ASSESSING THE ‘BLACK BOX’ OF TRANSPORTATION MODELING: MAKING EVERYDAY TRAVEL EXPERIENCE MATTER

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Abstract

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The black-boxing of contested knowledge into a transportation model is a process of establishing validity, thus dominance, over issues such as determining future transportation needs. Considering that the use of modeling and public participation are two of the most fundamental elements in long-term regional transportation planning, the black-boxing of issues into the transport model presents challenges for inclusion of public input. This dissertation discusses how the transportation modeling process is a discursive practice—wherein its assumptions produce outcomes—as shown in the disparity in participants' travel experiences. Understanding the transportation modeling process as a discursive practice, and identifying resistances to disciplinary power in everyday practices, provide potential praxis for inclusive transportation planning process and outcomes. Public outreach and engagement efforts can focus more on making everyday travel experiences matter rather than insisting on public meetings. Additionally, alternative data collection method can be used in the co-production of knowledge about future transport needs rather than inhibit meaningful participation.

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Chapter 1

TOWARD AN INCLUSIVE TRANSPORTATION PLANNING: PROCESS AND OUTCOME

1.1. Problem Statement and Scope

As an essential infrastructure for a metropolitan region, the transportation network not only provides mobility from one destination to another but also accessibility to opportunities in those places. Access to both the transportation network as well as to socio-economic opportunities is an essential part of daily urban life. Because transportation demand is derived from the need to travel from one place to another (Ortúzar S. and Willumsen 2011), lack of access to transportation networks affects access to employment, education and other important activities.

Recognition of the significant impacts of transportation to urban life led to the emergence of transportation planning as its own discipline in the 1950's, at the peak of heavy reliance on scientific knowledge and the application of microeconomics in the planning field (Kane and Del Mistro 2003). It was not until the 1960s that transportation planning and policies began to address the needs of disadvantaged populations, particularly those categorized as lower-income population groups (Bullard 1997; Sanchez 2008). The destructions of the inner city neighborhoods have been attributed, in part, to constructions of highways that separate lower-income communities in these neighborhoods (M. D. Meyer 2000; M. Meyer 2001; Jacobs 1992). The disconnect between transportation and land use planning also contributes to problems such as spatial mismatch between the location of jobs with workers, and urban sprawl (Wassmer 2008). According to Blumenberg and Manville (2004), jobs and lower-income population are more dispersed in sprawling urban areas, therefore, perpetuate "a modal mismatch"

(186) that widens the gap to socio-economic opportunities between between those who have access to cars and those who do not.

Critiques to address transportation exclusion typically have two different orientations: the lack of equity considerations in existing quantitative analysis and modeling methods; and the theoretical assumptions of transportation planning practices (Kane and Del Mistro 2003). The first approach typically leads to quantification of equity and to improve the modeling techniques (Sanchez 1998; Murray and Davis 2001; Martens, Golub, and Robinson 2012; Duvarci and Yigitcanlar 2007). The second approach addresses the underlying assumptions of methodological individualism and dominance of positivism that are central to the epistemology of transportation planning (e.g. Kane and Del Mistro 2003; Willson 2001; Hine and Mitchell 2001; Sheller 2008; Timms 2008). These different approaches signify ongoing debate about the importance of planning processes vs. outcomes. At the heart of this debate is the various meanings of what constitute as justice (Young 1990) and inclusion, not only as consideration of marginalized population and public participation but also as the ability to engage in the co-production of plans, programs, and policies (Quick and Feldman 2011). Therefore, inclusive transportation planning in both process and outcomes need to make explicit the connections between unequal distribution of transportation benefits with the production of knowledge about transportation needs in the decision-making process.

Federal legislation and mandates, beginning with the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), emphasize the need to incorporate accessibility, environmental impacts, equity, public participation and land use growth and management into all federal programs and policies (Sanchez 2008; Khisty 2000; Feitelson 2002). These policies also provide legitimacy for marginalized communities to participate in the decision-making process. Despite these directions to incorporate the

above goals and public participation, most transportation planning practices continue to be dominated by what Owens (1995) calls the 'Predict and Provide' approach. The 'Predict and Provide' approach uses instrumental rationality, the utilization of scientific knowledge and technology to inform decision makers to inform the decision-making process. In the 'Predict and Provide' approach, transportation planners assume the role of technical experts that use a series of analytical steps and computer modeling to predict future transportation needs (R. Wilson 2001; Khisty and Arslan 2005; Owens 1995).

Although the extent of the role of transportation models in policy decision-making process depends on the planning's institutional context (Hatzopoulou and Miller 2009), transportation model is widely used in regional transportation planning process. Metropolitan Planning Organizations (MPOs) coordinate transportation planning and projects in the United States. Most MPOs employ either the traditional Four-Step model or other types of transportation models in their regional transportation planning (Transportation Research Board 2007). Since modeling continues to be an essential tool for long-term regional transportation planning in the United States, there is a need to understand how knowledge is produced in the transportation modeling's process , and the ways knowledge about future transportation needs are presented in the transportation planning and decision-making processes.

The Four-Step transportation model uses a set of assumptions on travel behavior based on socio-demographic data. The outputs of this process forecast how future travel demands—in the form of number of trips distributed amongst a set of travel modes—are going to affect the capacities of existing transportation infrastructures (Ortúzar S. and Willumsen 2011). Contested issues in transportation, of who-gets-what-when-and-where, are black-boxed into a series of quantitative analysis and computer programming. The term black-box typically refers to a complex mechanism or set of commands where only

the input and output are known, while the process itself remains hidden (Latour and Woolgar 1986). The transportation modeling process is carried out in the manner of a black-box to process information about transportation needs. Latour and Woolgar (1986) argue that the process of "black-boxing" simultaneously determines what knowledge is valid and discourages alternative knowledge by increasing the costs of producing knowledge. In this sense, the dominant discourse in transportation planning utilizes the transportation modeling process as a black box where potentially contested knowledge about the distribution of transportation benefits is settled based on mathematical equations and computer programming. Consequently, the transportation model's outputs mostly go unchallenged because the cost of doing so is too high, particularly for those with limited resources.

Most transportation planning agencies that use the traditional Four-Step transportation model rely somewhat on the model to make informed transportation decisions but still use planners intuition to enhance the decisions (Hatzopoulou and Miller 2009). However, agencies that use more complicated models have higher confidence in the modeling result and rely more on the models. Agencies that resist the transportation model as an analytical tool to support decision-making see transportation decisions as "societal choices" (Hatzopoulou and Miller 2009, 333). Others situate the modeling process as part of a communicative process where the model's outputs can be used together with other forms of knowing in a collaborative and deliberative planning process, emphasizing on the need for meaningful public participation in transportation planning (Willson, Payne, and Smith 2003; Khisty and Arslan 2005).

Knowledge about transportation needs is affected by planners' and modelers' understandings about travel behavior of the targeted population and relationships with the existing built environment and transportation system (Ortúzar S. and Willumsen

2011). These understandings of how the world works are called “world views” (Timms 2008, 406). “World views” can be seen as grounded in the historical context that produces them, with narratives that frame and guide individual actions (Foucault 1980). Changes to these practices need to be localized and can only be done through an in-depth case study with a highly contextualized inquiry (Foucault 1980; Fischler 2000). The deliberate emphasis on rationality, or at least, the ability to provide a rationalization, is a mechanism of coercive power in the decision-making process (Flyvbjerg 1998). A variety of stakeholders benefits from giving legitimacy to forecasts as “objective, scientific statements”, rather than as political arguments for a particular position (Klosterman 2013). Therefore, there is a need to investigate how transportation planning and modeling practices can be understood as a discursive practice and could become inclusive in the face of powerful interests. Additionally, more research is needed to understand the interactions between planners with modelers engaged in the transportation planning and modeling process.

1.2. Purpose and Contribution

This dissertation investigates the transportation planning and modeling process in the Dallas Fort-Worth (DFW) Metropolitan Area to answer the following research questions: How do understandings of various communities and residents’ transportation needs get produced and incorporated into transportation planning, modeling and policy-making process?; and how do these understandings affect the transportation planning process and outcomes? To do so, the dissertation is organized around the following detailed objectives:

- to investigate how historical contexts and directions of transportation policies in the United States influence planning and modeling practices;

- to demonstrate what knowledge dominates the transportation planning and modeling process;
- to explore the implications of discursive experts knowledge (e.g. transportation model) on the everyday travel experiences;
- to investigate whether or how inclusion of alternative knowledge is considered in the existing planning and modeling practices; and,
- to delineate ways for mutual learning between experts and experience-based knowledge into the transportation planning and modeling process.

