which are identified in the process of public participation or community engagement and relevant to five domains, could further be adopted in the future for evaluating transportation projects. These might lead to initiatives and interventions that lead beyond transportation systems, per se, into other realms of human behavior, including health and income support.

Another limitation of CA is its focus on human agency and individualism. However, Robeyns (2015) has argued that CA does account for social relations and constraints and that opportunities provided for individuals depend on social structure and institutions. First, the social structure and institutions where people live influence the conversion process of resources to functionings. Second, an individual's exercise of agency - the agent's choice of choosing functionings from capability sets - is influenced by the social constraints. Thus, expanding the freedom of people to travel or travel from place to place does not mean that the sole goal of equity in transportation is to provide great car access to everybody. Policymakers have no choice but to confront the trade-offs between expanding individual freedom of car access and public interest of alleviating congestion and air pollution. If the public interest objective of alleviating congestion and air pollution is a goal prioritized by society, the social institution has either implicitly or

explicitly concluded that individual freedom of mobility capabilities should be constrained by goal That is, the mobility-related goal should be tp expand the mobility capabilities under these constraints. Since the potential of car access is different from the actual use of a car, the social constraints could be applied into the process of the act of choice. Despite these challenges and limitations, the CA has potential to reshape and reorient the focus of transportation equity from its current emphases on outcomes to a new focus on capabilities and freedom to choose among transportation options that enable diversity of functionings.

To illustrate this potential, the CA is applied to the next two chapter as a descriptive conceptual framework in the examination of various aspects of transportation equity. Specifically, the CA facilitates both the formulation and analysis of the key research questions in next two chapter. In Chapter 3, I focus on people living in low-car ownership households, and explore the variation or distribution in opportunities freedom of traveling and mobility outcomes within the specific group. Differing from previous studies on assessing the distribution of mobility outcomes only, Chapter 3 also evaluates the variation of four of five domains in mobility capabilities, access, physical movement, opportunities for active travel to identify the disadvantage. In Chapter 4, I examine the disparities in travel mood among social-demographic groups, and explore how the disparities in opportunity freedom of traveling people have correlate with disparities in travel mood (the functioning outcome).

3. Chapter 3: Is Low-Car Ownership a Disadvantage or Choice: A Capability Approach Perspective

3.1 Introduction

Vehicles are a necessity for most people living in the US. Almost all US households have cars; 93% of households own at least one car, and more than 65% own two or more vehicles (NTHS, 2017). Car ownership has been extensively studied and shown to have a positive correlation with a range of well-being outcomes, such as employment, earnings, and health. However, owning multiple cars also brings additional costs to households and contributes to urban sprawl, congestion, and pollution. Therefore, policy-makers and scholars have paid attention to alleviating the negative impacts of restricted car ownership on well-being and, at the same time, reducing car use. Previous studies have shown that the transition from zero to one car is very different from one to two cars. Practically, it is more feasible to encourage households to reduce their cars than forgoing ownership of cars entirely (Golob, 1990; Hanly and Dargay, 2000), especially given the existing urban sprawl in the US. However, comparatively less is known about people living in low-car ownership households, where they need to share one car with other drivers in the households.

Increased understanding of these people could translate into more policy imperatives. The choice of low-car ownership could be the result of two different reasons. On the one hand, a household's choice of low-car ownership may be because they have other sufficient travel alternatives encouraged by policy and planning practices to reduce driving. On the other hand, this choice of low-car ownership may also be because of household constraints. For example, these households may both not be able to afford sufficient cars and also may lack other mode alternatives. For these households, low-car ownership limits their mobility and access to opportunities. Thus, the distinction between these different low-car households helps identify the disadvantages and explore the inequalities, thus informing policy initiatives to alleviate the disadvantages. Moreover, to identify factors enabling households to be low-car households out of choice, it could potentially guide policies to enable the situation to lower car ownership.

The Capability Approach differentiates two important concepts in the context of transportation, mobility capabilities, and functioning outcomes. Mobility capabilities refer to the substantial opportunities people have to travel or travel to the desired destinations (Chapter 2), while functionings outcomes measure the actualized travel behaviors such as mode choice, number of trips, and vehicle miles traveled or activity participation. The existence of alternative options or the number of alternative mode options to travel around plays a crucial role in determining the opportunities people living in low-car ownership have to travel. People who have other alternative mode options are more likely to choose to have low-car ownership out of choice and are less likely to be stuck. In contrast, when other household members occupy the only household vehicle, people who do not have alternative options may have low-car ownership out of constraints. The joint comparison of alternative mode viability and functioning outcomes may help examine how individuals shape their actualized mobility outcomes when faced with limited mode options and inform the transportation inequities.

The work aims to assess transportation inequities within people who live in low-car ownership households and need to share the only household vehicle with other household drivers. Guided by the CA, the assessment focuses on both people's actualized functioning outcomes (travel behavior) and the existence and number of alternative options, as measures of access and freedom of physical movement. Specifically, using the data from the 2017 National Household Travel Survey, the essay answers two research questions:

1. How do mobility capabilities, measured as alternative mode option availability for traveling from place to place, and functioning outcomes, measured as mobility behavior outcomes, vary among socio-demographic groups?

2. How do mobility capabilities translate into functioning outcomes?

The remainder of this essay is organized as follows. The next section reviews the literature on car ownership, low-car ownership households, alternative mode options, and activity participation. Then, I present the research design, including data, measurement of key concepts, and methodology. Descriptive and regression results are reported in the next section. The essay concludes with conclusion and discussion.

3.2 Literature Review

3.2.1 Car access and mobility outcomes

Most households in the US have at least one car. Low-income households are willing to acquire a car even though they are faced with limited financial resources. Studies have shown that households with car access have higher mobility outcomes, measured as larger personal miles traveled, compared to households without access to cars. Car ownership also has dominant impacts on mode choice; the share of car use increases from 34% to 82% after households acquire their first car (Pucher and Renne, 2003).

Cars provide greater access than transit to work and non-work destinations (Grengs, 2010; Grengs, 2015). Cars also offer a more convenient mode for some trip purposes. Some trip types, such as trip chaining, escorting children, and shopping, are more easily fulfilled via cars than other transportation modes (Mattioli et al., 2016). Thus, a growing number of studies have shown a positive relationship between car ownership and objective well-being such as labor market outcomes and health outcomes.

3.2.2 Low-car households

Despite many studies on car ownership, few studies have examined low-car households, especially those households with multiple drivers but only one car. Some studies have started to note internal competition for and sharing of household vehicles in low-car households (e.g., Vance et al., 2015). These studies have primarily focused on the role of gender in intra-household car allocation and revealed that males are often the dominant car users in low-car households. Delbosc and Currie (2012) focus on the mobility and travel behavior of low-car households in Melbourne, Australia, and find that people living in involuntary low-car households have limited travel outcomes and low levels of psychological well-being. Blumenberg et al., (2020) examined the determinants of low-

car households in California, where the number of drivers is larger than the number of vehicles, and compared the mobility outcomes of low-car households compared with zero-car and fully equipped car households. The study found that low-car households tend to have nonwhite and young heads, have a small number of children, be low-income, have more workers, and travel less compared to fully-equipped households. The study also examined the disparities in actual travel among low-car households at different income levels and revealed that high-income "low-car" households travel more and that low-income "low-car households" have higher miles per vehicle compared to low-income full equipped households.

3.2.3 Factors influencing the viability of alternative options and travel behavior outcomes

I mainly review the travel behavior literature to identify factors influencing the viability of alternative modes and travel behavior outcomes. Specifically, the viability of alternative options and travel behavior outcomes are the outcome of three different factors: socio-demographics, resources, and residential location.

Measures of socio-demographics reflect the roles persons play in households and society, which correspond to the ability and perceptions of using alternative modes and the responsibility for traveling. For example, mothers take more care of children and make various complicated trips, making trips of using alternative modes challenging (e.g., Scheiner & Holz-Rau, 2017; Blumenberg, 2000). Workers often need to travel from and to workplaces every day.

There are also persistent differences in the perception and use of alternative modes among gender and race. Social norms, psychological reasons, and home-work relationships that females experience have been incorporated in the transportation literature to explain the disparities in perception and use of alternative transportation modes (Fan, 2017; Blumenberg, 2004; Schwanen, 2017). The racial differences reflect the persistent structural inequities in the society, as a manifestation in financial resources, segregated residential location, and cultural norms (Giuliano 2003).

Travel behavior and viability of alternative options are also a function of resources. People with the limited financial resource are often unable to use newly emerging travel options such as car-sharing services or transportation network companies. People with a higher level of financial resources may have higher activity participation and thus travel more.

Many studies examine the relationship between residential location and travel. The built environment around residential locations influences traveling and the potential of using alternative mode options via determining the density of nearby destinations and relative easiness of using alternative modes (Crane 2000, Ewing and Cervero, 2010). Socio-demographics and resources also influence the residential location (Cao et al., 2007). For example, people with higher financial resources could locate in a desirable location to accommodate travel needs and preferences.

3.2.4 Conceptual framework

Based on the literature reviewed in the above section, I created the following conceptual framework to compare alternative mode options and functioning outcomes among people in low-car ownership households (Fig.3-1).

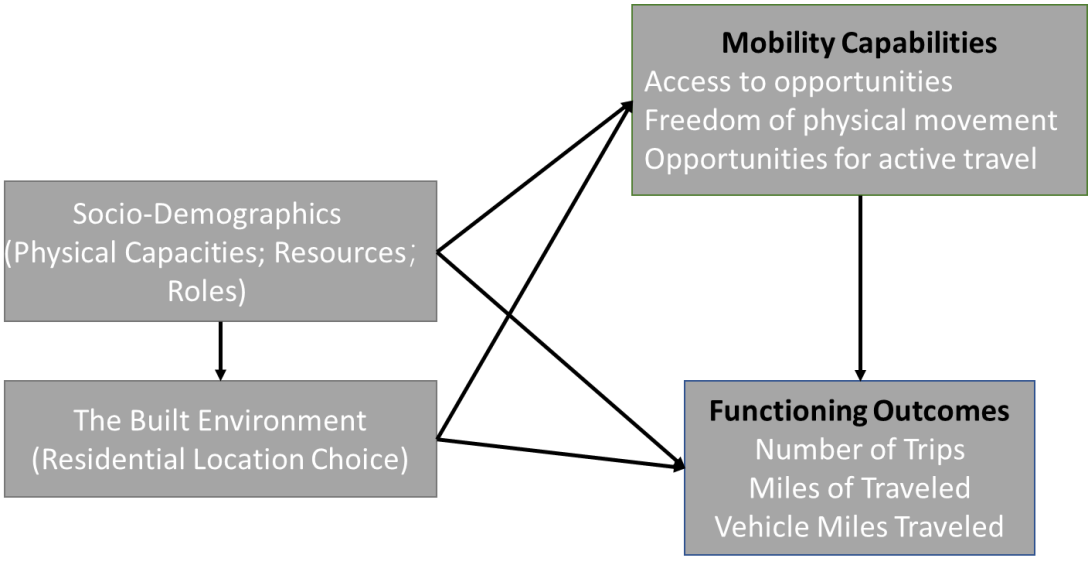


Figure 3-1: Conceptual framework for analyzing the disparities of mobility capabilities and functioning outcomes

Here I am not positing a causal relationship. Instead, I seek to understand the inequalities of mobility capabilities and functioning outcomes among people in low-car ownership households. Conceptually, the viability of alternative mode options as the measure of three of five domains (see chapter 2, Figure 2-2) and measures of mobility outcomes are related to various factors, such as those mentioned in the literature review section. In the empirical models that follow in this essay, the measures of mobility capabilities and functioning outcomes are the dependent variables that are influenced by the socio-demographics and the built environment variables.

3.3 Data and Measurements

3.3.1 Sample and data

The data used for the analysis are from the 2017 National Household Travel Survey (NHTS) (Federal Highway Administration, 2017). Data were collected from a stratified random sample of US households based on a random selection of residential addresses. There are two phases in the 2017 NHTS, a mail-based household recruitment survey, and a web-based person-level retrieval survey. In the mail-based survey, general information about households, transportation, and travel behavior is collected. In the retrieval survey, each participant reports daily and long-distance trips taken during a pre-assigned day. The participants record the associated trip times, means of transportation, which household vehicle was used, if any, trip purpose, and presence of household and non-household members on these trips.

About 10% of urban populations live in low-car households, where there is only one household vehicle but have two or more drivers (Table 3-1). Compared to carless car households, low-car households tend to have lower proportions of the lowest household income categories, the presence of children, a large household size, more workers, and residences in low and medium density areas. Compared to fully-equipped car households (number of household vehicles ≥number of household drivers), they are more likely to have a higher proportion of medium and high household income, smaller numbers of workers, and live in comparatively dense areas.

In total, 264,234 individuals completed the survey. This study focuses on the people living in low car households where there is one car but more than one driver in the households. Participants were excluded from the final analytic sample if they were under 18, used the proxy report, had missing data, lived in households without cars, or had two or more cars. Because the residential location is central to the analysis, I exclude households living in out of urbanized or urban cluster areas. The final analytic sample of people in low-car ownership households is 7,433. All reported results are weighted at the household level.

Table 3-1: Descriptive statistics of household characteristics by household types in urban areas (carless households, low-car households and fully-equipped car households)

	Carless households	Low-car households	Fully-equipped car households
N (Population)	13,489	16,602	141.590
Proportions of population[#]	7.3	9.2	78.2
Household Income (%)			
<25,000	65.8***	27.5***	15.0
25,000-50,000	14.3***	28.1***	20.3
50,000-100,000	11.7***	24.2***	31.2
>100,000	8.3***	20.1***	33.5
Household size	2.0***	3.0***	2.8
Number of workers	0.7***	1.2***	1.5
Population density (person per square miles)			
<2000	15.1***	27.1***	34.9
2,000-4,000	13.9***	20.4***	23.9
4,000-10,000	27.1***	28.3***	29.5
10,000-25,000	16.8***	13.6***	8.8
25,000-999,999	27.1***	10.6***	2.8
Employment density (worker per square miles)			
<1,000	20.0***	33.8***	41.3
1,000-2,000	17.9***	22.2***	24.1
2,000-4,000	17.9***	19.0***	21.8
4,000-999,999	44.3***	25.0***	12.9

Note: # households where number of vehicles equals to or over two and number of drivers is larger than number of vehicles are exclude from the table (5.3%)

All descriptive statistics are weighted at the household level;

*** p<0.001; **p<0.01; * p<0.05. Compared with Fully-equipped households

3.3.2 Measuring mobility capabilities, mobility outcome and other variables.

Measuring mobility capabilities

In the 2017 NHTS retrieval survey, participants who are drivers and live in households with at least a car were asked, "*If you were unable to use your household vehicle(s), which of the following options would be available to you to get you from place to place?"*

Respondents could select from the following options: *public transit, walk, bike, rental car, taxi, something else and ride from others.* The answers to the survey question are directly related to the concept of mobility capabilities and serve as a core element, representing the modes available to travel around or travel to access activities. In the analysis, I do not consider ride from others as a component when measuring the mobility capabilities. Independence is an important component in deciding well-being (Schwanen, 2011); elderly persons often have negative feelings when they rely on others to travel around. I identify four types of transportation modes: public transit (rail and bus), bike, walk, and car programs, including traditional taxi, car-sharing programs, and transportation network companies. I create dummy variables to indicate the existence of a specific alternative mode option available for people to get from place to place. I also create a dummy variable to indicate whether there existed at least one alternative option and a count variable indicating the total number of alternative choices. 24.7% of people in the finalized sample indicate no other options for traveling around except the only car in the households. Less than 30% of people indicate that there are 3 and 4 options available.

Over half of the respondents in the analytical sample reported the viability of transit. Over 40% reported the viability of walk and car programs. However, only 20% reported the viability of the bike (Table 3-2). These variables are also strongly correlated (Table 3-3) with coefficients over 0.2. Walk and bike have the largest coefficient of 0.45, suggesting people who state the viability of walk are also more likely to state the viability of bike for walk and bicycling.

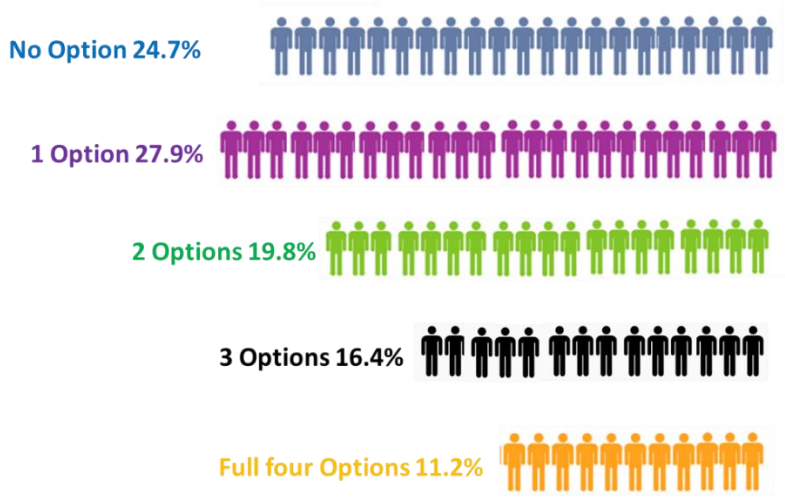


Figure 3-2: The size of alternative choice sets

Table 3-2: Mobility capabilities measured as available modal choice

Modal Option Viability (Mobility Capabilities) (N=7,433)	**Yes (%)**	**No (%)**
Transit	54.4	45.6
Bike	19.7	80.3
Walk	41.5	58.6
Car programs	45.9	54.1

Table 3-3: Correlation coefficients among viability of alternative mode options

Modal Option Viability (N=7,433)	Transit	Bike	Walk	Car programs
Transit	1.00			
Bike	0.26	1.00		
Walk	0.35	0.45	1.00	
Car programs	0.24	0.20	0.25	1.00

The measurement of capabilities is challenging, even in Sen's original works in operationalizing the Capability Approach (Alkire, 2008). First, self-reported measures suffer from the issue of adaptive preference. Adaptive preference refers to the situation in which people who are in disadvantaged positions adjust their own expectations and adapt their situation (Nussbaum, 2011). In this study, people with limited travel choice sets to travel may still perceive the bicycling as a viable option even though there are not safe bike lanes for them. The issues of self-reported measures can be linked to the issues of dependence paths and self-selection problems. Second, the challenge is about the difficulty of how capabilities should be and whether it is possible or fair to compare different individuals. Further research to better design the measures of capabilities would be needed to address adaptive preference.