Chapter 2 discusses the historical frameworks in which transportation policies shape the narratives in planning practices and decision-making practices. This chapter provides a genealogy of transportation planning and policy in the U.S by identifying how federal policies influence the notion of inclusion and the paradigm developments in transportation planning. According to Foucault (1980), a genealogy functions to uncover "historical knowledge of struggles"(81) by identifying how these other kinds of knowledges are suppressed by the dominant discourse. Similarly, a historical analysis of scientific knowledge situates the historical integrity of science in its own time (Kuhn 1970).

When I discuss paradigm development in transportation planning, I follow Kuhn's definition of paradigm as a set of theories that guides how planners practice planning to show how alternative sets of theories often invoke resistance from the existing practitioners. When I discuss discourse in transportation planning, I refer to how the narratives of an established normal science or dominant paradigm are embedded into the practice of everyday life. Hence, planners and modelers are no longer conscious that their disciplinary training affects how they understand and make decisions about

transportation needs. In a larger context, people make decisions about their daily travel as part of a routine rather than, in part, as a consequence of a variety of constraints imposed by the existing land and transportation built-environment as well as societal conditions.

Chapter 3 discusses the methodological frameworks used in this dissertation. The research uses case study as a methodology to conduct in-depth inquiries required by the objectives previously stated, mainly to make explicit connections between transportation and modeling practices with implications for everyday life. Although the transportation modeling process often outlines the limitations of the assumptions and errors associated with the models (Ortúzar S. and Willumsen 2011), there is limited discussion of how these assumptions compare to the everyday travel experiences of the targeted population. Mixed-methods of discourse analysis and spatial analysis in GIS are used to analyze data collected from travel diaries, photographs, semi-structured interviews, and planning documents. Other works have been conducted to explore travel experiences of particular population groups in their spatial context (e.g. Wiehe et al. 2008; Rogalsky 2010; Casas, Horner, and Weber 2009; Division 1997). This dissertation makes the connections between transport exclusion and discursive practices that produce spatial layouts that have disciplinary effects on daily travel experiences.

The findings of the research in Chapter 4 place a particular emphasis on critiques of the underlying assumptions used in the Trip Generation and Mode-Choice stage of the Four-Step transportation modeling process. These underlying assumptions are juxtaposed with the everyday experiences of residents in various communities to show whether the current planning practices adequately represent the needs of these communities. Thus, Chapter 4 makes explicit how the transportation modeling process is

a discursive practice wherein its underlying assumptions produce outcomes that constrain and may not meet the needs of everyday travel.

Chapter 5 focusses on how planning officials at the North Central Texas Council Of Governments (NCTCOG) can use information from everyday travel experiences to gain insights into ways that the planning process can be inclusive to produce more equitable outcomes. One contribution of this dissertation is to reassess existing practices and make explicit its implications on the daily lives of people. The assessment of the quantitative analysis and mathematical equations used in the Four-Step transportation model is beyond the scope of this dissertation. Works to improve the transportation modeling structure stem from critiques on the accuracy of forecasting capabilities of the the model (Zhao and Kockelman 2002; Duthie et al. 2010; Flyvbjerg, Skamris Holm, and Buhl 2005). Many other works have been conducted in this regard (see Martens 2006; Duvarci and Yigitcanlar 2007; Zhou, Kockelman, and Lemp 2009). In this regard, I follow Klostermann's reflection on his experience after decades of works in planning and modeling:

> . . . . A model is just a vehicle for tracing through the implications of the core assumptions that are chosen independently from, and prior to, the model that implements them. When the core assumptions are valid, the choice of methodology is either secondary or obvious. (Klosterman 2013, 163)

Additionally, this dissertation contributes to the discussion of how the ability of the transportation modeling process to forecast future transportation needs and its relationship with the existing built-environment is a form of power. This power is gained from the ability to unfold the world of science and technology with policymakers and the public (Pavlovskaya 2009). At the same time, the black-boxing of transportation issues into the transportation modeling process is a form of exclusion of alternative understanding of future transportation needs.

Chapter 2

NOT-SO-NEW DIRECTIONS IN URBAN TRANSPORTATION PLANNING: A LONG ROAD TOWARD INCLUSION

This chapter investigates how narratives surrounding transportation planning and policies affect both transportation planning theories and practices; and how the policies and practices that arise out of different understandings of what transportation planning *is* and *should be,* affect inclusion in transportation modeling process and outcomes. To address these questions, this chapter is divided into four sections. The first section provides an overview of transportation planning and policies in the U.S. and implications for inclusion. The second section discusses paradigm developments and narratives that frame transportation planning policies to understand what is being said about why we need certain kinds of transportation infrastructure and facilities. Galloway & Mahayni (1977) contend that evaluating paradigm development in urban planning is useful to review the social, political, and historical contexts that give rise to the diversity of planning practices. This section aims to situate transportation planning and modeling practices as part of a discourse where these practices are normalized. The third section focuses on how different views of rationality in the planning and decision-making process affect the roles of planners. Communicative rationality is situated within the transportation discourse to understand how the knowledge about transportation needs is contested even in the transportation modeling process. The fourth section discusses the Four- Step transportation modeling process and its underlying assumptions.

2.1. Review of Historical Contexts

Demand for transportation has unique characteristics compared to other goods because it is derived from the needs of people to travel from one place of activities to another (Ortúzar S. and Willumsen 2011). Transportation has temporal and spatial characteristics. The temporal characteristic is attributed to the way time of travel influences the ease and comfort of travel as well as the costs. For example, people typically need transportation facilities and services in the peak-hour of home-work-home travel time, rather than midnight. The spatial characteristic is attributed to the way transportation investments typically spur land development and, therefore, have many implications on how people relate value to the land (see Waddell et al. 2007). The spatial nature of transportation demand adds another complexity in transportation planning due to the connections between land use and transportation planning and policies (Iacono, Levinson, and El-Geneidy 2008). Transportation improvements typically induce land development, increase land value and have significant implications on when-and-where transportation improvements should be located (Bullard 1997; Bullard 2004; Schweitzer and Valenzuela 2004; Blumenberg and Manville 2004; Forkenbrock and Schweitzer 1999). Therefore, decisions on who-gets-what-when-and-where are contested.

Additionally, transportation infrastructures are typically bulky and require expensive long-term investments. Therefore, regional transportation planning typically is conducted for future investments in 15 to 20 years range (Ortúzar S. and Willumsen 2011). Transportation facilities and their impacts also transcend jurisdictional boundaries and require regional coordination and collaborative effort (Goetz, Dempsey, and Larson 2002; Kane and Del Mistro 2003; Hatzopoulou and Miller 2009). Although transportation planning practices appear to be technical, transportation decisions are interconnected with institutional and systematic practices (Willson 2001). Problems associated with the

provision of public resources are inherently tied to the institutional context. Figure 2-1 shows a diagram of the role of Metropolitan Transportation Planning Organizations (MPO) in transportation planning. In the United State, MPOs facilitate the implementation of federal's and state's transportation policies at a local level.

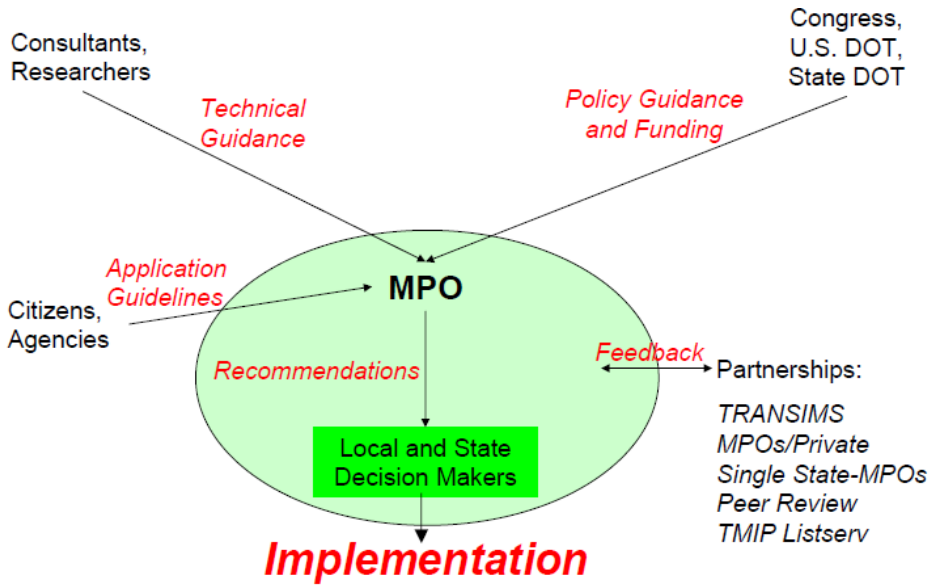


Figure 2-1 Role of the Metropolitan Planning Organization (MPO) in Transportation Decision-making (Cervenka 2006)

Transportation infrastructure has been a fundamental part of urban development and increasingly so since the Industrial Revolution of the 19th century. The vast demand to transport people and goods in subsequent decades resulted in innovations in transportation technologies. The balance between meeting the needs of the urban traveler with gaining economic benefits developed as a unique set of problems (Arnold 1911). Since then, transportation planning mainly uses the 'Predict and Provide' approach (Owens 1995). The 'Predict and Provide' refers to the planning practices that largely consist of predicting future travel demand and aims to match the forecasted demand for building more transportation infrastructures (Owens 1995; Vigar 2002).

Although there has been general agreement on the validity of methods used in transportation planning practices, the multi-dimensional problems associated with provision of transportation infrastructure and services in an urban context lead to calls for new directions in transportation planning (Dittmar, 1995; Kane & Del Mistro, 2003; Meyer, 2000; Miller, 1973; Weiner, 1982).

Similar themes continue to emerge in these calls for new directions in transportation policy and planning practices, indicating the presence of "wicked problems"–a term Rittel & Webber (1973) use for problems that involve many dimensions and cannot seem to be resolved. Urban planning practices in the 1800s involved "tame problems" with measures such as efficiency of building roads in the early industrial era because it was seen as a common good needed by society. Problems challenging transportation planning became "wicked problems" as a society became more diverse, competing for resources, particularly in urban areas. These "wicked problems" are the problems of present-day diverse society where there are inherently competing interests and inequality in the allocation of limited resources such as transportation funding. Rittel and Webber (1973) contend that the most difficult part of resolving "wicked problems" lies in the problem definition, location of the problem, and then identifying actions to the "what-is" with "what-should-be." The use of a science and engineering paradigm cannot be applied to resolve the problems of "open societal systems" (Rittel and Webber 1973, 160). Transportation planning is particularly problematic due to the heavy reliance on analytical methods, computer modeling, and engineering, widely adopted methodologies for considerations in the allocation of public funding.

According to Sanchez (2008), transportation policies that began to address the inclusion of lower income population's mobility are punctuated by the 1960s and the 1990s. Social unrest and movements in the 1960s brought attention to planners that

current practices and public policies adversely affect the lower income population. Construction of highways across cities separates neighborhoods and perpetuates the decline of the inner city (Jacobs 1992). Lack of mobility and accessibility to employment contributed to the high rate of unemployment amongst inner-city, especially, African-American population, due to the migration of manufacturing jobs to the suburbs (Wacquant and Wilson 1989). Subsequently, the mid-1960s saw the emergence of the *systems approach* that evaluated transportation infrastructures as a part of an urban system and simultaneously addressed transportation and land use issues. Inclusion was narrowly situated in a public participation stage at the end of the planning process. However, these various social movements raise questions on how transportation planning can accommodate multiple, sometimes conflicting, interests.

Transportation planners typically view decisions to resolve conflicting interests as outside of planners' operating realm and see goals as "consensual, not controversial" (Wilson, Payne, and Smith 2003, 355). If the consensual goal of transportation planning is to relieve congestion, then, a narrow and pragmatic solution such as to build more roads to improve mobility continued to be a major strategy. The lack of flexibility to incorporate various goals into the planning process is problematic especially as the Interstate Highway system neared completion in the 1990s. Consequently, transportation planners continue to face challenges to maintain existing infrastructure and mitigate negative impacts of transportation projects.

In some ways, policy changes that began in the 1990s stemmed from the completion of the Interstate Highways system (Goetz, Dempsey, and Larson 2002a). Allocations of federal funding continued to be increasingly tied to incorporation of goals such as environmental justice, equity and integrated land use-transportation planning (Kane and Del Mistro 2003; Goetz, Dempsey, and Larson 2002a; Feitelson 2002;

Amekudzi and Meyer 2006). The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 began to provide resources for transportation policies and programs for lower income population. However, the overall effectiveness of transportation policies and programs directed toward social improvements both in the 1960s and 1990s has been difficult to measure (Sanchez 2008). Approaches to incorporate the environmental and equity goals into transportation planning can be divided into efforts to improve the planning process such as adapting more advanced transportation models to the traditional Four-Step transportation model (Ortúzar S. and Willumsen 2011; Kitamura, Fuji, and Pas 1997; Iacono, Levinson, and El-Geneidy 2008); and to improve the outcomes of transportation decisions by incorporating more public participations (Goetz, Dempsey, and Larson 2002a; Bullard 1997; Bullard 2004; Khisty 2000; Schweitzer and Valenzuela 2004).

In regards to inclusion, the Environmental Justice Executive Order of 1994, TEA-21 of 1998, and the SAFETEA-LU of 2004 require public participation to be implemented in federal programs and projects. Although public participation and inclusion continues to be a challenge in many aspects of planning and policy-making, transportation remains to be one of the planning areas where public participation and collaboration continue to be elusive (see Innes and Gruber 2005). Table 2-1 shows how the emerging focus on public participation in federal policies has a dialectic impact on the implementation and outcomes of these policies. Transportation plans are increasingly viewed as programs that need to be executed and to some extent seen as a binding agreement between various stakeholders and the government (Weiner 2008).

Table 2-1 Federal Policies and Implications for Inclusion

Timeline	Milestones in Federal Policies	Inclusion in transportation planning
Late 1800s-early 1900s	The Federal Highway Act of 1921- focus on connecting urban centers up to the 1930s.	Transportation as public expenditure to transport labor and goods.
1900s - mid 1950s	The establishment of the American Association of State Highways Officials (AASHTO) in 1914, leads to standardized highway and road designs.	The AASHTO's design standards for highways and roads result in "Questions of setting, context or community are treated as exceptions or anomalies" (Dittmar 1995, 8).
1950s- early 1960s	The Interstate Highway Act of 1956 and the Federal Highway Trust Funds allocates funds only for highways.	Federal support for large-scale transportation studies on regional highway networks with emphasis on cost-benefit analysis (Weiner, 2008); The Four-Step Model. Critiques of constructions of highways in inner cities (e.g. Jacobs 1961).
1960s-early 1970s	Formation of the Departments of Transportations (DOTs) in 1966 reorganizes the state and local governments' transportation projects.	States are required to have an inventory of their transportation network and more involvement in transportation planning analysis (Miller 1973). High documentation by federal reinforces the legitimacy of the technician (Innes and Gruber 2005). Critiques on large-scale modeling (Lee 1973).
1970s- early 1990s	The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) emphasizes on transportation-land use connections.	Funding resources are limited to mainly highways and airports, therefore, limit the capabilities of state and local to allocate funding to other modes such as mass transit (Miller 1973
1990s-present ?	EJ Executive Order of 12898 in 1994. Transportation Equity Act for the 21st Century (TEA-21) of 1998. Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005	EJ provides legitimacy for marginalized communities (Rast). SAFETEA-LU of 2005 required the use visualization techniques for stakeholders and public participation process for long-range transportation plans. Increasing emphasis on public participation results in more buy-ins from stakeholders (Weiner 2008). Possibilities of Communicative rationality (Willson 2001; Khisty and Arslan 2005; Timms 2008)

Nevertheless, public participation is mostly treated as a separate step in the planning process rather than as a continuous reiteration throughout the planning process (Khisty 2000). Although community participation in transportation planning has increased since planning in the 1960s, the participation does not go beyond providing input on goals and reaction to "alternatives that reflect predetermined issue frames" (Wilson et.al. 2003, 355). The next section reviews paradigm development in transportation planning and the narratives that influence planning practices; and why, in spite of requirements to incorporate public participation in federal transportation policies, knowledge about transportation needs is one that is contested.