Measuring functioning outcomes

Functioning outcomes in transportation themselves are multidimensional with multiple facets, which could be measured in different ways, including those measures developed in the study, activity participation, commuting time, commuting distance, non-work activity participation, etc. Analyzing specific aspects of travel in isolation leaves many questions unanswered. The study used three common measures in transportation. Further exploration about other functioning outcomes of low-car ownership households would also be interesting and needed to understand the actualized outcomes of this specific group of population.

Mobility outcomes in the transportation context are measured via three variables: number of trips per day, personal miles travelled (PMT), and vehicle miles traveled(VMT). The number of trip per day is used to measure the level of destination accessibility a traveler reaches. Personal miles travelled not only reflect trip frequency but also the distance each trip a people travel to access to opportunities and destinations. Vehicle miles traveled measure the intensity of car use for each household.

Table 3-4: Functioning outcomes

	Mean	**Standard Deviation**
Mobility outcomes		
Number of Trips	3.7	2.9
Personal miles traveled	19.3	27.3
Vehicle miles traveled	11.7	22.2

Measuring other variables

The independent variables are drawn from the conceptual framework, including socio-demographics and residential location (Figure 3-1). The socio-demographics are measured as female, age groups, race, having a child in the household, the number of workers in the household, college degree or above, employment status, and household income. Three extra control variables are also added into the analysis: measures of self-reported general healthy condition, driving limitations, and weekends, indicating the day of traveling.

The residential location choice is measured as two variables:

- Population density of the household's Block Group (8 categories)
- Employment density of the household's Census Tract (8 categories)

The original NHTS report density using a categorical variable with eight categories. The variation in terms of travel behavior and alternative options at the lowest density is little, thus I re-categorized the population density variables into five types, <2,000, 2000-3,999, 4,000-9,999, 10,000-25,000 and >25,000 while I re-categorized the job density variables into four types, <1,000, 1,000-2,000, 2,000-4,000 and >4,000.

Table 3-5: Descriptive statistics of variables for people in Low-car ownership households

N=7,433	Mean/percent	Std. Dev.
Mobility Outcomes		
Number of Trips	3.7	2.9
Personal Miles Traveled	19.3	27.3
Vehicle Miles Traveled	11.8	22.3
Mobility Capabilities: Alternative Mode Options		
Transit Option	0.5	0.5
Bike Option	0.2	0.4
Walk Option	0.4	0.5
Car Program Option	0.5	0.5
Number of Options	1.6	1.3
No Option	0.2	0.4
Individual Characteristics		
White	0.6	0.5
Female	0.5	0.5
Age group(%)		
18-25	0.1	0.3
25-44	0.4	0.5
45-65	0.3	0.4
>65	0.2	0.4
Bachelor Degree	0.7	0.4
Employment Status (%)		
Unemployed	0.5	0.5
Worker	0.5	0.5
Student	0.0	0.2
Having Driving Limitation	0.0	0.2
Travel day: Weekend	0.3	0.4
Household Characteristics		
Household size	2.9	1.3
Household income (%)		
<25,000	0.3	0.4

25,000- 50,000	0.3	0.4
50,000 - 100,000	0.3	0.4
>100,000	0.2	0.4
Number of Workers	1.2	0.9
Pop Density （%）		
<2,000	0.3	0.4
2,000-4,000	0.2	0.4
4,000-10,000	0.3	0.5
10,000-25,000	0.1	0.3
>25,000	0.1	0.3
Job Density		
<1,000	0.3	0.5
1,000-2,000	0.2	0.4
2,000-4,000	0.2	0.4
>4,000	0.3	0.4
Health Status	2.4	1.0
excellent	0.2	0.4
very good	0.4	0.5
good	0.3	0.4
fair	0.1	0.3
poor	0.03	0.2

3.4 Statistical Methods

I estimate different statistical models to answer different research questions.

Research Question 1: How do the mobility capabilities, measured as viable alternative options, and functioning outcomes vary among different socio-demographic groups?

Through answering the research question 1 and comparing disparities of capabilities and functioning outcomes, I illustrate how the joint evaluation of different measures informs the equity and transportation disadvantages.

To examine the disparities of mobility capabilities, measured as the existence or number of alternative mode options, I construct structural equation models (SEM) to account for the interrelationship among socio-demographics, the built environment and mobility capabilities. SEM is often used to examine the relationships among multiple endogenous and exogenous variables. Compared to regular regression models, SEM can model the relationships among any number of dependent and independent variables and examine the mediating, direct, and indirect effects among variables (Maruyama, 1997). In recent years, scholars in travel behavior have adopted the use of SEM to modeling the complex relationship between the built environment and travel behavior (Cao et al., 2007; Van Acker & Witlox, 2010).

The residential-selection problems have been widely recognized in the literature of travel behavior, which is used to reflect people's ability, preference, and attitude to choose residential places (Cao et al., 2007). In the study, SEM is used to partially account for the residential selection issue via modeling the relationship between socio-demographics and population and job density. I construct three different models for comparing the disparities of mobility capabilities. In the first model, four dependent variables are included to indicate whether the respondent stated that he/she could take the transit, walk, bike, or use new car programs to travel from place to place (Figure 3-3a). The error covariance matrix of each of the alternative options is also added in the model as it is reasonable to believe that there are some unexplained portions of the correlation between stating transit as a viable option and stating walk as a viable option.

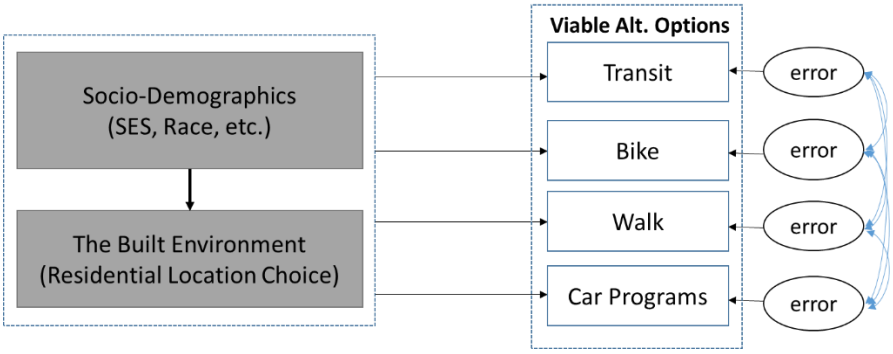
In the second model, the mobility capability is measured as a dummy variable indicating whether there is no other option available (Figure 3-3b). The measurement has significant policy and practice implications. People who do not have any other mode options are more likely to be stuck at home when their household members occupy the household car. As in the first and second models, the mobility capabilities are measured as dummy variables. The basic assumption of the SEM that all endogenous variables in the models have the multivariate normal distribution is not likely to be held. Thus, a mean- and variance-adjusted weighted least square parameter estimator (WLSMV) is used in the

first and second models. The estimation method also has been used in transportation literature (e.g., Van Acker & Witlox 2010). All the analyses are completed in the R Package Lavaan. In the third SEM model, I model the size of alternative choice set (Figure 3-3c). A bootstrap approach is used in the model estimation to account for the potential bias caused by non-normal distribution.

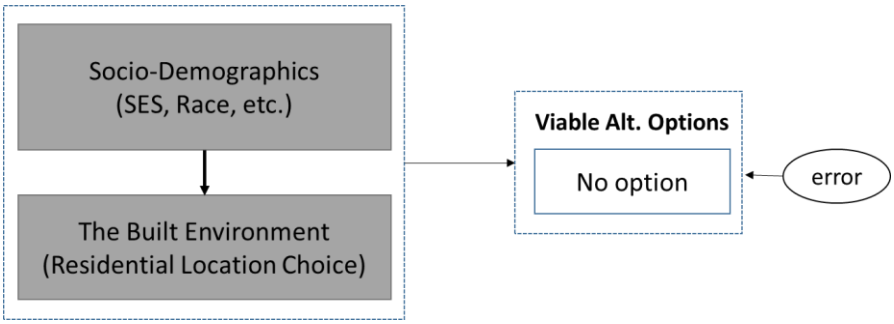
I estimate different statistical models to answer different research questions. In terms of modeling behavioral mobility outcomes, I employ negative binomial models to estimate the trip frequency and linear regression models to estimate the vehicle miles traveled and personal miles traveled. I take the natural log of vehicle mile traveled, and personal miles traveled for the consideration of the normality.

Research Question 2: How do the mobility capabilities translate into mobility outcomes?

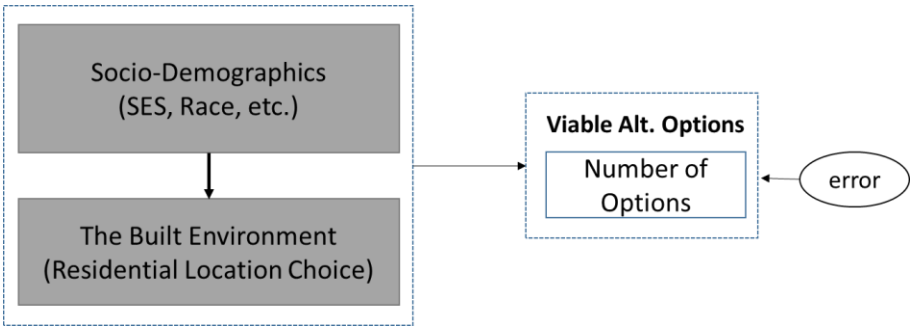
To answer research question 2, I expand linear regression models for estimating mobility outcomes by adding the measures of mobility capabilities.



a: SEM 1



b: SEM 2



c: SEM 3

Figure 3-3: SEM models

3.5 Disparities in Mobility Capabilities

3.5.1 Direct effects of socio-Demographics on the viability of alternative mode option

The following section presents the estimation results of three SEM models of the existence of viable alternative options. All the models have a reasonably good fit based on model fit indices, CFI, RMSEA, and TLI, according to the criteria presented in Hu and Bentler. In model 2, the CFI is lower than 0.9. Kenny (2015) argued that CFI is not a good measure of goodness of fit if the RMSEA of the null model is less than 0.158 (http://www.davidakenny.net/cm/fit.htm). Thus, I report TLI as another measure for goodness of fit.

Table 3-7 reports the direct effects of social-demographic variables on mode viability, revealing the heterogeneity among low-car ownership households. The disparities in racial ethnicities among low-car ownership households reflect the persistent structural inequalities; white people are more likely to state the viability of these specific mode options. The disparities are larger in terms of walk, bike, and car programs with larger path coefficients. The gender disparities only exist in the stated viability of bike: females are 22% less likely to state bicycling is a viable option. Females are also more likely to state no other options and are less likely to have large choice sets compared to males. The heterogeneities across the age group are consistent in all models: compared to the middle age group (24-45), young or elderly persons tend to have limited alternative options. In terms of age, middle-age persons (age 25-44) are more likely to state transit, bike, walk,

car programs as viable options. The disparities between age 24-45 and elderly persons (over 65) are comparatively larger, suggesting the limited option choices for elderly persons in low car ownership households.

Table 3-6: Measures of model fit

Measures of goodness fit	SEM Model 1	SEM Model 2	SEM Model 3
CFI	0.958	0.837	0.987
RMSEA	0.037	0.037	0.04
TLI	0.976	0.981	0.967

Employment status is correlated with the possibility to state the viability of alternative mode options to travel around. Workers and students, compared to non-workers, are more likely to state transit as viable mode options. However, workers are less likely to state walk as a viable option. This may be because workers need to commute every day, which often cannot be accomplished by walking. Students are more likely to state bicycling as a viable mode option compared to non-workers because most campus areas are bike-able, facilitating the viability of bicycling. After controlling with other variables, no consistent disparities in car programs are revealed among non-workers, workers, and students. People with high educational attainment are also much likely to have alternative options.

In terms of household characteristics, the results are also in line with our expectations. People who report alternative viable mode options are more likely to live in high-income households. The coefficients increase with the household income level, reflecting that the higher the household income, the more likely to have alternative options viable. High-income households have more financial resources to deal with the mobility constraints of one car, such as using the car-sharing programs, living in areas with dense transit supply, all of which expand viable alternative modal options.

It is also interesting that people without the bike, walk, and car program options tend to live in households with larger household sizes compared to people with the options, indicating the negotiation of car use in the low-car households with a large number of

members may be more competitive. As the number of household size increases, the needs of the car may increase. However, these households are more likely to still maintain one car as a result of constraints.

3.5.2 Residential self-selection and indirect effects of socio-demographics on alternative mode option availability

The residential self-selection issues are partially addressed in the analyses via modeling the relationship between socio-demographics and the built environment. The direct effects of socio-demographic variables on the population and job density are all statistically significant, reflecting the presence of residential self-selection (**Table 3-8 and Figure 3-9**). Households with higher income are more likely to live in neighborhoods with a higher population and job density to accommodate the only one household car, which further improves access to alternative mode options. Low-car ownership households with multiple workers could also cater to their travel needs via living in dense areas. The household size is negatively associated with population and job density, further lowering the propensity to have alternative options available.

Table 3-7: Direct effects of variables on the viability of alternative mode options

	SEM Model 1								SEM Model 2		SEM Model 3	
	Transit		Walk		Bike		Car Programs		No options		Number of Options	
	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P
White	-0.02	0.499	0.43	0.000	0.52	0.000	0.18	0.000	-0.05	0.217	0.37	0.000
Female	-0.04	0.204	-0.05	0.144	-0.22	0.000	-0.04	0.163	0.08	0.014	-0.08	0.002
Age group (24-45)												
18-24	-0.24	0.001	-0.05	0.471	-0.38	0.000	-0.34	0.000	0.37	0.000	-0.32	0.000
45-65	-0.13	0.003	-0.19	0.000	-0.27	0.000	-0.22	0.000	0.17	0.001	-0.23	0.000
>65	-0.34	0.000	-0.64	0.000	-0.74	0.000	-0.36	0.000	0.50	0.000	-0.59	0.000
College	0.26	0.000	0.36	0.000	0.34	0.000	0.29	0.000	-0.33	0.000	0.35	0.000
Emp Status (ref.=non-worker)												
Working	0.10	0.033	-0.09	0.050	0.01	0.875	0.09	0.060	-0.11	0.022	0.04	0.320
Students	0.23	0.017	0.03	0.733	0.30	0.005	-0.09	0.357	-0.16	0.158	0.09	0.317
Household Income (ref.=<25,000)												
25,000-50,000	-0.05	0.254	-0.08	0.091	0.01	0.941	0.21	0.000	-0.01	0.756	0.03	0.439
50,000-100,000	0.00	0.945	0.00	0.968	0.18	0.004	0.37	0.000	-0.14	0.003	0.17	0.000
>100,000	0.15	0.004	0.27	0.000	0.44	0.000	0.75	0.000	-0.36	0.000	0.55	0.000
Household Size	-0.07	0.000	-0.04	0.010	-0.03	0.119	-0.17	0.000	0.14	0.000	-0.11	0.000
# of Workers	0.02	0.365	-0.01	0.789	0.08	0.011	-0.06	0.022	0.09	0.002	0.01	0.724
Pop density	0.19	0.000	0.05	0.031	0.03	0.282	0.02	0.320	-0.08	0.002	0.10	0.000
Job density	0.19	0.000	0.08	0.001	0.05	0.136	0.06	0.020	-0.13	0.000	0.15	0.000

Health Status (ref.=Poor)												
Excellent	0.31	0.003	0.64	0.000	0.40	0.010	0.08	0.459	-0.54	0.000	0.42	0.000
Very good	0.29	0.004	0.55	0.000	0.30	0.057	0.08	0.427	-0.48	0.000	0.36	0.000
Good	0.21	0.033	0.40	0.000	0.09	0.554	0.02	0.818	-0.34	0.000	0.22	0.006
Fair	0.19	0.065	0.14	0.216	-0.11	0.504	-0.05	0.596	-0.25	0.015	0.08	0.350
Having driving limitation	0.10	0.139	-0.27	0.000	-0.39	0.002	0.13	0.051	-0.08	0.214	-0.02	0.719
Constant											0.64	0.000
Sample size (N)	7,202								7,202			7,202

Note: shaded-statistically significant at P<0.05

Table 3-8: Residential self-selection: effects of household characteristics on population and job density

	Population Density		Job Density	
	Coef.	P>z	Coef.	P>z
Household Income (<25,000)				
25,000-50,000	0.02	0.642	0.03	0.416
50,000-100,000	0.18	0.000	0.26	0.000
>100,000	0.65	0.000	0.74	0.000
Household size	-0.05	0.000	-0.07	0.000
# of Workers	0.24	0.000	0.21	0.000
Constant	2.30	0.000	2.11	0.000

Note: shaded-statistically significant at P<0.05

Table 3-9: Indirect effects of household characteristics on viability of alternative mode options via residential self-selection

	SEM Model 1								**SEM Model 2**		**SEM Model 3**	
	Transit		**Walk**		**Bike**		**Car Programs**		**No options**		**Number of Options**	
	Coef.	**P>z**	**Coef.**	**P>z**	**Coef.**	**P>z**	**Coef.**	**P>z**	**Coef.**	**P>z**	**Coef.**	**P>z**
Household Income (<25,000)												
25,000-50,000	0.009	0.503	0.003	0.475	0.002	0.489	0.002	0.463	-0.005	0.479	0.000	0.975
50,000-100,000	0.081	0.000	0.030	0.000	0.017	0.002	0.018	0.000	-0.046	0.000	0.050	0.000
>100,000	0.262	0.000	0.093	0.000	0.053	0.000	0.056	0.000	-0.145	0.000	0.180	0.000
Household size	-0.023	0.000	-0.008	0.000	-0.005	0.003	-0.005	0.001	0.013	0.000	-0.010	0.027
# of Workers	0.085	0.000	0.029	0.000	0.017	0.000	0.017	0.000	-0.046	0.000	0.080	0.000

Note: shaded-statistically significant at P<0.05

3.6 Disparities in Functioning Outcome: Mobility Outcomes

Table 3-10 shows the disparities in mobility outcomes among different social-demographic variables. The model fit for mobility outcomes are low, but comparable to previous models (Blumberg & Pierce, 2012; Giulinao & Dargary, 2006).