2.2. Discourses and the Process of Paradigm Change in Transportation Planning

A discourse frames what is “truth” according to its historical and cultural context; and it is the discourse that produces knowledge (Foucault 1980). Meanings are communicated, appropriated and re-appropriated by people under the influence of the dominant discourse (Hall 1999). Subjugated or disqualified knowledge is considered meaningless to the production of knowledge if it does not conform to the norms and disciplines of the established “regime of truth” (Hall 2003, 49). Therefore, a discourse also produces the subject within that knowledge and “the place for the subject” (Hall 2003, 56). In this case, a transportation discourse articulates disciplinary practices that simultaneously produce those engaged in these practices—e.g.planners, modelers—and the institutions wherein they carry out these practices. According to Healey (1997), an institutionalized discourse becomes powerful and able to gain legitimacy to ignore other evidence, values and claims in the policy agenda. “In this way issues can become ‘black-boxed’ and the assumptions that underpin a particular practice are rarely challenged” (Vigar, 2011, 27). These planning practices are institutionalized into the transportation discourse once the narratives of an established normal guide actions in daily life.

Kuhn (1962) argues that challenges to normal science, occur when there are punctuations in history or “anomalies” that cannot be explained by the dominant paradigm. These ‘anomalies’ are similar to what Foucault (1980) calls the “subjugated knowledges” in a discourse (81). These anomalies—the subjugated knowledges—are present throughout the paradigm stages but appear more so in the Paradigm Anomaly stage when the current social and political context draws more attention to these anomalies.

Foucault (1980) highlights the various ways power is exercised to subjugate alternative knowledge through subtle regulations on individuals’ behavior or actions in their daily lives. The discussion of power is central to policymaking because power relations determine who makes decisions, when and how decisions are made, which represents *the first face of power*; whether decisions are not made which represents *the second face of power* (Bachrach and Baratz, 1962); or even when problems are kept from the policy agenda by institutional and systematic practices that represent *the third face of power* (Lukes, 2004). Power can be exercised not only by making a decision on an issue but also by institutional practices that discourage conflict and decision-making. For example, local public meetings can be structured and organized in a way that discourages meaningful public participation. Public meetings might be scheduled on weekdays thus leaving out single working mothers on a second job, and only those who have capital investments, typically property owners, are present. Luke’s (2004) third face of power represents how analytical methods may be seen as normal practices if conformed to the dominant paradigm. The suppression of other kinds of knowledge occurs simultaneously with preference to use these methodologies over others. Similarly, Foucault (1980) argues that power operates in a net-like behavior that is exercised

through subtle ways of institutional practices to subjugate the way people behave in their everyday lives.

Galloway and Mahayni (1977) summarize Kuhn's evolution of scientific development into the following stages: Pre-paradigm, Paradigm Development, Paradigm Articulation, Paradigm Anomaly, and Paradigm Crisis. The process of paradigm change begins with the Pre-paradigm stage in which debates on what is considered "true" occur. The Paradigm Development stage involves coalescence of knowledge where the majority of the scientific community begins to agree on what is considered "knowledge" and becomes a standard for future knowledge. It is in this stage that boundaries between knowledge begin to be drawn, giving birth to discipline. The Paradigm Articulation stage involves the formation of boundaries into a "body of knowledge" through the writing of textbooks and teachings. These activities attempt to remove historical knowledge of what was considered "false" by the dominant paradigm. The Anomaly stage occurs when there are phenomena that cannot be understood by the existing dominant paradigm. When attempts to resolve an anomaly fail, the presence of these anomalies supported by changes in social and political structures mark the Paradigm Crisis and begin the shift toward alternative paradigms.

Although Kuhn (1970) presents the process of paradigm change in stages, it is important to note the process of the paradigm is not meant as a linear process. Central to Kuhn's critique is how the dominant paradigm finds mechanisms, such as circulation of textbooks, to make it appear as though knowledge accumulates in a linear fashion in which innovations happened by building on previous knowledge. According to Kuhn (1970), a new theory is not just an increment built upon previous knowledge, but assimilation of new theories which require "the reconstruction of prior theory and the re-evaluation of prior fact" (p.7) that are not accomplished by a single person or overnight. In

other words, new theories appear when people ask questions that need to be asked within an organically developing time frame, and look back to those that were considered “anomalies.” Once a certain kind of knowledge starts to be seen as more true than other knowledge , and becomes a dominant paradigm, other kinds of knowledge are suppressed from the discourse using various mechanisms of power (Foucault 1980).

Table 2 – 2 illustrates applications of Kuhn’s paradigm stages to urban planning and with transportation planning. Galloway and Mahayni (1977) evaluate historical contexts that give rise to paradigm development in urban planning. Their analysis is juxtaposed with reviews of transportation policies to illustrate how transportation discourses produce narratives that influence how transportation issues are framed and its consequent planning practices.

Table 2-2 Paradigm Stages of Transportation Planning and Policies

Kuhn's Paradigm stages (Galloway and Mahayni 1977)	**Transportation Planning**
Preparadigm (Late 1800s-early 1900s) • NYC Zoning Resolution (1916) • City Beautiful, Park movement	• Urban transportation as "public expenditures" to fulfill the need of the industrial revolution (Taebel and Cornehls 1977).
Paradigm Development /Coalescence of truth/knowledge (1900s - mid-1950s) • Euclid vs. Ambler (1926) • Comprehensive land use planning • American Planning Institute is formed	• Transportation shapes urban form with economic growth via public expenditures (Weiner 1982); • standardized designs for highways and roads; • transit still largely remains in private companies.
Paradigm Articulation/Indoctrination of Ideas (Mid 1950s- early 1960s) • Rational Comprehensive Planning • Entrance of social scientists • Federal programs support research and visual communication techniques.	• The "National Defense" narrative (Taebel and Cornehls 1977) • large-scale transportation studies on regional highway networks with emphasis on cost-benefit analysis (Weiner, 2008); • transportation planning as a discipline (Kane and Del Mistro); • transportation modeling and large-scale urban modeling efforts; • "Predict and Provide" (Owens 1995)
Paradigm Anomaly/ Normal Science (1960s-1970s) Civil Rights and Environmental movements Critiques of RCP and the inability to deal with social and racial problems.	• "environmental protection" competes with the "national defense" narrative (Taebel and Cornehls 1977); • System planning for a continuous, comprehensive, and coordinated planning; between federal, state and local level (Miller, 1973).
Paradigm Crisis /Anomaly Stage (1970s- early 1990s) • Comprehensive land use planning • Substantive vs. Procedural theories in planning • Changing the role of planners	• Economic development and tourism narratives combined with fiscal planning and engineering also seen as "Products of processes" (Weiner 2008, 152); • Public-private partnerships lead to tollways or even converting state highways into tollways; • Concerns about errors in forecasting techniques (Lee 1973).

Table 2.2—*Continued*

Scientific Revolution or Preparadigm (1990s-?) • Communicative rationality • Collaborative rationality • Postmodern planning • Radical planning	• "Sustainable development" narrative; • Transportation investments aligned with economic development; • States are required to have a continuous state-wide plan modeled in the metropolitan transportation planning plan; • Advanced transportation models that include environmental-air quality-and equity

The Pre-paradigm Stage in transportation planning can be traced back to the late 1800s, lasting until the early 1900s. Transportation at the time is considered as a necessary “public expenditure” to facilitate economic growth while shaping urban form (Weiner 2008). The “public expenditure” narrative implies that there was a consensus on what is considered as a problem of urban transportation. The invention of railroads, steam engines, and high-rise building structures allowed agglomeration of economies in cities and grew cities on an unprecedented scale (Bluestone 2008). The City Beautiful, Park movement, Master planning and city functional movements emerged in this era. Urban transportation complemented the physical determinism that characterized urban planning between the 1800s to the early 1900s. The underlying assumption behind these movements is that the physical environment can impose order on the social, economic, and political structures of society (Galloway and Mahayni 1977). Transportation planners were considered experts, particularly so because transportation planning became the domain of civil engineers. Provision of transportation infrastructure and services received increasing concerns along with the vast increase in the need for transporting people and goods. Roads were built to connect urban centers, although they were not necessarily interconnected with each other.