The disparities in racial ethnicities among people in low-car ownership households are expected. Compared to non-white people, white people have lower personal mile traveled, and vehicle miles traveled even though they complete the same number of trips. Gender disparities only exist in household vehicle access use. Females completed the same number of trips and the same miles traveled, but fewer vehicle miles traveled than males. Only the difference between the youngest group (18-24) and middle age group (25-44) is significant; no significant heterogeneities of mobility outcomes exist among other age groups compared to the middle age group. The youngest group (18-24) completed fewer trips, traveled fewer miles, and used fewer vehicles compared to the middle age group (25-44). Education and employment are both indicators of economic resources; people with high educational attainment and workers have a high level of mobility outcomes as measured of more trips, more PMT, and more VMT.

In terms of household characteristics, the results are also unexpected. The mobility outcomes do not increase along with household income. People in different levels of household income households completed the same number of trips. Households in the category of 50,000-100,000 have a high PMT compared to the lowest income. Compared to the lowest income level, people in the highest income have a smaller VMT. I also find a strong correlation between the number of workers and VMT.

Notably, population density is negatively correlated with personal mile traveled and vehicle miles traveled, with larger effects in the highest dense areas. However, population density does not exhibit a significant correlation with the number of trips.

Table 3-10: Estimation results of mobility outcomes

	Number of Trips		Personal Miles Traveled		Vehicle Miles Traveled	
	(Negative Binomial)		(Log)		(Log)	
	Coef.	P>z	Coef.	P>z	Coef.	P>z
White	0.016	0.470	-0.119	0.002	-0.145	0.000
Female	-0.008	0.665	-0.049	0.144	-0.435	0.000
Age group (ref.=25-44)						
18-25	-0.208	0.000	-0.257	0.001	-0.423	0.000
45-64	0.032	0.221	0.015	0.744	0.096	0.051
65-92	-0.039	0.225	-0.059	0.271	-0.021	0.716
College or above	0.096	0.000	0.119	0.004	0.201	0.000
Employment status (ref.=Non-worker)						
Working	0.098	0.001	0.552	0.000	0.467	0.000
Students	0.103	0.087	0.412	0.000	0.157	0.157
Household size	-0.013	0.239	-0.033	0.063	-0.003	0.865
Household income (ref. =<25,000)						
25,000-50,000	0.038	0.204	0.074	0.127	0.109	0.034
50,000-100,000	0.048	0.113	0.117	0.021	0.054	0.313
>100,000	0.051	0.138	0.027	0.648	-0.175	0.005
# of Workers	0.020	0.244	-0.023	0.413	-0.063	0.036
Pop density (ref.=<2,000)						
2,000-4,000	0.020	0.519	-0.055	0.285	-0.065	0.235
4,000-10,000	0.028	0.445	-0.139	0.025	-0.115	0.078
10,000-25,000	-0.050	0.313	-0.183	0.041	-0.266	0.005
>25,000	-0.053	0.357	-0.305	0.006	-0.635	0.000
Job density (ref.=<1,000)						
1,000-2,000	-0.052	0.098	-0.092	0.079	-0.008	0.878
2,000-4,000	0.039	0.297	0.078	0.225	0.052	0.439
>4,000	0.069	0.145	0.107	0.213	-0.070	0.445
Health status (ref.=poor)						
excellent	0.486	0.000	0.600	0.000	0.415	0.000
very good	0.456	0.000	0.688	0.000	0.525	0.000

good	0.404	0.000	0.667	0.000	0.484	0.000
fair	0.300	0.001	0.489	0.000	0.337	0.004
Having driving limitation	-0.160	0.001	-0.223	0.002	-0.331	0.000
Weekend	-0.125	0.000	-0.216	0.000	-0.197	0.000
Constant	0.755	0.000	1.523	0.000	1.178	0.000
Adjusted R2			0.070		0.080	
Pseudo R2	0.010					
Sample size	7,222		7,222		7,222	

Note: shaded-statistically significant at P<0.05

3.7 Joint Evaluation of Mobility Capabilities and Functioning Outcomes

In the following section, I jointly compare mobility capabilities and outcomes among different social-demographic groups. Specifically, I compare the following social-demographic groups, white vs non-white, female vs male, different age groups, and different household income groups. For the negative binomial models of number of trips, I report the differences between incidence rate ratios and one, representing % differences in terms of number of trips among groups. The coefficients of log-linear models of VMT and PMT are reported to represent the % difference in VMT and PMT. The coefficients of SEM models represent the difference between groups in terms of mobility capabilities. Only significant coefficients are illustrated in the following figures.

3.7.1 Racial disparities

The prior comparison of mobility outcomes illustrates inequalities between white and nonwhite individuals (Table 3-9). Nonwhites in low-car ownership households achieve the same number of trips compared to whites, but have higher PMT and VMT. The results perhaps reflect their need to make long-distance trips and high competition for the only household car in these households.

What is new if we take into account the comparisons of the measures of mobility capabilities, the viability of alternative mode options? Non-whites compared to whites are less likely to state the viability of bike and other car programs compared to whites to help

them fulfil travel needs, while there is no difference in perceived viability of transit between white and non-white. The limited viability of alternative options reflect the mobility constraints of non-white people in low-car ownership. Under the limited viability of alternative options, non-white still need accomplish higher PMT and VMT. This result means that they may need to negotiate the use of household vehicles with household member more carefully and manage their needs as once if their household members are using the household vehicles. Furthermore, the results also may suggest that the newly emerging transportation options such as bike share programs, Uber, and Lyft are unequally accessed by non-white groups.

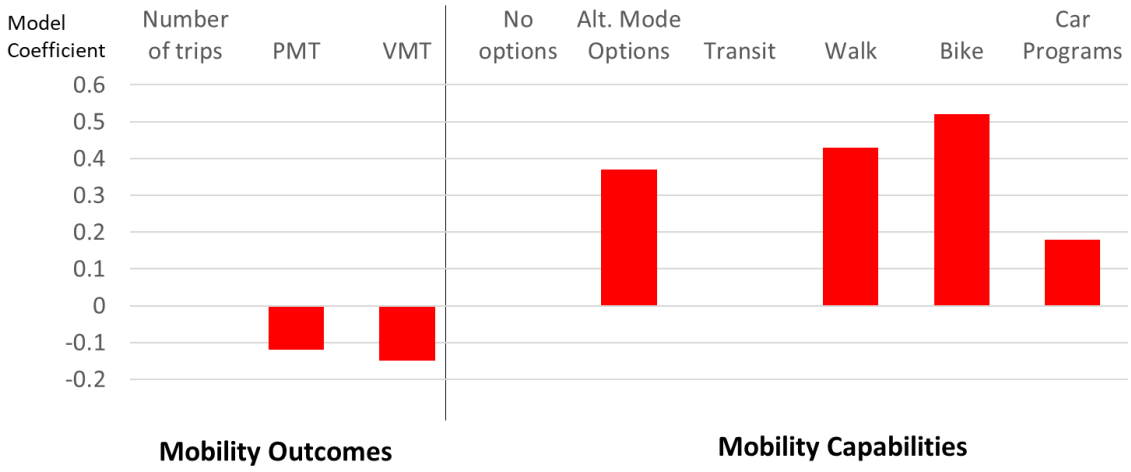


Figure 3-4: Racial disparities in mobility outcomes and capabilities

3.7.2 Gender disparities

The comparison of mobility outcomes between males and females has shown that females in low-car ownership have low access to the household car as reflected in the lower VMT, while they complete the same number of trips and PMT. This result may suggest the need to make more trips via alternative options. However, we could not tell that whether females prefer or are "forced" to use alternative options to accomplish travel needs. The comparison of viabilities of alternative options shows that females do not have better perceived viabilities of other options. The most obvious is their low perceived viability of bicycling; the persist gender disparities in using bicycling has been observed

in many previous studies (Wang, Akar, 2019). Females also compared to males are more likely to have no option viable to travel from a place to another. It indicates that they are highly possible to be stuck at home when their household members are occupying the only household vehicle.

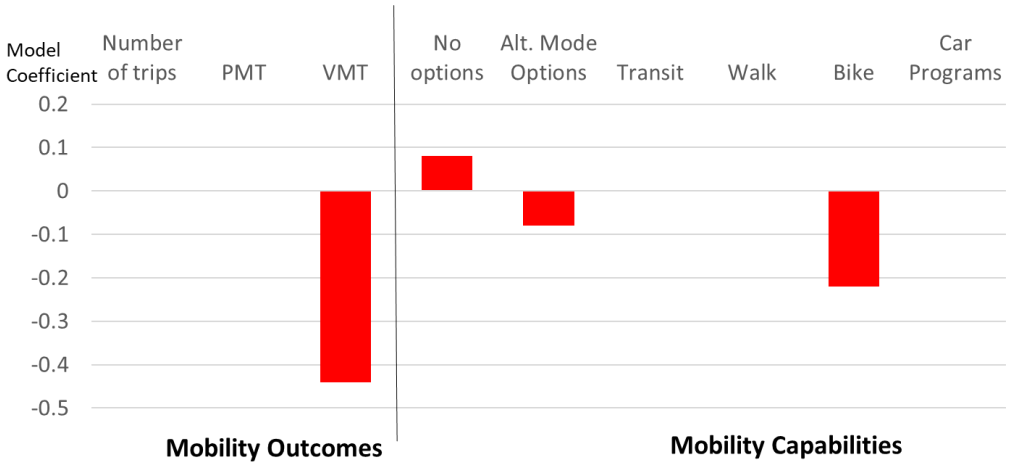


Figure 3-5: Gender disparities in mobility outcomes and capabilities

3.7.3 Disparities among age groups

The comparison of mobility outcomes among different age groups does not reveal statistically differences for 45-64 and over 65 age group compared to 24-45 age group in terms of number of trips, PMT, and VMT. This result does necessarily mean, however, that different age groups living in low-car ownership households have same level of mobility. The significant disparities in viability of alternative options among age groups reflects the different mobility capabilities of different age groups. Compared to middle age 24-45 group, both 45-64 and over 65 groups are less likely to have alternative options viable. Although the three age group accomplish similar mobility outcomes as measured as number of trips, PMT and VMT, age 45-64 and over 65 achieve the outcomes from constrained choices of modes. In terms of age group 18-24, the limitation of alternative options also corresponds to their limited mobility outcomes.

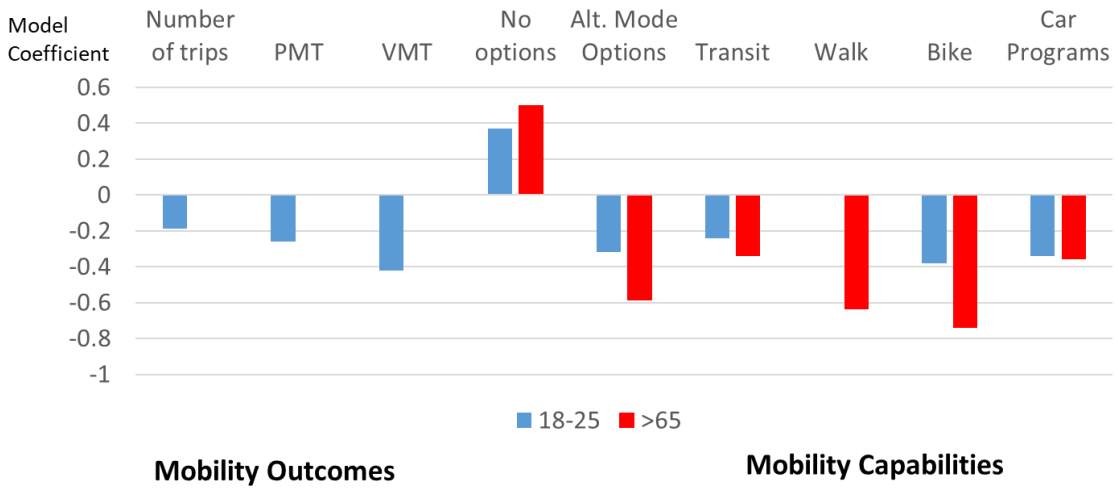


Figure 3-6: Disparities in mobility capabilities and outcomes among age groups

3.7.4 Household income disparities

The comparison of mobility outcomes among different household income groups also does not suggest any inequities as different household income completed the similar number of trips and PMT. The highest income people (>100,000) also have lower VMT compared to the lowest-income people. This result indicates that people in highest-income low-car ownership households have relied on alternative options to complete trips. Do results indicates that highest income groups have limited access to car and have mobility constraints? No. When we examine the disparities of alternative mode option viability, the significant disparities have been revealed. The higher the income, the more likely people have the alternative mode options viable. The lower VMT of highest income groups does not reflect disadvantages. The joint evaluation of these indicators reflect that under a limited choice set of modal option, people living in low-income low-car ownership need to achieve the similar mobility outcomes. The negotiation and sharing of the only household car may be more competitive in the households.

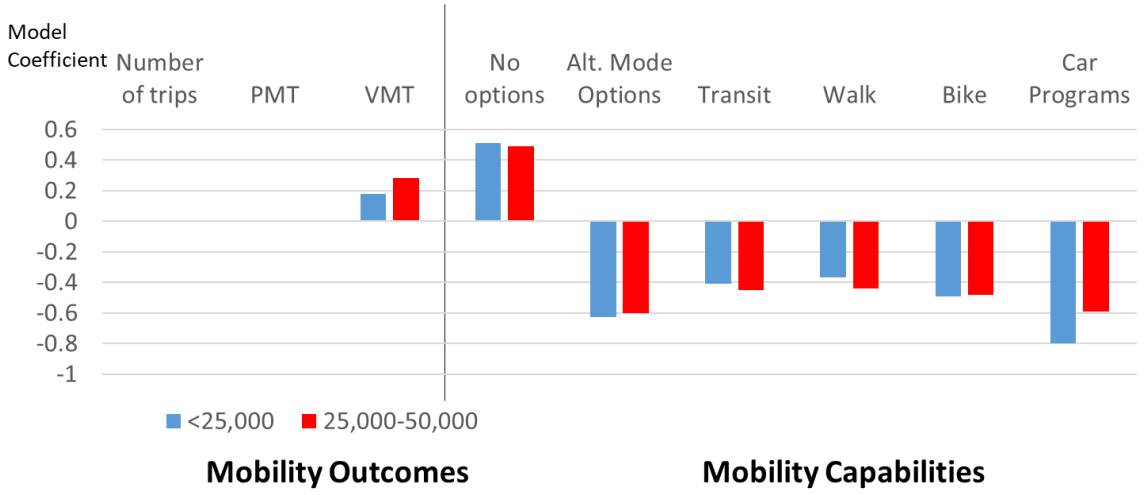


Figure 3-7: Income disparities in mobility outcomes and capabilities

3.8 Mobility Capabilities Matter: Perceived Alternative Mode Options and Access to Opportunities among People in Low-car Ownership Households

Do viability of alternative options actually affect mobility outcomes? Table 3-10 shows that compared to lower-car ownership with transit, bike, walk and car programs viable increase the number of daily trips. The effect size is largest for walk viability; people who perceived walk viable tend to have 1.15 times of more trips compared with people without having walk as a viable mode. People who perceived transit viable also have 1.10 times of more trips. However, the alternative option viability is not significantly correlated with lower VMT. The viability of car share programs, instead, increases VMT and PMT significantly; people with car share program viability have 12% higher PMT and 15% VMT compared to those without car share program viability.

Table 3-11: Estimation of mobility outcomes with adding variables of alternative options

	Number of Trips		Personal Miles Traveled		Vehicle Miles Traveled	
	(Negative Binomial)		(Log)		(Log)	
	Coef.	P>z	Coef.	P>t	Coef.	P>t
Transit	0.10	0.000	0.15	0.000	0.07	0.098
Bike	0.09	0.000	0.01	0.855	-0.09	0.097
Walk	0.15	0.000	0.08	0.060	-0.04	0.300
Car programs	0.07	0.000	0.11	0.002	0.14	0.000
White	-0.03	0.179	-0.14	0.000	-0.14	0.001
Female	0.00	0.953	-0.05	0.180	-0.44	0.000
Age group (ref=25-44)						
18-25	-0.18	0.000	-0.23	0.004	-0.41	0.000
45-64	0.05	0.042	0.03	0.470	0.10	0.042
65-92	0.03	0.437	-0.02	0.772	-0.02	0.750
College or above	0.06	0.027	0.09	0.039	0.19	0.000
Employment status (ref. group=Non-working)						
Working	0.11	0.000	0.55	0.000	0.47	0.000
Students	0.11	0.081	0.41	0.000	0.17	0.133
Household size	-0.01	0.623	-0.02	0.244	0.01	0.745
Household income (ref. group=<25,000)						
25,000-50,000	0.04	0.191	0.07	0.140	0.10	0.055
50,000-100,000	0.03	0.262	0.10	0.047	0.04	0.490
>100,000	0.00	0.936	-0.02	0.785	-0.20	0.002
# of Workers	0.01	0.386	-0.02	0.414	-0.06	0.041
Pop density						
2,000-4,000	0.00	0.964	-0.07	0.189	-0.06	0.236
4,000-10,000	0.01	0.877	-0.16	0.010	-0.12	0.062
10,000-25,000	-0.07	0.154	-0.21	0.018	-0.28	0.003

>25,000	-0.11	0.063	-0.36	0.001	-0.65	0.000
Job density						
1,000-2,000	-0.06	0.042	-0.11	0.037	-0.02	0.713
2,000-4,000	0.01	0.834	0.04	0.524	0.04	0.572
>4,000	0.02	0.716	0.05	0.552	-0.09	0.331
Health status (relative to poor)						
excellent	0.44	0.000	0.56	0.000	0.42	0.000
very good	0.42	0.000	0.66	0.000	0.53	0.000
good	0.38	0.000	0.64	0.000	0.48	0.000
fair	0.29	0.001	0.47	0.000	0.34	0.004
Having driving limitation	-0.15	0.002	-0.23	0.002	-0.35	0.000
Weekend	-0.13	0.000	-0.22	0.000	-0.20	0.000
Constant	0.67	0.000	1.43	0.000	1.12	0.000
Adjusted R2			0.07		0.08	
Pseudo R2	0.01					
Sample size	7,202		7,202		7,202	

3.9 Conclusions and Discussion

The purpose of this essay was to improve our understanding of people in low-car ownership households by jointly evaluating their mobility capabilities and outcomes. Using data from the National Household Travel Survey 2017 and constructing different statistical models, I examined both the influence of various socio-economic and built environment variables on viable alternative options and mobility outcomes and the direct effects of model options on mobility outcomes.

Although some low-car ownership households have multiple choices of alternative options and may opt into a lower-car ownership lifestyle, a proportion of lower car ownership households (25% without any alternative options viable and 45% without stating transit as viable) appear to be lower-car households because of constraints. Results of our univariate tests show that low-car ownership households are likely to have a lower income and live in dense areas than fully-equipped households. Within lower-car ownership households, people with different social-economic characteristics have

achieved different levels of mobility outcomes (travel patterns). These mobility outcomes have different meanings in terms of transportation disadvantage when considered in light of the variability of their mobility capabilities.

Within lower-car ownership households, the SEM results on the viability of alternative options (mobility capabilities) show that, compared to lower availability of alternative options counterparts, people with more viable alternative options live in higher density areas where they might be able to take advantage of high levels of transit service. The disparities of transit viability among different income groups are significant and large (coef. >0.1). Low-car ownership people with alternative options also tend to be white, males, in the middle age, have a higher household income, a better education, and small families. Conversely, people in lower-car ownership households and without alternative options tend to be female, non-white, older age, have low-incomes, lower educational attainment, and large families.

People with the different level of alternative option viability have also accomplished different levels of mobility outcomes. The white travel fewer miles, take the same number of trips, and make fewer use of the household car despite of their higher viability of alternative options. Despite the limited viability of alternative options, females still need to accomplish the same trips and personal miles traveled, but with fewer VMT. High-income people also accomplished similar miles and trips but fewer VMT; their travel patterns are more likely to be out of choice as they have higher viability of alternative options.

These results reinforce the warning about the long-held practice of including ‘car ownership’ as an indicator of advantage without accounting for variability within low-car households. Specifically, the results show that different levels of mobility outcomes have different implications in different contexts, and they underscore the importance of joint evaluation of mobility capabilities and outcomes. The joint evaluation of mobility outcomes and capabilities yields more information about transportation disadvantage that assessment of outcomes alone.

The study also examines how mobility capabilities translate into mobility outcomes. It reveals the positive relationship between the viability of alternative options and mobility outcomes, especially the significant and larger effects of the availability of transit, walking, and car programs. Improving the viability of walking may require long-term efforts from transportation and land use, including infrastructure investment and the provision of affordable housing near transit line. Expanding car programs to access-constrained, low-car ownership household members would be useful to improve their mobility outcomes and may be more feasible in the short term. To date, models of mobility capabilities shown, a high proportion of white, high educated and high income groups stated the potential of using newly emerging car share programs to fulfil their travel needs. There are many barriers to increasing accessibility to these car share programs: lack of physical access, lack of credit cards, lack of smartphone or internet access, or high costs associated with using the service. All of these barriers may inhibit constrained lower-car ownership residents from using these car programs (Daley, 2014). To extend mobility options to low-income households, planners and policy makers must ensure that car program access are available in these neighborhoods.

4. Chapter 4: Mobility Capabilities Matter: Mobility Capabilities, Daily Travel, and Travel Mood

4.1 Introduction

Via engaging with the CA, I argued that equity elevation of transportation should focus on the opportunities and agency freedom people have to travel or travel from place to place. The sole focus on travel outcomes (functionings) such as personal miles traveled cannot tease out the disparities in observed behavioral outcomes resulting from individuals' preferences and contextual constraints. Thus, they may misguide policy or planning practices to promote transportation equity. Emotions during travel are important discrete and general functionings under CA, and one of five goals in promoting transportation equity is to have psychologically satisfied traveling (see Chapter 2). A good understanding of subjectively "in moment" experienced well-being in daily travel is important for transportation and urban planning practice and policy. The in-moment experienced well-being is a critical component for designing and evaluating policies and programs to enhance transport service and promote transport equity.

In recent years, some researchers have shifted attention to the interactions between transportation and subjective well-being, either short-term affective well-being or long-term cognitive well-being (Diener et al., 2002; Ettema et al., 2011; Abou-Zeid and Ben-Akiva, 2014). Mood, feelings for a short period during an experience, has been recognized as a type of affective short-term subjective well-being, which also has potential links to long-term subjective well-being and objective well-being. However, previous studies have predominantly treated travel mood in the context of a single trip (travel outcomes), while ignoring the fact that mood would heavily depend on the context and choices people face (Mobility Capabilities). Our travel mood is not only associated with what we actually do or are (functionings) but also with our mobility capabilities (i.e., the substantive opportunities people have to travel around). For instance, people who choose to bicycle out of choice would be different from people choosing to bicycle due to a lack of other options; the experienced "mood" may vary between these two groups of people. Without considering mode choice availability when examining the

correlation between daily travel and mood, the result may misguide policies or planning practice.

The chapter is theoretically driven and examines how mobility capabilities and actualized behavioral outcomes relate to travel mood. I put the emotions during travel into the context of people with heterogeneous levels of mobility capabilities. Specifically, I examine the interactions among modal options, destination accessibility, actualized daily travel, and short-term "in moment" travel mood. I answer three research questions: 1) how do modal options, destination accessibility, and travel mood vary among different socio-demographic groups? 2) how do modal options and destination accessibility correlate with mood during travel? 3) How do mobility capabilities measured as modal options and destination accessibility moderate the relationship between mood and mode? To answer these three questions, I mainly rely on the data from the Neighborhood Environment, Daily Activities, and Well-Being Study conducted in six neighborhoods in the Minneapolis-St Paul Twin Cities area by the Sustainable Healthy Cities project from October 17, 2016, to October 25, 2017 (Fan et al., 2019). The respondents in the survey not only reported their perceived mode viability and destination accessibility but also recorded their trips and mood during travel within 7-day travel diary.

The remainder of this chapter is organized as follows. The next section reviews the relevant literature on travel and travel mood. Then, I present the study's research design, including data collection, measurement of key concepts, and methodology. Descriptive analysis results are shown in section. Next, the econometric model results are presented. The chapter concludes with a discussion of implications for policy and planning.

4.2 Literature Review

A growing number of studies have paid attention to the relationship between subjective well-being and travel (Abou-Zeid and Ben-Akiva, 2014). Researchers differentiate two types of subjective well-being: short-term affective well-being and long-term cognitive well-being (Diener et al., 2002). The short-term affective well-being often is used to evaluate the short-term feeling during activities, measured through different ratings (e.g.,

Lancee et al., 2017) while the long-term cognitive well-being refers to the general evaluation of life satisfaction, measured through scales such as the Cantril Ladder of Life scale (Cantril, 1965) or Diener's (1985) Satisfaction with Life scale. This chapter focuses on the affective feelings during travel, the short-term "in moment" positive and negative feelings during travel. Thus, the section reviews relevant studies on daily travel and short-term affective well-being during travel.

Researchers have used different travel mood measures based on the survey used in their studies or the questionnaires they have designed. Some studies (e.g., Lancee et al., 2017) used a single measure by asking travelers to rate their happiness from 0 to 10. This approach has often been criticized for its reliability because it relied on a single item. Some studies relied on the American Time Use Survey (ATUS) data to examine travel mood, where emotion feelings during travel are rated in five dimensions: happy, sad, tired, painful and stressed (National Research Council, 2012). Of these studies (e.g., Morris & Guerra, 2015; Fan & Zhu, 2017), researchers either developed an aggregated measure of mood from the five emotions or examined the five emotions separately. In a self-design survey, Ettema et al. (2011) used three measures from pleasant to unpleasant ((happy-sad, satisfied–dissatisfied, joyful–depressed) and three measures from activated to non-active (active-passive, alert–sleepy, awake–dull) to measure the emotions during activities.

4.2.1 Trip characteristics and travel mood

Many empirical studies have revealed that mood during travel is related to trip characteristics, including mode, duration, trip purpose and activities during travel. Travel mood varies by mode. Travelers are more likely to have positive moods when driving than taking transit (Ettema et al., 2011, Olsson et al., 2013, Morris & Guerra, 2015). Hiscock et al. (2002) conducted a qualitative study to look at the mood during travel. They found that automobile drivers had more feelings of protection, autonomy, reliability, and convenience. Some other studies have found that biking and walking are more likely to be associated with positive moods compared to driving and public transit (Lancée et al., 2017; Olsson et al., 2013; Mokhtarian & Salomon, 2001; Morris & Guerra,

2015; Zhu & Fan, 2018). Active travelers may view their trips more fun (Morris & Guerra, 2015). Besides, most bicyclists may choose to bike because they like it (De Vos, 2018), not because bicycling is a "forced" choice.

Empirical studies also have revealed the association between travel duration and mood, especially for commuting trips. These studies have shown that driving could be stressful, anger-inducing, and frustrating if drivers are completing long-distance traveling and encountering congestion (Higgins, et al., 2018). Long-distance biking and walking are also painful. Longer traveling duration tends to reduce emotional well-being (Ettema et al., 2011; Ettema, 2012), even after controlling for mode.

Travel mood also varies with destination activities. Trips are more pleasant if people travel to pleasant trip destinations (Mokhtarian and Salomon, 2001). Empirical studies (e.g., Morris & Guerra, 2015, Glasgow, et al., 2019, Zhu & Fan, 2018) have often incorporated trip purpose to examine the correlation between destination activities and mood during travel. They have revealed that recreational trips have better mood than commuting trips (Ettema et al., 2012; Zhu & Fan, 2018).

Activities during travel, such as listening to music, talking on the phone, or talking with friends, are associated with travel mood. Ettema et al. (2012), for example, have found that of the various activities that can be performed during travel (such as relaxing or enjoying entertainment); talking to another passenger is associated with best mood during travel. Transit riders may have positive feelings when reading or talking with friends (Russell, 2012). Some recent studies have shown that traveling with companions is positively associated with positive emotions (Goulias et al., 2013; De Vos, 2018; Zhu & Fan, 2018). Goulias et al. (2013) have found that interacting with another while traveling produces positive emotions while traveling alone produces a mix of positive and negative ones. Zhu and Fan (2018) have found that traveling with family members and friends tends to be happier than traveling alone.

4.2.2 Mobility capabilities, daily travel, and travel mood

Previous studies of mood during travel have predominantly focused on the trip itself and treated it as an independent event apart from the context of traveling. Theoretically, the context of traveling (i.e., the opportunity and agency freedom to travel or travel for destinations) could also link to the experienced mood during travel. People with higher mobility capabilities could have increased control over the places to when, where, and how they travel (Ziegler and Schwanen, 2011). Thus, the higher mobility capabilities could trigger more pleasant trips, and traveling for people with higher mobility capabilities is more likely to be pleasure activities.

Mobility capabilities, the opportunity, and agency freedom of traveling, could be shaped by socio-demographic and environmental factors. Different social-demographic groups have different levels of resources. People with limited financial resources (low-income people) often also have limited mobility resources. Those persons often could not afford to own vehicles, use car-sharing services, or afford to live in the transit-accessible areas. As a result, their opportunity freedom of traveling is restricted. Traveling may be a burden for them. Furthermore, the restricted opportunity freedom of traveling may also limit their agency freedom to complete some trips associated with a higher positive mood.

Besides, people in different social-demographic groups assume different household and social roles. Each role entails responsibilities and many of those responsibilities entail travel. Parents make trips for child's needs and workers commute to work. However, some of those travel responsibilities are shaped by social norms. For example, social norms of the females' role in families implicitly asks females to devote more time in household activities and taking household trips, which may restrict females' opportunity and agency freedom to fulfill the trips for eating/drinking and social purposes. As a result, females may more appreciate the opportunities of conducting trips for eating/drinking and social purpose and experience higher happiness compared to men (Archer et al., 2013).

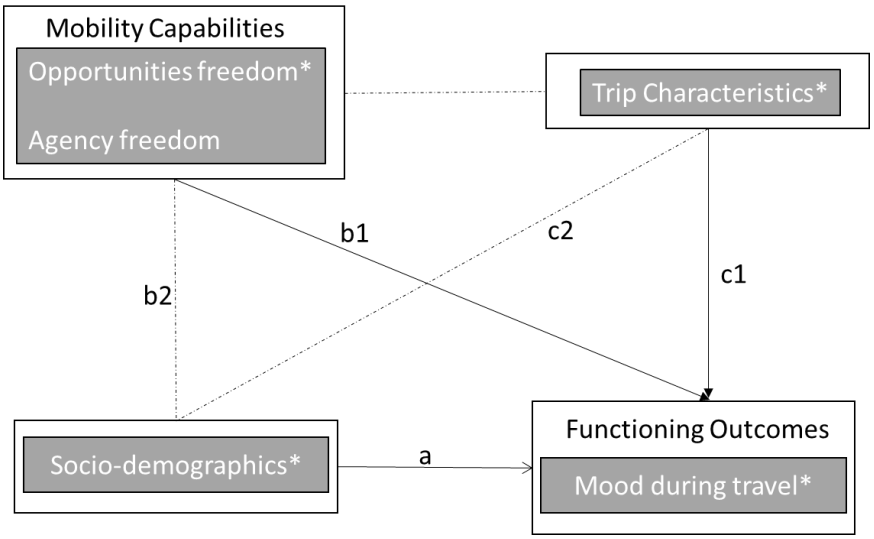
Some studies have revealed some disparities in travel mood among socio-demographic groups (Archer et al., 2013; Zhu & Fan, 2018; Glasgow et al., 2019). However, these studies have mixed results about the association between socio-demographics and travel mood. Archer et al. (2013) find that older adults and minorities experience higher happiness during travel while men experience lower happiness during social, eating/drinking, and maintenance travel. Zhu & Fan (2018) work on American Time Use Survey data and find that high-income people tend to experience lower levels of positive mood during travel. Glasgow et al., (2019) find no statistical associations between socio-demographics and mood. The only significant disparities in the travel mood are between white and nonwhite; white have better mood during travel than nonwhite. The mixed results of previous studies on social demographics and travel mood may be attributed to the fact that most studies directly incorporate social-demographics into the models without considering the disparities in potential opportunities to travel of different social-demographics

The nature and built environment could directly influence travel mood via influencing the experience during travel and indirectly via influencing the opportunity and agency freedom people have to travel. First, the natural and built environment around the travel route could directly influence the comfort and experience of one's trips. Several studies have examined the direct impacts of the natural and built environment along routes on moods (Berman et al., 2008; Stigsdotter et al., 2017; Fan, Das & Chen, 2011). The natural environment along travel routes, such as the existence of parks (Berman et al., 2008) and neighborhood greenness (Fan et al., 2011), are associated with positive mood during travel. A negative association is revealed with walkability and mood (James et al., 2017; Glasgow et al., 2019), which may attribute to the associated noise, congestions, and air pollution in urban walkable areas (Hankey et al., 2016). Second, the natural and built environment may influence people's freedom or choices of travel. Living in areas with dense services, for example, could provide more options for people to make the travel, thereby influencing travel mood.

4.3 The Conceptual Framework and Hypotheses

4.3.1 The conceptual framework

The literature review and the discussion with CA inform the conceptual framework for the analysis in the chapter (Figure 4-1). My research aim is to examine the interaction between mobility capabilities, daily travel and travel mood.



Relationships linked by an arrow (→) are examined in this analysis

Figure 4-1: Conceptual framework

Both Line a and Line b1 in Fig.4-1 are the primary relationships of interest. Line a represents the association between socio-demographics and mood during travel before and after adjusting for other factors of travel mood. As noted, travel mood is likely to be influenced by trip characteristics (arrow c1) and mobility capabilities (arrow b1). Disparities in travel mood could result from how these two factors are associated with social-demographic characteristics (arrow b2, and c2). I quantify the opportunity freedom via measuring viable modal options and destination access and incorporate these measures into the analysis. Agency freedom is difficult to measure in the individual-level analyses and is not addressed in this analysis.

I begin by measuring the unadjusted association between individual social-demographic characteristics and travel mood (line a) and the association between individual social-

demographic characteristics and mobility capabilities (line b2) to determine disparities in travel mood and mobility capabilities in the sample. Next, I adjust these associations for trip characteristics and opportunity freedom to examine how opportunity freedom influences travel mood and test whether socio-demographic disparities in travel mood persist after adjusting for these factors. If so, it is possible that they result from agency freedom or other observed relationships relevant to travel mood and socio-demographics.

4.3.2 Hypotheses

There are two sets of variables of measuring the opportunity freedom of traveling in the analysis. The first set of variables concern the access to modal options at personal level, including vehicle access and access to alternative mode options. The second group of variables concerns the access to destination opportunities. These variables and the hypothetical relationships with travel mood are discussed below.

Hypothesis 1: people with a higher level of car access could have better mood during travel.

> Vehicle access today is the norm of modern society in the US. To a certain degree, not having a private vehicle is equivalent to being confined in the status of being "inferior". Vehicle access is considered a guarantee of independence and freedom of movement (Flamm & Kaufmann, 2006). Car access could play an important role in determining the level of opportunity freedom to travel. Car access could not only offer individuals higher freedom in determining the time of traveling but also may allow individuals to have more choices of some types of destinations (Schwanen et al.; 2008). Thus, hypothetically, people with a higher level of car access could enjoy higher freedom of traveling, and traveling may be happier.

Hypothesis 2: people with a higher level of access to alternative mode options are more likely to have better mood.

Access to alternative mode options, similar to car access, could influence the opportunities people have to travel and travel to destinations. People with high access to alternative mode options could have a large choice set of mode when deciding how to complete trips. Thus, they could easily accommodate their own needs and preferences of travel. Hypothetically, the access to alternative mode options is positively associated with mood during travel.

Hypothesis 3: access to alternative mode options is more important for those who have limited car access in influencing their travel mood.

Travelers having restricted car access would be more dependent on alternative options and forced to use alternative options for all trips. In contrast, those who own cars could drive for trips that would be badly by other options. Thus, access to alternative options should be less important for them in influencing their travel mood.