In the 1920s, federal policies and programs began to focus on connecting the roads between urban centers. The Paradigm Development stage occurs sometime between the 1920s and reaches its peak in the 1950s when Rational Comprehensive Planning and Scientific analysis become the dominant paradigm. An increase in government trusts and availability of government funding allowed for robust research and inclusion of science and technology into planning to solve social problems (Galloway and Mahayni 1977; Schneider and Ingram 1997). Planning practices rely on scientific knowledge and technology to achieve a perceived common public goal through a series

of steps and systematic analysis of alternatives (Friedmann 1971; Galloway and Mahayni 1977; C. Lindblom 1959; Schneider and Ingram 1997) . *Instrumental rationality,* which refers to the utilization of scientific knowledge and technology to inform decision makers (Schneider and Ingram 1997) underlay planning theories and practices in the 1950s. This approach borrows heavily from the neoclassical economic concept of the rational man, arguing that individuals are mostly acting in their self-interests to achieve their optimum goal (Simon 1955). Therefore, optimum solutions can be achieved by weighing the advantages versus the disadvantages of the alternatives and selecting those that benefit the most people.

The "national defense" narrative initiated by President Franklin D. Roosevelt's gained support for building a national interstate highway system in the 1950s. Transportation planning practices in this era focused on technical exercise and cost-effectiveness (Weiner 2008). Standardized designs for highways and roads rendered social and political contexts of the surrounding areas invisible. Federal policies begin to support large-scale transportation studies on regional highway networks with emphasis on cost-benefit analysis (Weiner 2008). Shared assumptions derived from Microeconomics theories underlay the "Predict and Provide" approach as it became a dominant paradigm in transportation planning. This approach focuses on predicting future economic and population growth, with the underlying assumption of transportation planning's main task is to accommodate the forecasted travel demands by providing more transportation infrastructures (Owens 1995).

Since the 1950s, the advancement of computers allowed transportation planners to use transportation modeling to visualize impacts of transportation investments on urban development. Transportation planners roles were the technocratic experts, hence the dominance of engineers in transportation planning. Institutionalization of the "Predict

and Provide" happened in the Paradigm Articulation stage with the circulation of textbooks and teachings. The 'Predict and Provide' approach was institutionalized by the government and other institutions as the dominant policy discourse (Vigar 2002). This rational scientific discourse consists of narratives such as 'roads for prosperity' and practices such as forecasting techniques and modeling procedures (Vigar 2002). This era marks the emergence of transportation planning as a discipline (Kane and Del Mistro 2003).

Social unrest and movements in 1960s brought attention to urban planners that there are population groups that are adversely affected by public policies, particularly those surrounding urban life. Planners became aware that there is no single public goal in a pluralistic society, where multiple interests cannot be reflected in a single comprehensive plan and planners are not neutral experts (Friedmann 1971). The Paradigm Anomaly stage occurred as the "national defense" narrative began to be criticized as many highways cut through inner city neighborhoods, contributing more to urban decline (Jacobs 1992). An alternative narrative of "social equity" began to surface in this era (Taebel and Cornehls 1977). The infamous war between Robert Moses and Jane Jacobs surrounding this issue illuminated the tensions that existed in both urban and transportation planning.

It was not until the 1960s-1970s that the difference in practices between urban planners and transportation planners became evident. The 1970s marked the divergence of urban planning with transportation planning. Urban planning practices operated under diverse paradigms, a shift from rational scientific planning to communicative rationality in planning practices, toward a collaborative and consensual planning process (Innes 1995; Healey 2003; Fainstein 2000; Friedmann 1996). While urban planners realized that their role in the decision making process was not value-free, transportation planning continued

to rely on rational processes and computer modeling to project demands for transportation facilities and services (Kane and Del Mistro 2003). Transportation planners' role remains as technical experts to predict future travel demands, provide technical information, and leave the political implications for decision makers (Kane and Del Mistro 2003; Khisty and Arslan 2005).

In the Paradigm Crisis stage, urban planners began to review the theory *of* planning versus theories *in* planning and how the two inform planning practices. For transportation planning, the environmental movements in the late 1960s to early 1970s were finally able to present a compelling narrative that challenges the "national defense" narrative of the Interstate Highway (Taebel and Cornehls 1977). One explanation for why the "environmental protection" narrative is a stronger challenge than the previous "social equity" narrative, is that most people would agree to the protection of the environment as a universal problem. Whereas the "social equity" narrative is seen to involve only certain population groups. Nevertheless, critiques of transportation planning practices that disregard the social, political, and environmental contexts resurfaced with vigor.

The consequent highway programs are seen as "products of processes" (Weiner 2008, 152) due to the needs framed with "economic development and tourism" narratives combined with fiscal planning and engineering (Weiner, 2008). Since then, "economic development" continues to be the narrative to support transportation investments with an emphasis on public-private partnership. The need to accommodate future travel demands are met with public-private partnerships to fund constructions of tollways or even converting state highways into tollways. Funding resources, like the Highway Trust Fund, and Airport and Airways Act of 1970 are limited to highways and airports, and thus limiting the capabilities of state and local to allocate funding to alternative modes such as public transportation (Miller 1973).

In transportation planning, the formation of Departments of Transportations (DOTs) in 1966 reorganized states' and local governments' planning efforts (Miller, 1973). By 1972, continuing comprehensive and coordinated planning became a prerequisite for MPOs that want to use UMTA funding. The biennial National Transportation Study (NTS) in 1972 focuses on data collection and analysis. Since 1974, states are required to have an inventory of their transportation network and more involvement in transportation planning analysis. Not all DOTs have mass transportation programs; however, they all have state highways as a major element in the department and responsibilities for comprehensive and state master plans (Miller, 1973).

In the late 1970s, urban and transportation planners moved in separate directions and adopted different approaches in planning methods and theory (Kane and Del Mistro 2003). The theory of *Communicative Action* developed in urban planning, drawing from Habermas' idea that social and political structure in society as a communication structure (Forester 1980; Healey 2003). Additionally, planners face forces that systematically violate Habermas' communication rule, such as private interests that benefit only some population groups, therefore communicative rationality is a skill that planners must have to ensure that the planning process does not exclude anyone (Forester, 1980). The use of communicative rationality recognizes that knowledge to make social changes is socially constructed and uses communication to achieve mutual understanding of each other without wanting to dominate the conversation (Schneider and Ingram, 1997).

Calls to reevaluate both transportation planning methodologies and theoretical assumptions mark the Paradigm Crisis stage. One of them is the shift from "Predict and Provide" toward "Predict and Prevent" approach (Owens, 1995). Central to this approach is the view that future travel demands are not only predicted but also can be influenced

by planning and policies. Additionally, concerns about errors in forecasting techniques (Lee 1973) reemphasize the need to consider alternatives to the 'Predict and Provide' approach, particularly in the U.K. (Owens 1995). The 'Predict and Prevent' approach shifts focus from Transportation System Management (TSM) to Transportation Demand Management (TDM). While TSM focuses on managing the supply side by maintaining and rehabilitating existing transportation facilities, TDM focuses on managing the demand for transportation facilities and services, including strategies to induce travel behavior changes (Weiner 1982).

The 1990s marks the beginning of the "sustainable development" narrative in transportation planning (Weiner 2008). The continuing urban growth in metropolitan areas provides more justification for transportation investments aligned with economic development. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) puts more emphasis on transportation-land use connections and consequently comprehensive planning. Consequently, states are required to have a continuous state-wide plan modeled in the metropolitan transportation planning plan. In general, transportation planning continues to be dominated by the 'Predict and Provide' approach. Transportation modeling practices include more advanced transportation models that involve environmental-air quality parameters, in addition to the development of activity-based and agent-based modeling. As previously discussed in Section 2.2., the SAFETEA-LU of 2005 required the use visualization techniques for stakeholders and public participation process for long-range transportation plans. Although public participation process is institutionalized into transportation planning, Innes and Gruber (2005) find that the culture—everyday practices—in transportation planning often hinders meaningful participation.