Hypothesis 4: people with higher access to destination opportunities have better mood during travel.

Living in a highly accessible area with multi-destination opportunities, people tend to have more choices of destination opportunities, at least some types. As a result, people could make be able to take more rewarding trips. Hypothetically, people with large choice sets of destination opportunities are more likely to have a higher level of positive emotions during travel.

4.4 Data and Measurement

4.4.1 Sampling and data

Data used for the study are from the Neighborhood Environment, Daily Activities, and Well-Being Study conducted in the six neighborhoods in the Minneapolis-St Paul Twin Cities area by the Sustainable Healthy Cities project from October 17, 2016, to October 25, 2017 (Figure 4-1) (Fan et al., 2019). Blaine and Brooklyn Center are low-density suburban areas. There are four neighborhoods within the urban areas. Near North is a

low-income neighborhood and Saint Anthony Park is a middle-income neighborhood. Both these two urban neighborhoods do not have light rail service adjacent. Philips is a low-income neighborhood with a light rail station. Prospect Park is a middle-income neighborhood with light-rail access.

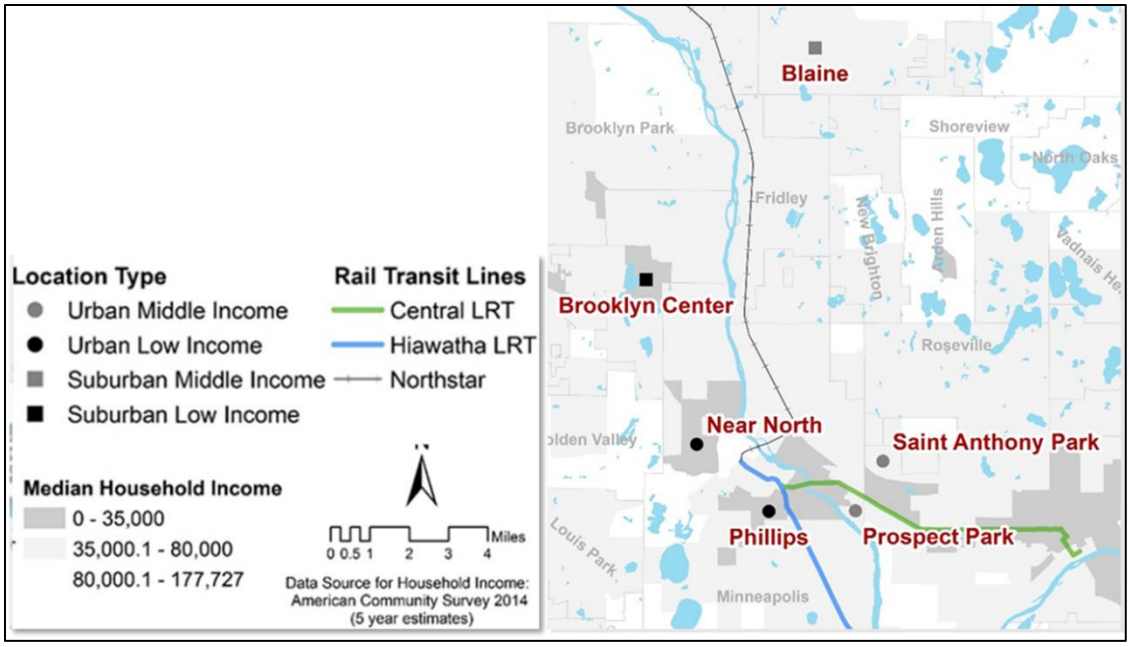


Figure 4-2: Study Area

(source: Fan et al., 2019)

The surveys have three sections, an entry survey, a seven-day use of a smartphone application, and an exit survey (Fan et al., 2019). The entry and exit surveys ask questions about demographics, perception of modes, destination opportunities, and other control variables. Respondents used the smartphone application to track their one-week trips and activities, including mode, purpose, companion, and emotions. The details about the survey design are in the paper by Fan et al. (2019).

This analysis focuses on utilitarian trips. People conducting purely leisure trips are often enthusiastic during the trips. Thus, I removed all leisure trips because I could identify whether the destination of trip is for leisure or the trip itself is for leisure. Further, I removed trips that did not include a specific trip mode or contained missing values. After processing, the final analytical sample includes 328 respondents and 7,628 trips. I

compare sample demographic characteristics with those of the population in the Minneapolis-St. Paul Metro Area (Table 4-1). Overall, females, elderly persons, and people with higher education are over-represented in the sample. Other demographic characteristics, including racial composition, income are comparable between the sample and the Metro Area. Thus, caution is needed when we interpret the results, and external validity is limited.

Table 4-1: Comparison of sample and Minneapolis-St Paul Metro Area

	Sample	MSP
% White	76.1	76.1
% African American	10.5	8.2
% Female	67.7	50.5
Age (median)	50.9	37.3
%Bachelor degree or higher	69.2	38.4
Household size	2.1	2.6
Child (under 18) presence	27.6	31.2
Less than 25,000	19.2	12.9
25,000-50,000	16.3	17.8
50,000-100,000	35.8	30.4
>100,000	28.7	37.2

Data source: ACS 2014-2018

4.4.2 Measurement

Travel Mood

The survey used the Day Reconstruction Method (DRM) to collect the data of emotion feelings during travel: participants are asked to keep a detailed diary of their daily events and associated feelings once at the end of each day (Kahneman et al., 2004; Kruegger & Schkade, 2008). The DRM asks participants to reflect on the day, break it up into episodes, and describe each episode, including travel and activities. The episodes then are rated using five of affective measures including happiness, tiredness, stress, sadness and

pain on scales ranging from 1 (not at all) to 7 (very strongly) that signify how strongly a participant felt a certain emotion during travel.

The four negative emotions are significantly correlated with higher coefficients (Table 4-2). Following the work of Bradburn (1969), Kahneman and Krueger (2006), and Morris and Guerra (2014), I develop an aggregated measure of "in moment" mood, Total Affect Score (TAS) via subtracting the mean of negative emotions from the mean of positive emotions (Total Affect Score= (Happiness-(Tiredness+Stress+Sadness+Pain)/4).

Table 4-2: Correlation coefficients between emotions

	Happiness	Tiredness	Stress	Sadness	Pain
Happiness	1.00				
Tiredness	-0.02***	1.00			
Stress	-0.23***	0.51***	1.00		
Sadness	-0.19***	0.37***	0.58***	1.00	
Pain	0.01***	0.39***	0.37***	0.43***	1.00

Note: ***p<.001

Mobility Capabilities

In the transportation context, the opportunity freedom means mode options and destination opportunities people have to travel. People with a variety of mode options and rich destination choices could conduct trips, which are more likely to be associated with better mood because they could have more choices when deciding when, where, and how they travel. Measures of viable mode options and destination accessibility are constructed via a few survey questions: respondents were asked to evaluate how they are satisfied with neighborhood characteristics on a five-point scale (1 very unsatisfied to 5 very satisfied). I focus on 14 attributes related to the modal options and destination accessibility. Since some of these variables are highly correlated to each other (See Table 4-3), I performed factor analysis on 14 attributes to extract the different dimensions of modal options and destination accessibility. Three factors were extracted: 1) viable alternative options; 2) car access; 3) destination access (Table 4-4).

Table 4-3: Pearson bivariate correlation analysis of measures of modal options and destination access

	Alt. Options			Car Access		Access to								
	Sidewalks	Bike trail/paths	public transportation	Vehicle ownership	Driver's license	quality leisure, recreation and entertainment	quality medical facilities	education institutions	quality childcare	community and public facilities	quality banks and other financial institutions	quality stores for all other purchases	grocery stores or famers markets	place of worship
Sidewalks	1.00													
Bike trail/paths	0.37**	1.00												
Access to public transportation	0.19**	0.20**	1.00											
Vehicle ownership	0.09	0.00	-0.13*	1.00										
Driver's license	0.13*	0.09	-0.08	0.47**	1.00									
Access to quality leisure, recreation and entertainment	0.25**	0.26**	0.16*	0.16*	0.13`	1.00								
Access to quality medical facilities	0.21**	0.25**	0.13*	0.05	0.16*	0.46**	1.00							
Access to quality schools and other	0.19**	0.11`	0.15*	0.02	0.04	0.36**	0.35**	1.00						

education institutions														
Access to quality childcare	0.13*	0.10	0.03	0.03	0.01	0.29**	0.23**	0.43**	1.00					
Access to community and public facilities	0.21**	0.21**	0.16*	0.11`	0.15*	0.43**	0.36**	0.27**	0.27**	1.00				
Access to quality banks and other financial institutions	0.22**	0.22**	0.13*	0.07	0.09	0.41**	0.40**	0.40**	0.36**	0.48**	1.00			
Access to quality stores for all other purchases	0.17**	0.15*	0.13`	0.05	0.03	0.48**	0.41**	0.32**	0.32**	0.45**	0.43**	1.00		
Access to grocery stores or famers markets	0.16**	0.18**	0.10`	0.00	-0.02	0.56**	0.37**	0.38**	0.31**	0.31**	0.35**	0.62**	1	
Access to place of worship	0.06	0.17**	0.09	-0.01	0.01	0.23**	0.32**	0.29**	0.27**	0.28**	0.37**	0.27**	0.24**	1

Note: **p<0.001; * p<0.01; `p<0.05

Table 4-4: Factor analysis for modal options and destination accessibility

	Viable alternative options	Car access	Destination access
Modal options			
Sidewalks	0.70		
Bike trail/paths	0.75		
Access to public transportation	0.59		
Vehicle ownership		0.83	
Driver's license		0.83	
Destination Access			
Access to quality leisure, recreation and entertainment			0.67
Access to quality medical facilities			0.59
Access to quality schools and other education institutions			0.65
Access to quality childcare			0.62
Access to community and public facilities			0.59
Access to quality banks and other financial institutions			0.68
Access to quality stores for all other purchases			0.74
Access to grocery stores or famers markets			0.73
Access to place of worship			0.53

Notes: The method was principal axis factoring with Oblimin with Kaiser normalization. Absolute value of loadings smaller than 0.3 were blanks.

Socio-demographics

Socio-demographics are measured as follows: age, gender, employment, education, income, and race and ethnicity.

Trip Attributes and Daily Mood

First, for each single trip, the following information is collected and measured: mode choice, trip duration, companionship, trip purpose. Second, the survey question asked

each respondent to rate their mood during the survey period on scales from not too happy, pretty happy to very happy.

Table 4-5: Descriptive statistics for all variables

Variables	Mean/percent	St. Dev	Min	Max
Total Affect	2.87	1.96	-6.00	6.00
Happiness	4.82	1.55	1.00	7.00
Stress	2.12	1.45	1.00	7.00
Pain	1.58	1.15	1.00	7.00
Tiredness	2.68	1.68	1.00	7.00
Sadness	1.44	1.04	1.00	7.00
Destination access	0.09	0.93	-3.33	2.16
Viable alternative options	0.02	1.03	-3.71	2.02
Car dependent	0.06	0.95	-3.67	1.14
Mode				
Car	61.51			
Rail	1.56			
Bus	5.12			
Bike	5.01			
Walk	26.81			
Trip duration				
<15 min	69.19			
15-30 min	21.55			
30-45 min	6.00			
>45min	3.25			
Trip Purpose				
Work	22.17			
Homebound	35.17			
Eating or Shopping	21.08			
Personal	15.39			
Other	6.20		0	100

Female	67.7	46.8	0.00	100
White	76.1	42.7	0.00	100
Education status				
school or below	9.6			
associate	21.2			
bachelor	31.5			
graduate	37.8			
Child Presence	27.6	44.8	0.00	100
Age group				
18/30	16.1			
31/45	23.6			
46/65	37.4			
66/91	22.9			
Household income				
<25,000	19.2			
25,000-75,000	35.5			
75,000-100,000	16.6			
>100,000	28.7			
Happy days				
Not too happy	8.6			
Pretty happy	55.8			
Very happy	35.6			

4.4.3 Statistical Methods

Descriptive analyses

Descriptive statistics and corresponding statistical tests (e.g., ANOVA) were used to examine the potential differences in modal option viability, destination access, and travel moods among different social-demographic groups.

Regression analyses

The linear random-intercept regression models were used to explore the interaction among modal options, destination accessibility, daily travel, and travel mood. The

modeling strategy allowed us to account for the two-level structure of the data; trips are clustered within individuals. The random-intercept model could control for individual-specific unobserved factors that influence trip evaluation of a single individual. The general specification for the model is presented in Eq. (1)

$$Y_{ij} = \beta_0 + \beta_1 CA_j + \beta_2 Trip_{ij} + \beta_3 Cov_j + \mu_j + \varepsilon_{ij}$$

Where í indexes trips, j indexes individuals, Y_{ij} is the dependent travel mood variable of interest, CA_j is a vector of measures of modal options and destination access for each individual, Cov_j is a vector of covariates for each individual, $Trip_{ij}$ is a vector of measures of trip characteristics, ε_{ij} is the error term, and μ_j is a random intercept term that shift regression line up or down for each individual. In this way, we estimated the relationship between travel mood and modal options and destination access while accounting for the variation between individuals.

4.4 Results

4.4.1 Descriptive analysis

The variations in modal options, destination access, and moods by socio-demographics are shown in Table 4-6. In the final analytical sample, significant disparities could be observed among different socio-demographics. Despite some minor inconsistencies, socio-demographic groups, including males, white, and higher-income people, experience higher positive emotions and lower negative emotions during traveling. They simultaneously have a higher level of car access, alternative mode option viability, and destination access. In terms of age groups, elderly persons in the sample, unexpectedly, have a higher level of destination access. It may attribute to their residential location choices of urban dense middle-income neighborhoods (Saint Anthony Park and Prospect Park (50%)). Traveling is also happier for them. In terms of educational attainment, people with higher educational status have higher car access, which does not translate into higher destination access. However, their traveling comparatively is associated with better mood, which may be associated with the spatial and temporal flexibility car access brings.

Table 4-6: Descriptive comparison of modal options, destination access and moods by socio-economic groups

	Modal options and destination access (Factor analysis) N=396			**Mood (1-7 scales) N=8,338**					
	Car access	**Alternative options**	**Destination access**	**Total affect**	**Happiness**	**Stress**	**Pain**	**Sadness**	**Tiredness**
Male	0.02	0.11	0.04	3.11	4.97	2.02	1.46	1.46	2.49
Female	-0.02	-0.06~	-0.02	2.72***	4.73***	2.18***	1.65***	1.42~	2.79***
Non-white	-0.81	-0.12	-0.22	2.46	4.86	2.53	1.99	1.89	3.18
White	0.25***	0.04~	0.07**	2.97***	4.81	2.02***	1.48***	1.32***	2.55***
Age group (vs.18-30)									
18-30	-0.11	0.005	-0.27	2.36	4.61	2.47	1.53	1.59	3.39
31-45	-0.12	-0.27~	-0.15	2.67***	4.68	2.33**	1.51	1.32***	2.88***
46-65	0.01	0.06	0.03*	3.00***	4.91***	2.04***	1.63**	1.53~	2.45***
>65	0.18~	0.19	0.29***	3.32***	5.03***	1.69***	1.62*	1.27***	2.25***
Education status (vs. high school or below)									
High school or below	-1.01	-0.22	0.44	2.35	4.73	2.51	1.83	2.09	3.06
Associate	-0.27***	-0.19	-0.30***	3.01***	5.15***	2.27***	1.81***	1.61***	2.86***
Bachelor	0.21***	0.09	-0.08**	2.99***	4.85	2.05***	1.39***	1.32***	2.67***
Graduate	0.24***	0.09~	0.13~	2.79***	4.66***	2.04***	1.59***	1.33***	2.53**

No Child	-0.01	0.05	0.06	2.90	4.84	2.09	1.62	1.46	2.62
Child presence	0.04	-0.14*	-0.16*	2.79*	4.76*	2.20**	1.48***	1.37***	2.83***
Household income (vs. <25,000)									
<25,000	-1.09	0.18	-0.004	2.49	4.73	2.30	1.99	1.72	2.94
25,000-75,000	0.10***	-0.002***	-0.06*	2.82***	4.86*	2.21~	1.66***	1.48***	2.81*
75,000-100,000	0.41***	-0.06***	0.08**	2.81***	4.62~	2.02***	1.40***	1.36***	2.45***
>100,000	0.40***	0.07***	0.21***	3.18***	4.95***	1.96***	1.38***	1.25***	2.46***

Notes: significance level ***p<.001; **p<.01; *p<.05; ~p<0.1

4.4.2 Models of total affect score

Table 4-7 presents the results of three multilevel regression models for the total affect score. Model 1 presents the basic model without incorporating the measures of opportunity freedom, modal options, and destination access. In Model 2, I added the measures of modal options and destination access to test hypotheses 1, 2, and 4. Model 3 added one interaction term of access to alternative modal options and car access to test hypothesis 3 and check whether alternative options are more important for people without car access in influencing travel mood. The higher intra-class correlation coefficients for all three models (0.51 for model 1, 0.50 model 2, and 0.49 for model 3) indicate the about 50% of the variance is explained by the between-person variability, justifying the usage of multilevel models.

The two variables indicating the viability of alternative mode options and car access are significantly correlated with a higher total affect score. People with high car access, all else equal, have a higher affect score. Owning a car is a necessity in most places in the US. The results indicate that people with lower car access do not only experience low mobility and accessibility (Grengs, 2002), but also are more likely to have a negative mood during travel. The better mood during travel for people with higher car access may associate with their spatial and temporal flexibilities the car brings. The total affect score also increases as access to alternative mode choice options increases. It means that regardless of their mode choice, people with higher alternative mode choice options have better moods during traveling. With the existence of multiple mode options, they could easily choose the mode option, which is more likely to associate with higher affect scores. The dataset does not reveal a significant association between destination accessibility and the affect score. In model 3, an interactive term between the measures of access to alternative mode options and car access (two significant measures in model 2) is added. It has a negative association with the total affect score. The results verified the hypothesis that access to alternative mode options is more important for people with lower car access in influencing mood.