The significant gap in inclusive planning practices between the urban planners and the transportation planners hinges on the different understanding of the use of rationality and power relations in the planning and decision-making process. Some of the most fundamental critiques of transportation planning are related to the underlying assumptions of the reliance on instrumental rationality in the planning process (Willson 2001; Kane and Del Mistro 2003; Khisty and Arslan 2005; Timms 2008). While urban planners began to realize that their role in decision-making processes is not value-free, transportation planners continue to rely on quantitative analysis computer modeling (Kane and Del Mistro 2003).

The problem lies in the claim of objectivity as the central tenets of instrumental rationality. Many urban planners move beyond instrumental rationality and consciously decide to advocate for marginalized populations (Davidoff 1965). The planners' role is no longer seen as an expert with objective knowledge but as facilitators in a democratic or participatory planning and decision making process (Innes 1995; Healey 2003; Forester 1980; John Friedmann 1996). Meanwhile, transportation planners continue to see their role as separate from the decision-making process. The review of the paradigm stages in transportation planning in the United States since the 1800s reveals the persistence of the 'Predict and Provide' paradigm. As Willson (2001) emphasizes, "Yet in practice and research, transportation planning has followed a schizophrenic path - acknowledging problems in instrumental rationality but continuing to employ it in research, practice and teaching" (9).

2.3. Rationality in Transportation Planning

Transportation infrastructure projects are typically large-scale, long-term, require large fixed capital investments and coordination between institutions (Ortúzar S. and Willumsen 2011). Consequently, the "Predict and Provide" approach has been dominant because of its reliance on science and technology (Owens 1995; Vigar 2002; Willson 2001). Within this approach, the main objective of transportation planning is to predict future travel demands and accommodate by building infrastructures. Transportation planners assume the role of experts to predict demand and provide necessary technical information for the decision-making process (Khisty and Arslan 2005). Rationality is seen as external and only brought into the process as instrument to achieve the objectives in an ends-means process by utilizing scientific knowledge and technology to inform decision makers (Friedmann 1971; Galloway and Mahayni 1977; Anne Larason Schneider and Ingram 1997; C. Lindblom 1959). Instrumental rationality produces underlying assumptions based on methodological individualism—applying neoclassical rational economic man—in transportation planning and modeling (Timms 2008).

Critiques of instrumental rationality address the impossibility of having comprehensive knowledge and a single public interest, therefore, there are no value-free decisions even in the problem definition, data collection, and analysis stages where decisions about what gets included and excluded are made (John Friedmann 1971; C. E. Lindblom 1959). In transportation planning, the body of literature that provides outline for a shift from instrumental to communicative rationality emerges at the beginning of the twenty-first century (Khisty and Arslan 2005; Khisty 2000; Willson, Payne, and Smith 2003; Willson 2001; Timms 2008). At the heart of these critiques are the lack of inclusions—of marginalized population in the decision-making process and outcomes—due to the dominance of instrumental rationality.

Willson (2001) provides a critique of the dominance of instrumental rationality in transportation planning and argues for a paradigm shift toward communicative rationality to solve the “wicked problems” in transportation planning. *Communicative rationality* refers to the inherent ways problems and strategies are communicated in the planning process (Schneider and Ingram 1997; Forester 1980; Innes 1995)**.** His underlying argument stems from the use of language in planning practices. He asserts that although there are areas in transportation planning does require the use of modeling and quantitative analysis, the outputs should not be presented as objective findings but rather as a part of a dialogue to explore alternative approaches and plans. Willson (2001) points out that although transportation planners mostly use the language of numbers that are "unambiguous representations of reality" (1), the very definition of the problem or phenomenon that those numbers represent is inherently a social and communicative process.

The use of communicative rationality draws from critical theory’s understanding that knowledge is socially constructed and Habermas’ idea that a democratic decision-making process involves sincere, true, comprehensible, and legitimate communication process. Forester (1980) argues that planning is a communicative practice because planners operate in the social and political structures that are inherently a communication structure. In its purest form, communicative rationality argues that dialogue in an open, sincere, true, and legitimate way can result in consensus that is inherently a democratic process (Forester 1980; Innes 1995; Fischler 2000). With communicative rationality, planning practice is a process that is reflective and deliberative where the production of knowledge, disclosing of values, of assumptions, and mutual learning between experts and experience-based knowledge (Forester 1980; Innes 1995; John Friedmann 2011).

A normative communicative rationality recognizes that knowledge that can bring social changes is one that is socially constructed and uses communication to achieve mutual understanding withoutone position dominating the conversation (Schneider and Ingram 1997). These practices aim to empower citizens through acknowledging that their knowledge is as valuable as the planners' or experts' knowledge. Similari to Habermas' communicative rationality, Friedmann (1973) also focuses on overcoming barriers to communication in dialog for transactive learning—mutual learning between experts and experience-based knowledge—to happen. The dialog between planners—as those containing expert knowledge—and clients happens based on sincerity, integrity, shared interests and commitments, reciprocity and mutual obligation. Additionally those engaged in dialog must be prepared to accept conflicting interests. This process of mutual learning occurs when planners acknowledge normative claims up front, are open to criticism and the possibility of introduction different kinds of knowledge.

Planning practices based on communicative rationality have been criticized for emphasizing a democratic planning process but not necessarily on equitable outcomes (Fainstein 2010). Planners are often situated amongst political interests, forces that systematically violate Habermas' communication rule, and the lack of power of planners to make decisions or set the rules on dialogue (Fainstein 2010; Innes and Gruber 2005). The inherent inequality in society manifests in unequal power-relations when parties engage in dialog (Young 1990; Young 2004). Often decisions are already made when it reaches public hearings where options are already laid out (Fainstein 2010; Fischler 2000; Talvitie 2001; Arnstein 1969).

In summary, critiques to applications of communicative rationality are directed to the various forms of how power is exercised to exclude meaningful participation in the decision-making process. Exclusion not only takes the form of physical restraints but

also in the use of language, signs, and images that are incomprehensible to particular audiences (Arnstein 1969). In this sense, power is exercised by the various forms of practices that appears to be normal to much of those engaged in a discourse (Foucault 1980). Power is exercised through social and institutional practices that prevent the larger society from seeing injustice because they are not directly affected by the problem (Lukes 2004). Planning practices claim to be objective in making decisions about who-gets-what-when-and-where because these decisions are based on technical foundations. Similarly, requirements to use modeling techniques and public input serve the interest of these decisions.

Different approaches such as the 'Predict and Provide', the 'Price is Right' and the 'Planning Panacea' come out of different ways transportation problems are framed (Owens 1995). 'The Price is Right' approach comes out of the argument that transportation users should also pay the costs of externalities associated with private car use that includes social and environmental impacts. The 'Price is Right' approach aims to address the limited resources in providing transportation infrastructures and services. The 'Planning Panacea' approach is a response to the chicken-and-egg relationship between transportation and land use connection. The Interstate Highway system facilitates the outward expansions of urban development (Jackson 1987), but as metropolitan regions in the U.S. are increasingly fragmented, there are increasing reliance on auto and transportation infrastructures. This chicken-egg relationship between the existing built-environment and travel demand indicates that focus on, for example, modeling the 'most efficient' land use pattern relationship with transportation can be misguided (Owens 1995). In particular, because models only provide a simplified mathematical abstraction of an actual observation, and, therefore, the outputs perpetuate existing condition.

Communicative rationality that is situated in a discourse is concerned with the strategic use of language to define and frame problems when confronted with disciplinary power (Fischler 2000). Communicative rationality need not be seen as an ideal approach rather a pragmatic one when confronting with the political nature of planning (Hoch 2007). In order to do so, a pragmatic communicative action focuses on how inquiries are conducted to gain richer understanding of new relationships that emerged when problems are defined differently. Planners, as those containing the expert-based knowledge, must acknowledge that their role is not as decision makers, but as mediator working to "locate lines of weakness, strong points, positions where instances of power have secured and implanted themselves" (Foucault 1980, 62). In this way, planners deliberate on who are excluded from decisions as a consequence of the methods they used.

Community groups might utilize scientific knowledge and technical expertise to gain legitimacy when advocating their interests to change policy directions (e.g. Rast 2006; Corburn 2003). These community groups mobilized and articulated their 'local knowledge' (Corburn 2003), the 'concrete, experience-based knowledge ' (John Friedmann 2011), alternatives to the expert-based knowledge. Data and technology can be used with a bottom-up planning approach to bring policy changes in regional planning practice by producing and presenting data to gain legitimacy (Sabatier and Jenkins-Smith, 1999). This strategy represents the application of both instrumental and communicative rationality in the planning and decision-making process. Those with expert knowledge engage in a dialog, and concerns of these communities are translated into quantifiable measures and speak in the language of "science". Participation becomes inclusion when communities mobilized and articulated their grievances in a form accepted by the dominant institutions.