As model 1 shows, those who are males with a higher income and elderly tend to have higher affect scores. The positive associations may result from their high opportunity and agency freedom to conduct travel (when, how, where, etc.). Males, people with higher income and elderly persons than their counterparts tend to have higher modal option choices and destination access (Table 4-3). When the variables of modal options and destination access are added to the model 2 and controlled, the effects of socio-economic characteristics on the total affect score change, variables of modal options and destination access absorbed some effects of socio-economic characteristics on the total affect score. The variables of female and household income become insignificant. People at 45 to 65 or over 65 years older still have higher affect scores than people aged 18 to 30 and 31-45 after adding variables of access to mode options and destination access. These elderly persons tend to have more temporal flexibility than people at 18 to 30 and 31-45. Their trips are more likely to be deliberate trips (such as shopping or eating trips (23% for the age group 65-91, and 17% for the age group 18-30 and 31-45) instead of mandatory trips (such as commuting or schooling).

The relationships between trip characteristics and the total affect score are expected and consistent with previous studies (e.g., Fan & Zhu, 2017 & Morris, 2015). Taking rail transit, bicycling, and walking is likely to associate with higher affect scores than driving. 15-30 min trips compared to trips shorter than 15 min is positively associated with the total effect. People tend to have better mood when traveling for homebound and eating or shopping trips than when traveling for commuting or schooling trips. Having companions during traveling is also associated with better mood. The variable of emotions during recent days is positively correlated.

Table 4-7: Multilevel regression of the total affect score

	Total Affect (1)			Total Affect (2)			Total Affect (3)		
	β	**Sig.**	**95% CI**	**β**	**Sig.**	**95% CI**	**β**	**Sig.**	**95% CI**
Variables of Interest									
Destination access				0.12		[-0.04, 0.28]	0.11		[-0.05, 0.27]
Viable alternative options				0.25	***	[0.10, 0.40]	0.26	***	[0.11, 0.41]
Car access				0.20	*	[0.00, 0.40]	0.16		[-0.04, 0.36]
Variable alternative options*car access							-0.14	~	[-0.29, 0.02]
Trip Characteristics									
Mode(ref.=Car)									
Rail	0.31	*	[0.04, 0.58]	0.32	*	[0.05, 0.60]	0.32	*	[0.05, 0.60]
Bus	-0.07		[-0.26, 0.12]	-0.06		[-0.26, 0.13]	-0.06		[-0.25, 0.13]
Bike	0.76	***	[0.58, 0.94]	0.76	***	[0.58, 0.94]	0.76	***	[0.57, 0.94]
Walk	0.46	***	[0.37, 0.54]	0.46	***	[0.38, 0.55]	0.46	***	[0.38, 0.55]
Trip duration (ref.=<15min)									
15-30min	0.08	*	[0.01, 0.16]	0.08	*	[0.01, 0.16]	0.08	*	[0.01, 0.16]
30-60min	-0.01		[-0.13, 0.10]	-0.01		[-0.13, 0.10]	-0.01		[-0.13, 0.10]
>60min	0.07		[-0.17, 0.31]	0.08		[-0.16, 0.32]	0.08		[-0.16, 0.32]
Trip purpose(ref.=commuting or schooling)									
Homebound	0.19	***	[0.1, 0.27]	0.19	***	[0.11, 0.27]	0.19	***	[0.11, 0.27]
Eat out or shopping	0.24	***	[0.14, 0.33]	0.24	***	[0.14, 0.34]	0.24	***	[0.14, 0.34]
Personal	0.06		[-0.04, 0.17]	0.06		[-0.04, 0.17]	0.06		[-0.04, 0.17]

Other	0.13	~	[-0.01, 0.28]	0.14	~	[-0.00, 0.28]	0.14	~	[-0.00, 0.28]
Having companions	0.40	***	[0.33,0.47]	0.40	***	[0.33, 0.47]	0.40	***	[0.33, 0.47]
Socio-demographics									
Female	-0.27	~	[-0.59, 0.04]	-0.26		[-0.57, 0.05]	-0.26		[-0.56, 0.05]
White	0.18		[-0.22, 0.59]	0.05		[-0.35, 0.46]	0.06		[-0.35, 0.46]
Age group(ref.=18-30)									
31-45	0.26		[-0.22, 0.74]	0.40		[-0.08, 0.88]	0.40		[-0.08, 0.88]
46-65	0.72	***	[0.29, 1.15]	0.72	***	[0.3, 1.15]	0.72	***	[0.30, 1.15]
>65	0.89	***	[0.37, 1.4]	0.78	**	[0.26, 1.29]	0.81	**	[0.29, 1.32]
Education status(ref.=high school or below)									
Associate	-0.11		[-0.76, 0.54]	-0.17		[-0.84, 0.50]	-0.15		[-0.82, 0.51]
College	-0.21		[-0.86, 0.44]	-0.37		[-1.03, 0.30]	-0.35		[-1.02, 0.31]
Graduate	-0.44		[-1.10, 0.22]	-0.59	~	[-1.26, 0.07]	-0.58	~	[-1.24, 0.09]
Child presence	-0.17		[-0.55, 0.2]	-0.21		[-0.57, 0.16]	-0.16		[-0.53, 0.20]
Household income(ref.=<25,000)									
25,000-75,000	0.16		[-0.3,0.62]	0.15		[-0.32,0.62]	0.16		[-0.30,0.63]
75,000-100,000	0.18		[-0.36,0.72]	0.15		[-0.41,0.71]	0.17		[-0.39,0.73]
>100,000	0.44	~	[-0.07,0.95]	0.33		[-0.2, 0.85]	0.36		[-0.17,0.88]
Happy days									
Pretty happy	0.62	~	[-0.00,1.24]	0.56	~	[-0.04,1.17]	0.58	~	[-0.02,1.19]
Very Happy	1.09	***	[0.44, 1.75]	0.90	**	[0.25,1.56]	0.92	**	[0.27,1.58]
Constant	1.34	**	[0.52, 2.17]	1.68	***	[0.80,2.56]	1.61	***	[0.73,2.49]

Random-effects Parameters	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
Personal level variance	1.68	[1.42,1.98]	1.59	[1.35, 1,88]	1.58	[1.34, 1,86]
Trip level variance	1.62	[1.57,1.67]	1.62	[1.57, 1.67]	1.62	[1.57, 1.67]
Intra-class correlation	.51		.50		.49	
Individuals	328		328		327	
Sample Size	7,621		7,619		7,619	

Note: ****p<0.001; **p<0.01; *p<0.05; ~p<0.1*

4.4.3 Models of five emotions

Table 4-8 examines the five emotions separately to explore the dynamics among modal options, destination access, and positive and negative emotions. The three variables of interest do not correlate with the five emotions in the same way. Expectedly, stress decreases significantly with destination access. People with lower destination access, all else equal, feel more stressed during traveling. The other four emotions are not statistically correlated with destination access, with 95% confidence intervals. Are people have higher car access happier during travel? Unexpectedly, car access is not statistically significantly correlated with positive mood while significantly associated with decreasing stress and pain. However, even after controlling the destination accessibility and car access, having higher viability of alternative mode options is associated with increasing happiness and decreasing stress and sadness.

The relationship between trip characteristics and emotions are almost consistent across the five models. Bicycling and walking are associated with higher happiness, and lower stress and pain; taking rail transit is associated with less stress while bus is associated with higher fatigue. Longer trip duration is associated with more negative moods as a result of more stress and fatigue. People tend to have less negative mood when traveling for eating or shopping trips and other purpose trips than when traveling for commuting or schooling trips. Notably, homebound trips are associated with more happiness, fatigue, pain, and less stress than commuting or schooling trips. It may be because people decide to come back home when they feel tired or painful. Thus the homebound trips are happy but also tiring and painful. Having companions during traveling is positively correlated with more happiness and less stress.

Table 4-8: Multilevel regression of five emotions

	(4) Happiness		(5) Stress		(6) Pain		(7) Sadness		(8) Tiredness	
	β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
Variables of Interest										
Destination access	0.04	[-0.09, 0.17]	-0.12~	[-0.24, 0.01]	-0.06	[-0.18, 0.06]	-0.04	[-0.13, 0.05]	-0.04	[-0.18, 0.10]
Viable alternative options	0.15*	[0.03, 0.28]	-0.15*	[-0.27, -0.04]	-0.02	[-0.13, 0.09]	-0.11*	[-0.20, -0.03]	-0.10	[-0.23, 0.04]
Car access	0.04	[-0.12, 0.2]	-0.19*	[-0.34, -0.04]	-0.21**	[-0.35, -0.06]	-0.09	[-0.20, 0.02]	-0.13	[-0.30, 0.04]
Trip Characteristics										
Mode(ref.=Car)										
Rail	0.17	[-0.04, 0.38]	-0.32**	[-0.53, -0.10]	-0.06	[-0.21, 0.10]	-0.02	[-0.17, 0.13]	-0.21~	[-0.47, 0.03]
Bus	-0.02	[-0.17, 0.13]	-0.11	[-0.26, 0.04]	0.01	[-0.11, 0.12]	0.03	[-0.07, 0.14]	0.19*	[0.01, 0.37]
Bike	0.71***	[0.57, 0.86]	-0.29***	[-0.43, -0.15]	0.14**	[0.03, 0.24]	-0.05	[-0.15, 0.04]	0.00	[-0.17, 0.17]
Walk	0.39***	[0.33, 0.46]	-0.23***	[-0.29, -0.16]	0.10***	[0.04, 0.14]	-0.06**	[-0.11, -0.02]	-0.08~	[-0.15, 0.00]
Trip duration (ref.=< 15min)										
15-30min	0.13**	[0.07, 0.19]	0.09**	[0.03, 0.15]	0.02	[-0.02, 0.06]	-0.03	[-0.07, 0.01]	0.08*	[0.01, 0.15]
30-45min	0.11*	[0.01, 0.21]	0.20***	[0.10, 0.30]	0.08*	[0.01, 0.16]	-0.02	[-0.09, 0.05]	0.17**	[0.05, 0.29]
>45min	0.01	[-0.12, 0.15]	0.14*	[0.00, 0.27]	0.03	[-0.07, 0.13]	-0.01	[-0.10, 0.08]	0.28***	[0.12, 0.44]
Trip purpose (ref.=commuting)										
Homebound	0.21***	[0.15, 0.28]	-0.24***	[-0.30, -0.17]	0.08**	[0.03, 0.12]	0.03	[-0.01, 0.08]	0.23***	[0.15, 0.31]
Eat out or shopping	0.15***	[0.07, 0.22]	-0.24***	[-0.31, -0.16]	0.00	[-0.05, 0.06]	0.01	[-0.04, 0.06]	-0.13**	[-0.22, -0.05]

Personal	0.03	[-0.05, 0.12]	-0.12**	[-0.20, -0.03]	0.04	[-0.02, 0.11]	0.01	[-0.04, 0.07]	-0.05	[-0.15, 0.05]
Other	0.12*	[0.01, 0.24]	-0.02	[-0.13, 0.09]	-0.01	[-0.10, 0.07]	0.09*	[0.02, 0.17]	-0.11~	[-0.25, 0.02]
Having companions	0.38***	[0.32, 0.43]	-0.06*	[-0.12, -0.00]	-0.03	[-0.07, 0.01]	-0.02	[-0.06, 0.02]	0.03	[-0.04, 0.09]
Socio-Demographics										
Female	-0.13	[-0.38, 0.12]	0.07	[-0.17, 0.31]	0.24*	[0.02, 0.47]	0.01	[-0.17, 0.18]	0.20	[-0.07, 0.47]
White	-0.24	[-0.58, 0.09]	-0.23	[-0.55, 0.09]	-0.35*	[-0.65, -0.06]	-0.21~	[-0.44, 0.02]	-0.37*	[-0.74, -0.01]
Age group(ref.=18-30)										
31-45	0.25	[-0.15, 0.64]	-0.11	[-0.49, 0.27]	0.14	[-0.22, 0.49]	-0.16	[-0.43, 0.12]	-0.52*	[-0.95, -0.09]
46-65	0.48**	[0.13, 0.83]	-0.41*	[-0.74, -0.07]	0.32*	[0.01, 0.63]	-0.03	[-0.27, 0.21]	-0.87***	[-1.25, -0.50]
>65	0.45*	[0.03, 0.87]	-0.62**	[-1.02, -0.21]	0.38*	[0.01, 0.76]	-0.12	[-0.41, 0.17]	-0.98***	[-1.44, -0.52]
Education status (ref.=< High school)										
Associate	0.06	[-0.48, 0.61]	0.30	[-0.23, 0.82]	0.41~	[-0.07, 0.90]	0.12	[-0.26, 0.50]	0.21	[-0.38, 0.80]
Bachelor	-0.30	[-0.84, 0.25]	0.22	[-0.30, 0.74]	0.05	[-0.44, 0.53]	-0.08	[-0.46, 0.30]	0.19	[-0.41, 0.78]
Graduate	-0.46~	[-1.01, 0.08]	0.25	[-0.27, 0.78]	0.20	[-0.29, 0.69]	0.04	[-0.34, 0.42]	0.11	[-0.48, 0.71]
Child presence	-0.16	[-0.46, 0.13]	0.00	[-0.29, 0.29]	0.05	[-0.21, 0.32]	-0.00	[-0.21, 0.20]	0.10	[-0.22, 0.42]
Household income (ref.=<25,000)										
25,000-75,000	0.18	[-0.2, 0.56]	0.18	[-0.19, 0.54]	-0.14	[-0.48, 0.20]	0.03	[-0.24, 0.29]	0.09	[-0.33, 0.50]
75,000-100,000	0.07	[-0.39, 0.53]	0.17	[-0.27, 0.61]	-0.30	[-0.71, 0.11]	0.01	[-0.31, 0.33]	-0.20	[-0.70, 0.30]
>100,000	0.21	[-0.21, 0.64]	0.04	[-0.37, 0.45]	-0.30	[-0.69, 0.08]	-0.06	[-0.36, 0.24]	-0.13	[-0.59, 0.34]

Happy days										
Pretty happy	0.49~	[-0.01, 0.98]	-0.09	[-0.56, 0.39]	0.03	[-0.41, 0.47]	-0.28	[-0.62, 0.07]	-0.01	[-0.55, 0.53]
Very Happy	0.79**	[0.26, 1.33]	-0.18	[-0.70, 0.33]	0.00	[-0.48, 0.48]	-0.30	[-0.67, 0.07]	-0.03	[-0.61, 0.55]
Constant	4.06***	[3.34, 4.77]	2.62***	[1.95, 3.32]	1.49***	[0.84, 2.13]	1.98***	[1.48, 2.48]	3.37***	[2.60, 4.15]
Random-effects parameter										
	β	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
Personal level variance	1.08	[0.91,1.27]	0.99	[0.84,1.17]	0.88	[0.74,1.03]	0.52	[0.44,0.61]	1.26	[1.06,1.48]
Trip level variance	0.99	[0.96,1.02]	0.98	[0.95,1.01]	0.54	[0.52,0.55]	0.47	[0.46,0.49]	1.38	[1.33,1.42]
ICC	0.52		0.50		0.62		0.52		0.48	
Individuals	328		328		327		327		328	
Sample size (N)	7,628		7,629		7,621		7,621		7,626	

Note: ****<0.001; **<0.01; *<0.05; ~<0.1*

4.4.4 Effects of modal options and destination accessibility on emotions by modes.

The estimation results in the 4.4.2 show that rail users, bicyclists, and pedestrians tend to have better mood compared to driving. The average effects of mode choice on mood may obscure substantial heterogeneities across groups of people with different levels of modal options and destination access. The relationship between mood during travel and mode may be heterogeneous. Two common approaches could be used to account for the effects of modal options and destination access on moods during trips of different mode, adding interaction terms and building separate models. For interpret the results easily, table 4-9 examines all six measures of emotions for each mode choice (the estimation results of trip characteristics and socio-demographic characteristics are not presented here). Because there are few observations for light rail trips (30 people and 120 trips), I did not develop separate models for the rail users.

For car trips, people with a higher access to alternative mode options tend to have a higher affect score of out of increasing happiness, and decreasing stress and sadness. Destination accessibility is significantly correlated with total affect score of car trips at significance level of $p<0.1$. People with higher level of perceived destination accessibility tend to have better mood during car trips (significance at $p<0.1$).

There are striking differences in mood during bus among people with different modal options and destination accessibility. High access to alternative mode options is associated with better mood out of less stress, sadness and fatigue. People living in the areas with viable alternative mode options tend to have less stressful bus trips. It is also interesting that the variable of destination accessibility is associated both with less happiness and less stress for bus trips. Higher destination accessibility not only offers rich activity participation opportunities, which may decrease the stress of bus trips. Simultaneously, areas with higher destination accessibility areas may also tend to have more stops and interaction with other modes, lowering the happiness.

Bike is the mode most strongly associated with positive mood. However, the emotions of bike trips vary with modal options and destination access. Destination accessibility

unexpectedly has a negative association with happiness during bicycling trips. Higher destination accessibility would increase the interaction of different modes during trips and thus decrease happiness. The model results do not reveal a significant association between the three variables and total affect score in terms of walking trips. However, car access decreases the stress, painfulness, and fatigue of walking trips. Destination accessibility also helps decrease the stress of walking trips.

Table 4-9: Results of multilevel regression models of emotions on modal options and destination access

		Car	**Bus**	**Bike**	**Walk**
		285 people	**59 people**	**57 people**	**257 people**
	Variables	**4,813 trips**	**341 trips**	**379 trips**	**1,966 trips**
Total Affect	Destination access	0.15~		-0.29~	
Total Affect	Viable alternative options	**0.22****	**0.68***		
Total Affect	Car access			0.43~	
Happy	Destination access		**-0.50***	**-0.26***	
Happy	Viable alternative options	**0.15***			
Happy	Car access				
Stress	Destination access		-0.37~		-0.14~
Stress	Viable alternative options	**-0.15****	**-0.45***		
Stress	Car access				**-0.22***
Pain	Destination access		**-0.49***		
Pain	Viable alternative options				
Pain	Car access	-0.19~		-0.41~	**-0.26****
Sad	Destination access				
Sad	Viable alternative options	**-0.10***	-0.30~		
Sad	Car access			**-0.50*****	
Tired	Destination access				
Tired	Viable alternative options		**-0.66****		
Tired	Car access				-0.17~

Note: *Non-significant=blanks**;** Significance level: ***<0.001; **<0.01; *<0.05; ~<0.1*

4.5 Discussion and Conclusions

The study aims at exploring the interaction among mobility capabilities, daily travel and mood. Overall, the findings show positive associations of mobility capabilities and positive mood during travel and revealed how social-demographics and mobility capabilities correlate with travel mood. In the descriptive analyses, significant disparities in modal options, destination accessibility, and travel mood are observed among different social-demographics. Males, white, elderly persons, and higher-income people experience higher positive emotions and lower negative emotions during traveling and simultaneously have a higher level of car access, access to alternative mode options, and destination access. The association of travel mood and socio-demographics persists after adjusting trip characteristics. However, the heterogeneities in travel mood are partially explained by their disparities in mode option viability and destination access, which are used to measure the opportunity freedom people have. It indicates that the heterogeneities in people's mobility capabilities partially explain the disparities of travel mood. Specifically, people with higher viability of alternative modal options and higher car access generally have better mood during travel. Moreover, the significance of the interaction term between a high level of access to alternative modal options and car access showed that access to alternative mode options is more important for people with restricted access to cars in improving travel mood.

The results on assessing the relationships among modal options, destination access, and five separate emotions again highlight the importance of improving the alternative mode options for mood improvement during travel. Specifically, the variable of measuring viable alternative modal options is significantly correlated with all the separate five emotions. The results are highly intuitive. People living in areas with high access to alternative options tend to have more choices about traveling. Thus, they could easily adapt their choices of travel for increasing positive emotions and reducing negative emotions. Destination access is significantly correlated with reducing stress for traveling. Do people with a higher level of car access have a higher level of happiness during travel? No, car access is significantly correlated with lower levels of stress and pain during travel. It suggests that people with different levels of car access do not have any

differences in terms of positive mood during travel but are less likely to experience negative emotions during travel.

Regarding the relationship between mode and mood, the results are consistent with previous studies that averagely, bicyclists are happiest, and pedestrians and rail users are happier than driving. However, the relationship also varies among groups of people with different modal options and destination access. Car trips are happier for people with a higher level of destination access and viable alternative options. Bus trips are happier for people with higher alternative modal options, and bike is happier for people with higher levels of car access.

These findings have important policy implications. First, mood during travel is becoming an important focus in transportation literature, and a growing number of studies have examined correlates with travel mood. It is important to improve the transportation service itself to improve travel mood, such as frequent bus service, shortening commuting time. However, the findings also show that the context of traveling, access to modal options, and destination access play an important role in determining their travel mood. Thus, as planners, we could not narrow the goals of promoting the better mood on the trip itself. However, the relevant context questions of traveling may further influence mood during travel. The findings highlight the necessity of holding a holistic view of promoting transportation equity and improving travel mood via improving the opportunities freedom people have to travel as the policy goals. Second, the heterogeneous relationship between mood and mode suggests the warnings about the widespread statement that cycling is the happiest mode without accounting for various choice contexts of cycling. The significant disparities in the mood of different modes have been revealed among people with different levels of modal options and destination accessibility. Cycling is the happiest mode only for people with a higher level of car access. Those without a higher level of car access are still more likely to experience negative mood during travel, and targeted policies are needed to improve mood during cycling for those with lower access to cars.

5. Chapter 5: Synthesis, Conclusions, and Policy Recommendations

5.1 Summary of Findings

I have argued In this dissertation that promoting transportation equity requires the production of equality of mobility capabilities for individuals. The argument is supported by both theoretical discussion and empirical evidence. I conducted a theoretical discussion of CA and transportation equity to explore how the CA informs the conceptualization and practices of transportation equity and proposed an evaluative framework for assessing transportation equity. Then informed by the CA, I conducted two empirical studies. The first empirical study evaluated the distribution of opportunity freedom of traveling and mobility outcomes within low-car ownership households, and the second assessed the interactions among mobility capabilities and mobility outcomes, including travel mood. This chapter synthesizes the preceding chapters and contextualizes the findings within the transportation literature.

The aim of Chapter 2 was to answer two main research questions:

- What should be evaluated for transportation equity?
- What is transportation equity?

A theoretical discussion of the CA and transportation was conducted to answer these two questions. Unlike other distributive justice theories, the CA argues that it is not sufficient to assess the distribution of available resources, such as the provision of services in transportation, or outcomes, such as personal miles traveled (PMT). We should understand and assess equity in terms of what people are effectively able to be and to do, that is, on their substantial freedom of travel or travel from place to place. The substantial freedom of traveling not only refers to opportunities freedom, which may be measured as potential lists of modal options or destinations, but also refers to agency freedom to make traveling choices without violence or shame.

To better link transportation and capabilities, I further linked the Nussbaum's list of 10 central capabilities with transportation to answer how transportation contributes to the

various capabilities that enable people to make choices of living a good life. As a result, I proposed five domains of evaluative focuses for assessing transportation equity, including:

1) Access to basic resources, services, and activities sites;
2) The freedom of physical movement around places;
3) Opportunities for active travel (walking and bicycling);
4) Opportunities to conduct safe and psychologically satisfied trips;
5) Access to political engagement activities.

Instead of being a transcendent theory of justice inquiring how society ought to be, the CA pays much attention to the process of the *production* of equality of mobility capabilities for individuals. It emphasizes the comparison of the environmental and social contexts where mobility capabilities of individuals are shaped. Thus, in the CA, equity is more likely to be a process to promote the advancement of justice, such as via removing barriers, instead of a static status. Thereby, I proposed the following definition of transportation equity: the process of expanding an individual's capabilities and freedom to choose among functionings and to exercise the functionings they have reason to value, including the removal of unwanted options and the freedom not to exercise unwanted mobility.

The aim of Chapters 3 and 4 was to apply this CA framework in two different empirical transportation contexts and explore how the application of CA informs the empirical practices in transportation. Specifically, in Chapter 3, I not only assessed the disparities of mobility outcomes within people living in low-car ownership households but also evaluated the disparities of opportunities freedom of travel, measured as the viable mode options of travel or travel from a place to another. The measure of opportunity freedom, viable mode options of travel, is relevant to three of five domains in the evaluative framework of Chapter 2, including *1) Access to basic resources, services, and activities sites; 2) The freedom of physical movement around places; 3) Opportunities for active travel (walking and bicycling)*. The study illustrated how the joint evaluation of the

disparities in opportunity freedom and mobility outcomes informs transportation disadvantage and equity. First, the results show that a substantial proportion of lower car ownership households own one car because of constraints (5% without any alternative options viable and 45% without stating transit as viable).

The model results related to the viability of alternative options show that people with higher viability of alternative options live in higher density areas where they might be able to take advantage of high levels of transit service or be able towalk or bike to access destinations. People in lower-car ownership households and without alternative options tend to be female, non-white, older age, have low-income, a lower education, and large families. These groups of people with different levels of alternative option viability have also achieved different levels of mobility outcomes. The non-white travel longer miles, take the same number of trips, and make more use of the household car when faced with limited viability of alternative options. Under the limited viability of alternative options, females still need to accomplish the same trips and miles but with fewer VMT. Low-income people also still need to accomplish similar miles and trips but with fewer VMT despite the fact they are less likely to have alternative options. Generally, given a limited choice set of modal options, people living in low-income, low-car ownership households need to achieve the similar mobility outcomes. The negotiation and sharing of the only household car may be more competitive in these households. These findings illustrate and confirm that the similar achievement of mobility outcomes does not reflect the non-existence of transportation disadvantages. The different levels of mobility outcomes also do not imply that the higher levels represent an advantage. Different stories of transportation disadvantage are revealed when considering the disparities in mobility capabilities.

In Chapter 4, I focused on one of five domains in the evaluative framework, i.e. *Opportunities to conduct safe and psychologically satisfied trips*. Specifically, I assessed the disparities in travel mood as the measure of the satisfaction of trips among different socio-demographic groups, and examined the interaction between *mobility capabilities*, measured as viable modal options and destination access, and *travel mood*. In the chapter,

I aimed at exploring the dynamics between mobility capabilities and functioning outcomes and justifying the importance of focusing on expanding mobility capabilities in transportation practices of promoting equity. Specifically, I tried to answer three research questions and test four hypotheses.

Research Question 1: how do modal options, destination accessibility, and travel mood vary among different socio-demographic groups?

Both univariate and regression analyses revealed that people who are males, have higher incomes, and elderly tend to have higher positive emotions and lower negative emotions during travel compared with their counterparts. Furthermore, the heterogeneities in travel mood are partially explained by their disparities in mode option viability and destination access, which are used to measure the opportunity freedom people have. These results indicate that the heterogeneities in people's mobility capabilities partially explain the disparities of travel mood. Specifically, people with higher viability of alternative modal options and greater access to cars generally have better mood during travel.

Research Question 2: how do modal options and destination accessibility correlate with emotions during travel? Three relevant hypotheses are tested related to question 2.

Hypothesis 1: people with a higher level of car access have better mood during travel.

In the analytical sample, I find evidence to support hypothesis 1. Car access has significant and positive association with the total affect score with a significant magnitude of effects. However, the positive relationship between car access and total affect score attributes to its effects on reducing negative emotions of stress and pain rather than increasing positive emotions.

Hypothesis 2: people with a higher level of access to alternative mode options are more likely to have better mood.

The results support this hypothesis. Access to alternative options has a significant and positive association with the total affect score as a result of increasing happiness and decreasing both stress and pain.

Hypothesis 3: access to alternative mode options is more important for those who have limited car access in influencing their travel mood.

The interaction term between alternative mode options and car access is negatively associated. This result supports hypothesis 3 that higher access to alternative mode options is important to people with lower level of car access to improve their travel mood.

Hypothesis 4: people with higher access to destination opportunities have better moods during travel.

The results did not support hypothesis 4: no significant associations were revealed in the analysis. However, a significant and negative association between destination access and stress is revealed at a significance level of $p<0.1$. Destination access appears to influence travel mood in two contradictory ways: higher destination access provides richer destination choices for travelers, making traveling easy and comfortable, while higher destination access also are associated with higher interaction of other modes, higher congestion, and air pollution, making traveling uncomforting and unhappy

Research Question 3: how do mobility capabilities, measured as modal options and destination accessibility, moderate the relationship between moods and modes?

The results show that the relationship between mood and mode varies among groups of people with different levels of access to modal options and destination access.

Taken together, these results provide evidence that illustrates the value and importance of using the CA to frame and guide empirical studies. Specifically, these results support

three of four hypotheses and generally confirm that mobility capabilities – assessed here as modal options and access to destinations – are associated with an important functioning, namely, travel mood. People in households with access to more modes are, all else equal, more likely to report better moods during travel, and people with greater access to destinations are less likely to feel stress when traveling. To the extent the poor and economically disadvantaged live in households with fewer available modes of travel or with lower access to destinations, their stress and/or moods during travel are likely to be adversely affected. These finding imply the importance of explicit consideration of opportunities freedom – especially model options and accessibility to destinations – in policy debates and planning initiatives.

5.2 Policy Implications

The following sections highlight policy implications informed by the findings and discussion in the dissertation.

5.2.1 Recognize the goal of transportation equity as promoting the equalities of mobility capabilities

Policymakers should recognize that pursuing transportation equity is not only about equalities of observed mobility outcomes, such as travel time, or about equalities of transport services, infrastructure, or accessibility. Although these traditional measures of transport services and observed travel outcomes will continue to play important roles in assessing distributional equity in transportation, planners should bear in mind that the goal of transportation equity is to promote the equalities of mobility capabilities and to expand the opportunity and agency freedom of travel. Planners and policymakers will face many challenges in re-orienting institutional processes to focus on goal of equalizing mobility capabilities. These challenges include measuring and assessing the five domains in practice. This type of challenge was illustrated in Chapters 3 and 4 by the use of surveys not originally designed to measure mobility capabilities (i.e., access to modes) for that purpose. Another challenge, addressed in Chapter 2, is that by itself, the CA does not provide guidance to planners on how to prioritize interventions when the goals of maximizing mobility capabilities and broader societal goals conflict. Thus, decisions by planners to embrace the CA and establish mobility capabilities as a goal will not resolve

the difficult challenges of allocating resources among competing goals and prioritizing interventions. Planners and policymakers will need to hold public discussions and engage individuals in collective reasoning to get a better understanding of the value of each domain for local residents and what transportation projects should be prioritized. Planners will need to deploy multiple metrics to test if proposed infrastructure will deliver benefits in an equitable manner for different groups of people or different communities andwhich account for the five domains of transportation capabilities. No single approach can capture the full range of equity impacts that transportation systems have on individuals and communities.

Similarly, planners should recognize that transportation disadvantage is a multi-faceted concept that encompasses the many ways in which persons have limited opportunity and agency freedom to complete the five domains of mobility capabilities. For example, a person may suffer from transportation disadvantage if he must rely on transit service of poor quality near his home. If we only look at whether he has transit access or he has a short commuting time by using transit to get to work, we may fail to capture the transportation disadvantage. Thus, an analysis of transportation disadvantages not only needs to look at the observed outcomes or the provision of the service or infrastructure, but also the quality of service and factors such as how it affects mood. We should also assess the context of his choice of transit, including the questions about whether transit is his only choice (physical freedom of travel), whether the transit service provides him a good accessibility to activity participation (access), and whether he feel comfortable and easy to use the transit service (satisfied). Thus, transportation planning and policy-making should keep in mind of diverse disadvantages when they act on their policy aims.

5.2.2 Transportation and land use policy to enhance mobility capabilities

Expanding mobility capabilities of individuals may conflict with some societal goals of alleviating congestions and reducing air pollution. Thus, I propose the following policy options to accommodate these aims.

Bike and pedestrian environment improvement

Bike and pedestrian environment improvement not only is relevant to encourage multimodality and offer active travel options for traveling and accessing destinations, but also directly relevant to one of five domains, opportunity for active travel. Improvements are often made in job and retail rich areas, informed by active travel demand analyses or areas with strong political capital for active travel. Improvements in the bike and pedestrian environment are also sometimes associated with the process of gentrification. Policymakers should pay more attention to areas with people without many transportation options and seek to increase options, including safe, efficient opportunities for walking and cycling.

New emerging options for everybody

Transportation network company (TNC) services such as Uber, Lyft and Zipcar are newly-emerging options across the that provide new and flexible options for urban residents. However, many barriers, such as high cost and requirements for smart phones must be overcome to make these services real choices for those people with less financial resources. Policymakers should work with these private companies to make sure that all residents could benefit from these new transportation options.

Afford housing in highly accessible areas.

Expansion of housing options in accessible areas could help expand the mobility capabilities of people with mobility constraints. There are several policy options that can be considered by policymakers and planners. First, by continuous coordination of transit investments and land use change, policymakers can make more areas accessible, especially areas concentrated with people with mobility limits. Second, policymakers can consider changes in zoning requirements by allowing high-density development in accessible areas or even make inclusive zoning for afford housing.

5.2.3 Recognize promoting transportation equity as a collaborative process

Although the goal of transportation equity is the equality of mobility capabilities, the CA approach is processual and emphasizes the importance of continuous pursuit of an equitable distribution of the five domains of capabilities. The process inevitably involves redistribution of various resources, which therefore likely requires efforts and commitments from other institutions. The most obvious inequalities highlighted in the work are gender and economic inequalities of opportunity freedom of traveling and mood. Females and poor people experience less opportunity freedom. Although transportation and land use planning solutions can alleviate some of inequalities, other policy areas should play a complementary role in targeting the inequality of mobility capabilities.

5.3 Capabilities and Transportation: Future Research Directions

The application of the CA opens new directions for future transportation research. The empirical work presented here was illustrative and only an initial foray into the use of CA in transportation studies. As I have discussed in the body of the work, measuring capabilities is challenging, as even Sen's own work to operationalize the Capabilities Approach demonstrates. The measurement, definition, and delimitation of concepts are all difficult. This application in transportation was no different. The five domains of capabilities in transportation simultaneously are conceptually difficult and standard measures are not available. One difficulty is associated with the issue of adaptive preference, in which people who are in disadvantaged situations have adjusted their expectations and adapted their preferences correspondingly. The issues of adaptive preference may make the self-report measures of choices or other subjective experiences invalid (i.e., self reports may not reflect the extent of their actual disadvantage) (Nussbaum, 2011). How could people who get used to poor quality of transit service know they are missing out on potentially better services? A comparison between objective evaluations from researchers and subjective self-report evaluations from research subjects could inform the adapt preference issue. Future research is needed to develop general measures of five domains of mobility capabilities.

Additional attempts to measure capabilities of some targeted groups would shed light on the feasibility of measuring mobility capabilities. The empirical work in chapter 2 is an example of the kind of research needed to better understand the potential contributions of the capabilities approach. For people living in low-car ownership households, the potential of using alternative options could partially reflect their mobility capabilities, as they need to share the only household vehicle. The measure could be more applicable for measuring mobility capabilities for carless people. This type of exploration may require new survey instruments specifically designed to accommodate and measure the characteristics of CA. For example, the question now asked in the NHTS is: "If you were unable to use your household vehicle(s), which of the following options would be available to you to get you from place to place?" This question is contingent on access to a household vehicle; it ignores the important group of carless people. The survey questions could be further refined to better reflect the five domains of mobility capabilities. For example, respondents could be asked to evaluate their feasibility of using a specific mode (such as transit) on a Likert-type scale of 0 to 10 and to rate their perceptions and satisfaction about specific modes even if they do not actually use them. These types of questions could be customized for carless people and low-car ownership people. Future studies of different groups could have their specific designs of survey questions tailored to their circumstances. The idea is that traditional travel surveys or diaries – including those digital programs like Daynamica used in this research – could not only record the actual behavioral outcomes but also the potential of traveling relevant to the five domains.

CA emphasizes the agency freedom people have to exercise their choices within constraints. A limitation of the empirical studies in this dissertation is the failure to analyze measures of the agency freedom. Adoption of qualitative ethnographical methods would be helpful to explore the how different groups of people or a specific group of people accommodate their mobility capability constraints.