Latour and Woulgar (1986) show that research is “a fierce fight to *construct* reality” (243, emphasis by the authors). The construction of knowledge occurs not only through the object of research but also from daily interactions with literatures, other scholars and other sources of knowledge. The ways of gathering, selecting, analyzing and presenting information in the quantitative analysis and transportation modeling process is also a process of constructing knowledge. Thus, knowledge produced in the modeling process is not finite and can be challenged by communities who can construct alternative knowledge about their needs.

In this sense, changes can only happen if methods of inquiries are highly contextualized to gain richer understanding of new relationships that emerged out of the process. The goal of the planning process is to focus on telling narratives, uncovering cases, instances where power relations shift through collective struggles (Fischler 2000). The role of experts is to examine existing normalized practices and identify resistances to power that is exercised by producing methods, research, apparatus control that produces and circulates knowledge (Foucault 1980). Praxis for inclusive transportation planning must be precedence by critically examining the cultural practices—how transportation planners practice transportation planning everyday—to question what appears to be normal practices and to focus on:

> [How]… power relations are expressed in the dynamics of interaction between specific actors, in the deliberative processes through which some actors seek to dominate the way others work (as in the deliberate structuring of governance processes, economic markets, cultural practices, etc.), and finally in the deeper level of cultural assumptions and practices. (Healey 2003, 113)

2.4. The Four-Step Transportation Model: What It Is and What It Is Not

The traditional Four-Step transportation model, sometimes referred to as the classic travel demand model, consists of Trip Generation, Trip Distribution, Mode-Choice, and Trip Assignment stages (Ortúzar S. and Willumsen 2011). Each stage utilizes

specific assumptions and algorithms to produce input for the following stages to produce forecasted traffic flows in the whole transportation network (Figure 2-1). The Trip Generation stage measures number of trips produced in and attracted to each Traffic Survey Zone (TSZ) within a given planning area. The Trip Distribution stage is where the number of trips produced in the Trip Generation stage is distributed based on paired Origin (O) and Destination (D). The Mode-Choice stage allocates these trips by alternative travel modes available in the planning area, based on the algorithms used to determine the probability of travelers to select a particular travel mode. The Traffic Assignment Step distributes trips produced in the previous step and assigns these trips into links in the transportation networks.

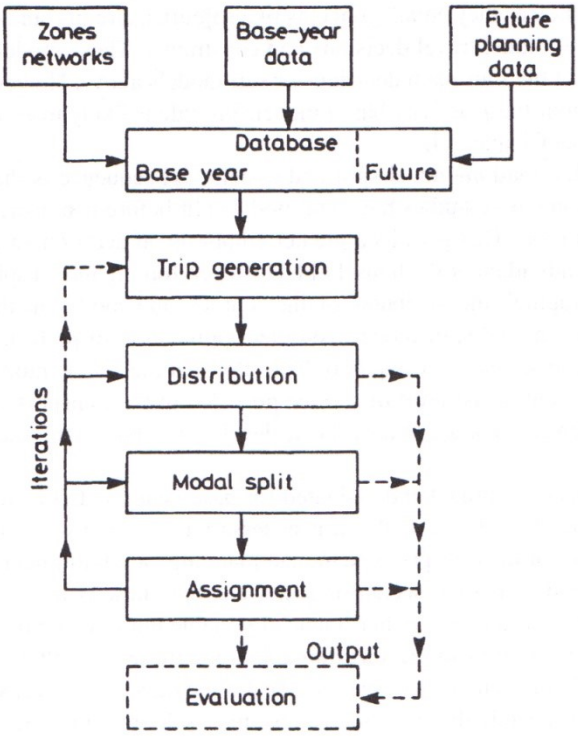


Figure 2-2 The Four-Step Transportation Model (Source: Ortúzar S. and Willumsen 2011, 21)

This dissertation focuses on the underlying assumptions used in the Trip Generation and the Mode-Choice stages of the Four-Step Transportation model, because different assumptions in these stages can have very different policy outcomes (Ortúzar S. and Willumsen 2011). The Trip Generation stage output is the number of trips produced from one traffic analysis zone (TAZ) and attracted to another TAZ zone. Socio-demographic characteristics of the population within these TAZs, such as households income, number of children per households and other related variables affect the number of trips of a household (Ortúzar S. and Willumsen 2011). The Four-Step modeling process inherently benefits higher mobility groups—that of higher income households—because it produces outputs that correlate households' income with future travel demands (Martens and Hurvitz 2011). These underlying assumptions about households' characteristics in the Trip Generation stage affect the outputs from this stage and the subsequent stages.

The Mode-Choice stage determines the distribution of total trips amongst available transportation modes based on assigned utility functions and probability of people traveling with each mode (Ortúzar S. and Willumsen 2011). For example, if the utility function for a private car is the same as bus transit, then the model distributes the same number of trips to both travel modes without considering that a bus can accommodate more passengers than private cars. Furthermore, travel behavior for private car and public transit is interrelated (Figure 2-3). An increase in income typically increases car ownership, induces more trips, results in congestion and delay. Thus, busses cannot make as many trips, increase operating costs and ultimately affect the fares by users. An increase in car ownership also means that demand for buses decreases, affects bus frequency, results in longer travel time and in traveling by car as more attractive.

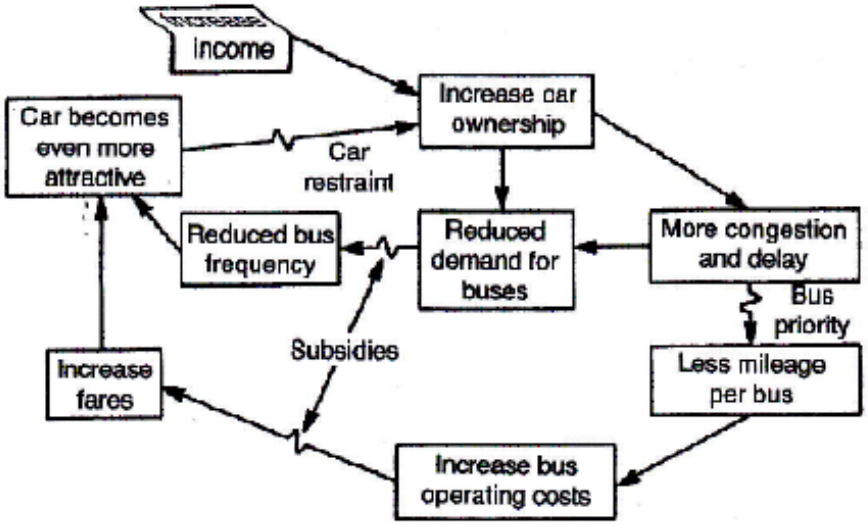


Figure 2-3 The Car/public Transportation Vicious Cycle (Source: Ortúzar S. and Willumsen 2011)

The Four-Step transportation model underlying assumptions include that all individuals are rational and the cost of travel in minutes determine their travel patterns. Timms (2008) divides modeling applications into two eras: the social physics era (1950s-1970s) and the economics era (1970s-present). The social physics era focuses on analogies, like the gravity-based modeling, using applications of traditional physics to transportation modeling. The economics era focuses on neo-classical economic concepts and methodological individualism, in particular, using the “representation of people as rational choice utility-maximizers, interacting together to form a state of equilibrium" (402). For example, variables considered in the model are often abstracted and aggregated to simplify the modeling process. The result of this trade-off between cost and accuracy is that data is often “corrected” where “outliers” are “anomalies.” Therefore, households’ travel experiences that do not conform to predefined assumptions between socio-economic characteristics and number of trips taken by these households would be rendered invisible once the data is aggregated. Traditional transportation modeling, as a

result, neglects travel patterns of young people, women, single women households, elderly and people whose travel behavior and pattern do not conform with existing transportation infrastructures (e.g. Sanchez 2008; Schweitzer and Valenzuela 2004; Blumenberg and Manville 2004; Blumenberg 2004).