Applications of CA often lack explicit consideration of temporal aspects. An ideal empirical approach of applying the CA requires the use of longitudinal data that records

resources, mobility capabilities and outcomes over time. A person's conversion factors, choices, decision-making processes and responses to circumstances could vary over time. Inequalities over time could aggregate inequalities. In the work, I mainly use cross-sectional data, which is the major limitation of the applications in the work. Future work should address this limitation.

Bibliography:

Alkire, S. (2005). Valuing freedoms: Sen's capability approach and poverty reduction. Oxford University Press on Demand.

Abou-Zeid, M., and M. Ben-Akiva. (2011). "The Effect of Social Comparisons on Commute Well-Being." Transportation Research Part A: Policy and Practice 45: 345–361

Archer, M., Paleti, R., Konduri, K. C., Pendyala, R. M., & Bhat, C. R. (2013). Modeling the connection between activity-travel patterns and subjective well-being. Transportation Research Record, 2382(1), 102–111.

Attoh, K. A. (2012). The Transportation Disadvantaged and the Right to the City in Syracuse, New York. Geographical Bulletin, 53(1).

Basta, C. (2015). From justice in planning toward planning for justice: A capability approach. Planning Theory, 1473095215571399. doi:10.1177/1473095215571399

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. Psychological Science, 19(12), 1207–1212. https://doi.org/10.1111/j.

Beyazit, E. (2011). Evaluating Social Justice in Transport: Lessons to be Learned from the Capability Approach. Transport Reviews, doi:10.1080/01441647.2010.504900

Blumenberg, E., Ong, P. (2001). Cars, buses, and jobs: welfare participants and employment access in Los Angeles. Transp. Res. Rec. J. Transp. Res. Board 1756, 22–31.

Blumenberg, E. (2004). En-gendering effective planning: spatial mismatch, low-income women, and transportation policy. Journal of the American Planning Association, 70(3), 269-281.

Blumenberg, E., Pierce, G. (2012). Automobile ownership and travel by the poor: evidence from the 2009 national household travel survey. Transp. Res. Rec. J. Transp. Res. Board 2320, 28–36.

Blumenberg, E., Taylor, B.D., Smart, M., Ralph, K., Wander, M., Brumbagh, S. (2012). What's Youth Got to Do with it? Exploring the Travel Behavior of Teens and Young Adults.

Blumenberg, Evelyn, Anne Brown, and Andrew Schouten.(2020). "Car-deficit households: determinants and implications for household travel in the us." Transportation 47.3: 1103-1125.

Boisjoly, G., & El-Geneidy, A. M. (2017). How to get there? A critical assessment of accessibility objectives and indicators in metropolitan transportation plans. Transport Policy, 55, 38-50.

Booth, C., & Richardson, T. (2001). Placing the public in integrated transport planning. Transport policy, 8(2), 141-149.

Cao, X., Mokhtarian, P. L., & Handy, S. L. (2007). Do changes in neighborhood characteristics lead to changes in travel behavior? A structural equations modeling approach. Transportation, 34(5), 535-556.

Chen, N., & Akar, G. (2017). How do socio-demographics and built environment affect individual accessibility based on activity space? Evidence from Greater Cleveland, Ohio. Journal of Transport and Land Use, 10(1), 477-503.

Crane, R. (2000). The influence of urban form on travel: an interpretive review. Journal of Planning literature, 15(1), 3-23.

Cresswell, T. (2006). The right to mobility: The production of mobility in the courtroom. Antipode, 38(4), 735–754. doi:10.1111/j.1467-8330.2006.00474.x
Cresswell, T. (2010). Towards a politics of mobility. Environment and Planning D: Society and Space, 28(1), 17 – 31. doi:10.1068/d11407
Dargay, J. M. (2001). The effect of income on car ownership: evidence of asymmetry. Transportation Research Part A: Policy and Practice, 35(9), 807–821. https://doi.org/10.1016/S0965-8564(00)00018-5
Davis, S. C., Williams, S. E., & Boundy, R. G. (2016). Transportation Energy Data Book, Edition 35 (No. ORNL-6992). Oak Ridge, TN: Oak Ridge National Laboratory.
Delbosc, A., and G. Currie. (2011). "Exploring the Relative Influences of Transport Disadvantage and Social Exclusion on Well-Being." Transport Policy 18: 555–562
Delbosc, A., & Currie, G. (2012). Choice and disadvantage in low-car ownership households. Transport Policy, 23, 8–14.
De Vos, J. (2018). Do people travel with their preferred travel mode? Analysing the extent of travel mode dissonance and its effect on travel satisfaction. Transportation research part A: policy and practice, 117, 261-274.
Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. Journal of personality assessment, 49(1), 71-75.
Diener, E., Lucas, R. E., & Oishi, S. (2002). Subjective well-being: The science of happiness and life satisfaction. Handbook of positive psychology, 2, 63-73.
Ettema, D., Gärling, T., Eriksson, L., Friman, M., Olsson, L. E., & Fujii, S. (2011). Satisfaction with travel and subjective well-being: Development and test of a measurement tool. Transportation Research Part F: Traffic Psychology and Behaviour, 14(3), 167–175. https://doi.org/10.1016/j.trf.2010.11.002.
Ettema, D., Friman, M., Gärling, T., Olsson, L. E., & Fujii, S. (2012). How in-vehicle activities affect work commuters' satisfaction with public transport. Journal ofTransport Geography, 24, 215–222. https://doi.org/10.1016/j.jtrangeo.2012.01.023.
Ettema, D., Friman, M., Olsson, L. E., & Gärling, T. (2017). Season and weather effects on travel-related mood and travel satisfaction. Frontiers in Psychology, 8(140), https://doi.org/10.3389/fpsyg.2017.00140
Ewing, R., Cervero, R.: Travel and the built environment. J. Am. Plan. Assoc. 76(3), 265–294 (2010)
Fainstein, S. S. (2010). The just city. Ithaca: Cornell University Press.
Fan, Y., Das, K. V., & Chen, Q. (2011). Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact. Health & Place, 17(6), 1202–1211.
Fan, Y. (2017). Household structure and gender differences in travel time: spouse/partner presence, parenthood, and breadwinner status. Transportation, 44(2), 271–291. https://doi.org/10.1007/s11116-015-9637-7
Fan, Y., Brown, R., Das, K., & Wolfson, J. (2019). Understanding trip happiness using smartphone-based data: the effects of trip-and person-level characteristics. Transport Findings.
Flamm, M., & Kaufmann, V. (2006). Operationalising the concept of motility: a qualitative study. Mobilities, 1(2), 167-189.

Fraser, N. (1995). Recognition or Redistribution? A Critical Reading of Iris Young's Justice and the Politics of Difference*. Journal of Political Philosophy, 3(2), 166–180. doi:10.1111/j.1467-9760.1995.tb00033

Giuliano, G. (2003). Travel, location and race/ethnicity. Transportation Research Part A: Policy and Practice, 37(4), 351-372.

Giuliano, G., & Dargay, J. (2006). Car ownership, travel and land use: a comparison of the US and Great Britain. Transportation Research Part A: Policy and Practice, 40(2), 106–124.

Giuliano, G. (2009). Her money or her time: a gendered view of contemporary transport policy. In: Herbel, S., Gaines, D. (eds.) Women's Issues in Transportation: Summary of the 4th International Conference. Conference Overview and Plenary Papers, vol. 1, pp. 78–93. Washington, DC: Transportation Research Board

Goulias, K.G., Ravulaparthy, S., Polydoropoulou, A., Yoon, S.Y. (2013).An exploratory analysis of the time-of-day dynamics of episodic hedonic value of activities and travel. Paper presented at 92nd Annual Meeting of Transportation Research Board, Washington, DC

Grengs, J. (2010). Job accessibility and the modal mismatch in Detroit. J. Transp. Geogr. 18 (1), 42–54.

Grengs, J. (2015). Nonwork accessibility as a social equity indicator. International Journal of Sustainable Transportation, 9(1), 1-14.

Hägerstrand, T. (1966). Aspects of the spatial structure of social communication and the diffusion of information. In Papers of the Regional Science Association (Vol. 16, No. 1, pp. 27-42). Springer-Verlag.

Hananel, R., & Berechman, J. (2016). Justice and transportation decision-making: The capabilities approach. Transport Policy, 49, 78-85.

Hankey, S., Lindsey, G., & Marshall, J. D. (2016). Population-level exposure to particulate air pollution during active travel: Planning for low-exposure, health-promoting cities. Environmental Health Perspectives, 125(4), 527–534

Hanly, M., & Dargay, J. M. (2000). Car ownership in Great Britain: Panel data analysis. Transportation Research Record, 1718(1), 83-89.

Hansen, W. G. (1959). How accessibility shapes land use. Journal of the American Institute of planners, 25(2), 73-76.

Harvey, D. (2009). Cosmopolitanism and the Geographies of Freedom. Columbia University Press.

Higgins, C. D., Sweet, M. N., & Kanaroglou, P. S. (2018). All minutes are not equal: Travel time and the effects of congestion on commute satisfaction in Canadian cities. Transportation, 45(5), 1249–1268.

Hiscock, R., Macintyre, S., Kearns, A., & Ellaway, A. (2002). Means of transport and ontological security: Do cars provide psycho-social benefits to their users?. Transportation Research Part D: Transport and Environment, 7(2), 119-135.

Kahneman, D. (1999). "Objective Happiness." In Well-Being: The Foundations of Hedonic Psychology, edi- ted by D. Kahneman, E. Diener, and N. Schwarz, 3–25. Washington, DC: Russel Sage Foundation.

Kahneman, D., and B. Krueger. (2006). "Developments in the Measurement of Subjective Well-being." The Journal ofEconomic Perspectives 20 (3): 3–24.

Kain, J. H., & Persky, J. J. (1969). Alternatives to the gilded ghetto. The Public Interest, 14, 74.
Karlström, A., & Franklin, J. P. (2009). Behavioral adjustments and equity effects of congestion pricing: Analysis of morning commutes during the Stockholm Trial. Transportation Research Part A: Policy and Practice, 43(3), 283-296.
Kaufmann, V., Bergman, M. M., & Joye, D. (2004). Motility: mobility as capital. International journal of urban and regional research, 28(4), 745-756.
Kim, S., & Ulfarsson, G. F. (2004). Travel mode choice of the elderly: effects of personal, household, neighborhood, and trip characteristics. Transportation Research Record, 1894(1), 117-126.
Kronlid, D. 2008. "Mobility as Capability." In Gendered Mobility, edited by T. Priya Uteng and T. Cresswell, 15–34. Aldershot: Ashgate.
Lancée, S., Veenhoven, R., & Burger, M. (2017). Mood during commute in the Netherlands: What way of travel feels best for what kind of people?. Transportation Research Part A: Policy and Practice, 104, 195-208.
Litman, T. (2002). Evaluating transportation equity. World Transport Policy & Practice, 8(2), 50-65.
Lucas, K. (2006). Providing transport for social inclusion within a framework for environmental justice in the UK. Transportation Research Part A: Policy and Practice, 40(10), 801-809.
Lucas, K. (2012). Transport and social exclusion: Where are we now? Transport Policy, 20, 105–113. doi:10.1016/j.tranpol.2012.01.013
Lucas, K., Bates, J., Moore, J., & Carrasco, J. A. (2016a). Modelling the relationship between travel behaviours and social disadvantage. Transportation Research Part A: Policy and Practice, 85, 157-173.
Lucas, K., Van Wee, B., & Maat, K. (2016b). A method to evaluate equitable accessibility: combining ethical theories and accessibility-based approaches. Transportation, 43(3), 473-490.
Martens, K. (2011). Substance precedes methodology: on cost–benefit analysis and equity. Transportation, 38(6), 959–974. doi:10.1007/s11116-011-9372-7
Martens, K. (2012). Justice in transport as justice in accessibility: applying Walzer's 'Spheres of Justice' to the transport sector. Transportation, 39(6), 1035–1053. doi:10.1007/s11116-012-9388-7
Martens, K., & Golub, A. (2012). A justice-theoretic exploration of accessibility measures. In K. Geurs, K. J. Krizek, A. Reggiani, & Network on European Communications and Transport Activity Research (Eds.), Accessibility analysis and transport planning : challenges for Europe and North America (pp. 195–210). Cheltenham: Edward Elgar.
Martens, K., Golub, A., & Robinson, G. (2012). A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States. Transportation Research Part A: Policy and Practice, 46(4), 684–695. doi:10.1016/j.tra.2012.01.004
Maruyama, G. M. (1997). Basics of structural equation modeling. sage publications.
Mokhtarian, P. L., & Salomon, I. (2001). How derived is the demand for travel? Some conceptual and measurement considerations. Transportation Research Part A, 35(8), 695–719. http://dx.doi.org/10.1016/S0965-8564(00)00013-6

Morris, E. A., & Guerra, E. (2015). Mood and mode: Does how we travel affect how we feel? Transportation, 42(1), 25–43. http://dx.doi.org/10.1007/s11116- 014-9521-x.
Mattioli, G., Anable, J., & Vrotsou, K. (2016). Car dependent practices: Findings from a sequence pattern mining study of UK time use data. Transportation Research Part A: Policy and Practice, 89, 56-72.
National Household Travel Survey, 2017
Nordbakke, S., & Schwanen, T. (2014). Well-being and mobility: A theoretical framework and literature review focusing on older people. Mobilities, 9(1), 104-129.
Nussbaum, M., & Sen, A. (Eds.). (1993). The quality of life. Clarendon Press.
Nussbaum, M. C., & Glover, J. (Eds.). (1995). Women, culture, and development: A study of human capabilities. Oxford University Press.
Nussbaum, M. C. (2011). Creating Capabilities: The Human Development Approach. Cambridge, MA: The Belknap Press of Harvard University Press
Olsson, L. E., Gärling, T., Ettema, D., Friman, M., & Fujii, S. (2013). Happiness and satisfaction with work commute. Social Indicators Research, 111(1), 255–263. http://dx.doi.org/10.1007/s11205-012-0003-2.
Ong, P., & Blumenberg, E. (1998). Job access, commute and travel burden among welfare recipients. Urban Studies, 35(1), 77-93.
Pereira, R. H. M., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. Transport Reviews, 37(2), 170–191. doi:10.1080/01441647.2016.1257660
Pucher, J., & Renne, J. L. (2003). Socioeconomics of urban travel. Evidence from the 2001 NHTS.
Robeyns, I. (2005). The Capability Approach: a theoretical survey. Journal of Human Development, 6(1), 93–117. doi:10.1080/146498805200034266
Ryan, J., Wretstrand, A., & Schmidt, S. M. (2015). Exploring public transport as an element of older persons' mobility: A Capability Approach perspective. Journal of Transport Geography, 48, 105–114. doi:10.1016/j.jtrangeo.2015.08.016
Schwanen, T., & Kwan, M. P. (2008). The Internet, mobile phone and space-time constraints. Geoforum, 39(3), 1362-1377.
Schwanen, T. (2011). Car use and gender: the case of dual-earner families in Utrecht, The Netherlands. Auto motives: Understanding car use behaviours, 151-171.
Schwanen, T., and F. Ziegler. (2011). "Wellbeing, Independence and Mobility." Ageing and Society 31: 719–733.
Schwanen, T., & Atkinson, S. (2015). Geographies of wellbeing: An introduction. The Geographical Journal, 181(2), 98-101.
Scheiner, J., & Holz-Rau, C. (2017). Women's complex daily lives: a gendered look at trip chaining and activity pattern entropy in Germany. Transportation, 44(1), 117-138.
Sen, A. (1979). Equality of what? The Tanner Lectures on Human Values, 1, 353–369.
Sen, A. (1999). Development as freedom. New York: Anchor books.
Sen, A. (2005). Human Rights and Capabilities. Journal of Human Development, 6(2), 151– 166. doi:10.1080/14649880500120491
Sen, A. (2009). The idea of justice. Cambridge, Mass: Belknap Press of Harvard Univ. Press. Serebrisky,Urry, J. 2007. Mobilities. Cambridge: Polity Press.

Smith, N., Hirsch, D., & Davis, A. (2012). Accessibility and capability: the minimum transport needs and costs of rural households. Journal of Transport Geography, 21, 93-101.
Soja, E. W. (2010). Cities and states in geohistory. Theory and Society, 39(3-4), 361-376.
Stigsdotter, U. K., Corazon, S. S., Sidenius, U., Kristiansen, J., & Grahn, P. (2017). It is not all bad for the grey city–A crossover study on physiological and psychological re- storation in a forest and an urban environment. Health & Place, 46, 145–154
Welch, T. F., & Mishra, S. (2013). A measure of equity for public transit connectivity. Journal of Transport Geography, 33, 29-41.
Van Wee, B., & Roeser, S. (2013). Ethical theories and the cost–benefit analysis-based ex ante evaluation of transport policies and plans. Transport reviews, 33(6), 743-760.
Van Acker, V., Witlox, F.: Car ownership as a mediating variable in car travel behaviour research using a structural equation modelling approach to identify its dual relationship. J. Transp. Geogr. 18(1), 65–74 (2010)
Veenhoven, R. (2010). Capability and happiness: Conceptual difference and reality links. The Journal of Socio-Economics, 39(3), 344-350.
Vance, C., & Hedel, R. (2007). The impact of urban form on automobile travel: disentangling causation from correlation. Transportation, 34(5), 575–588. https://doi.org/10.1007/s11116-007- 9128-6
Uteng, T. P., & Cresswell, T. (2008). Gendered mobilities. Aldershot: Ashgate.
Wang, J., & Lindsey, G. (2017). Equity of bikeway distribution in Minneapolis, Minnesota. Transportation research record, 2605(1), 18-31.
Walzer, M. (1983). Spheres of justice : a defense of pluralism and equality. New York: Basic Books
Welch, T. F. (2013). Equity in transport: The distribution of transit access and connectivity among affordable housing units. Transport Policy, 30, 283–293. doi:10.1016/j.tranpol.2013.09.020
Young, I. M. (1990). Justice and the Politics of Difference. Princeton University Press.
Ziegler, F., & Schwanen, T. (2011). 'I like to go out to be energised by different people': an exploratory analysis of mobility and wellbeing in later life. Ageing and Society, 31(5).
Zhu, J., & Fan, Y. (2018). Daily travel behavior and emotional well-being: Effects of trip mode, duration, purpose, and companionship. Transportation Research Part A: Policy and Practice, 118, 360-373.