Joseph Schumpeter, an economist, first presented the term 'methodological individualism' in the early1900s, and the term entered the field of sociology in the 1960s (Hodgson 2007). Economists define 'methodological individualism' as "the view that all social phenomena should be traced back to their foundation in individual behavior" (Blaug 1980, 227). This definition views social relations as based on individuals acting in their interests. Hodgson (2007) critiques the use of methodological individualism because social relations and interactions are necessary frameworks for carrying out the actions of individuals.

To address the critiques on the overt reliance on assumptions of rational individuals' travel behavior, there have been efforts to improve the modeling techniques with microsimulation models that simulate closer to how people actually travel (Iacono, Levinson, and El-Geneidy 2008). Activity-based travel models use microsimulation techniques that disaggregate travel based on a series of trip-chaining activities. Agent-based models involve simulations of activity patterns based on a set of agents in which their decisions and actions are governed by a set of rules (O'Sullivan and Haklay 2000). Figure 2-4 shows representations of an individual's travel experiences in different types of transportation modeling process. Travel activities in the Four-Step transportation model are *trip-based*, meaning that travels are categorized into trips that each consists of one Origins (O) and Destinations (D) pairs.

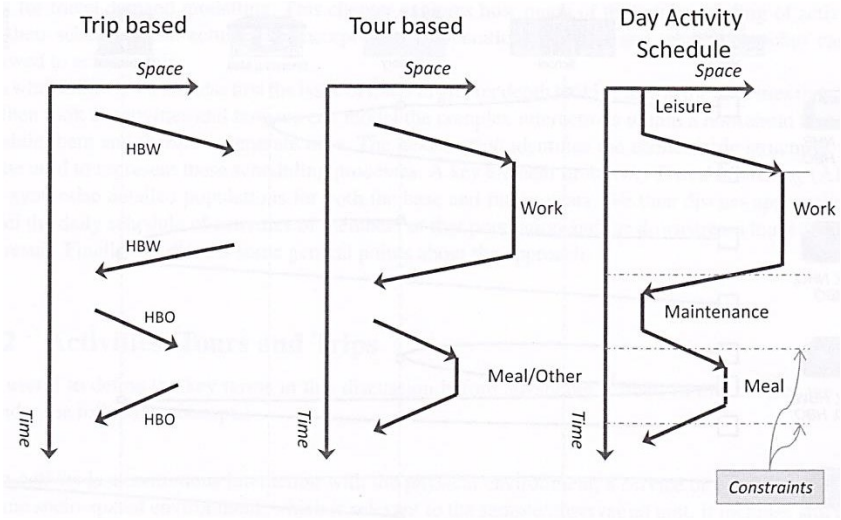


Figure 2-4 Different Representations of an Individual's Travel Experiences (Source: (Ortúzar S. and Willumsen 2011)

Nevertheless, O'Sullivan and Haklay (2000) contend that although agent-based models are more advanced in representing real-world situations compared to the traditional Four-Step model, these models still inherently apply methodological individualism assumptions. Agent-based models aim to represent the real-world context based on simulation of individual agents with specific characteristic traits (O'Sullivan and Haklay 2000). As a result, each agent represents their individualistic interests if subjected to certain situations. Methodological individualism is necessary for the modeling process to simplify individuals' travel behavior to make modeling more effective and understandable (O'Sullivan and Haklay 2000; Timms 2008).

Hatzopoulou and Miller (2009) review the role of modeling in the decision-making process and find that planning agencies that use more advanced modeling have more confidence in the result of their modeling. Their findings suggest that agencies using agencies that use the traditional Four-Step transportation model acknowledge the usefulness of the model, but these agencies also rely on experts' knowledge to improve

decisions. In instances where transportation planning agencies do not use modeling, modeling is not viewed as an essential part of the decision-making process. Most transportation planners see modeling as a tool to inform decisions, and present the model's output as neutral, objective, and separate from planners' and modelers' world view. The output from transportation models is meaningful if the dominant discourse accepts the model's output as a legitimate source of knowledge. These findings imply that, in reality, the role of transportation planners is far from being neutral experts that predict and provide transportation needs.

Agencies that invest heavily into these advanced models tend to depend more on the modeling for making transportation decisions (Hatzopoulou and Miller 2009). However, the process of modeling often requires the skill set and trainings that are not afforded to the general population. The dominant 'Predict and Provide' paradigm uses instrumental rationality that relies heavily on scientific knowledge and technology that are costly to build and maintain. Transportation planners and engineers have to choose between efficiency, costs and accuracy (Ortúzar S. and Willumsen 2011). Statistical analysis often treats 'outliers' as 'anomalies' so that the data can be abstracted and aggregated to simplify the modeling process. The transportation modeling process requires skill set and trainings that are not always afforded to the general population. For example, a household's travel pattern that does not conform to preconceived assumptions of socio-economic characteristics would be rendered invisible by aggregated data. The dilemma arises when assumptions built into these models are not explicitly stated. Moreover, decision-makers are not always aware of the assumptions used in the model. Similar to Max Weber's warning about the rise of bureaucratic power, Friedmann (1973) contends that reliance on a super model or super computer will only widen the gap between knowledge and action. In this case, too much emphasis on

technical analysis can result in the transportation model becoming the planning process (Willson 2001).

For example, large-scale infrastructure projects such as airports and highways are typically decided on the national and state government level. The planning process largely relies on the ability of models to project future regional growth and capacity. Therefore, this approach—as exemplified by the Four-Step transportation model—tends to exclude the subjugated knowledge or the experience-based knowledge of the targeted population. Even though these large scale projects rarely receive oppositions because these projects are deemed to benefit the regional or state, these projects may bear negative impacts on local communities (Sicotte 2010). Thus, requirements to use modeling as a visualization technique and inclusion of public input are often at odds. The capabilities of local communities to participate meaningfully in the decision-making process are limited by the ability of institutions to provide a rationalization that the citing of these types of project as beneficial for all (Flyvbjerg 1998). Therefore, a significant flaw of the 'Predict and Provide' practices is the lack of inclusion of the 'subjugated knowledge' or the 'experience-based knowledge' of the targeted population.

Klostermann (2013) concludes that models need to be simplified with clearly communicated assumptions to allow dialog and meaningful participation in a planning process. Additionally, Simpson's (2001) review of visual simulation literatures in planning shows that visual simulation can be a helpful tool to understand alternatives of policy impacts in planning. However, there is not much in-depth understanding of whether or not planners incorporate public input in the modeling process.

My argument for this dissertation is to make a stronger link between methodological individualism to transportation planning practices, particularly the Four-Step modeling process. Methodological individualism is inherent in the assumptions that

people make their choice on how, when, and where people travel-to after considering all their options. For example, methodological individualism does not consider that people will either have to travel with private cars, walk or bike in a city that does not provide public transportation. The assumption that people can choose their travel mode, in the absence of real choice, is particularly problematic in a metropolitan region where employment centers and land use are typically dispersed. Thus, people can seem to prefer private cars over other travel modes in the absence of other alternatives. The lack of public transit can be seen as a collective demand of the public regardless of the significant flaws in the assumptions about mode-choice in the modeling process. In this way, the modeling process *produces* what it *assumes*.

Chapter 3

METHODOLOGY

This dissertation investigates the transportation planning and modeling process in the Dallas-Fort Worth (DFW) Metropolitan Area to understand how transportation needs get produced and incorporated into transportation planning and modeling, and the implications of different understandings about transportation needs on the process and outcomes of the transportation planning and modeling. This dissertation uses case study as a methodological framework and utilizes mixed-methods research of discourse analysis, and spatial analysis in GIS to analyze travel data collected with GPS recorders, self-written form, photographs, semi-structured interviews, and planning documents. Table 3-1 provides a diagram of how the methodologies are tied to the guiding research questions as well as the layout of the data collection process and expected outcomes.

This research was approved by the University of Texas at Arlington's IRB protocol #2013-0774 on July 17, 2013. The data from the travel diaries were collected from August 2013-September 2014. Interviews with participants were conducted approximately in two weeks after the collection of the travel diaries, with an exception of three participants interviewed between January-February 2015 due to scheduling issues. Planners and modelers from the North Central Texas Council of Governments (NCTCOG) were interviewed from May 2014 - September 2014.

Table 3-1 Methodology Diagram

Guiding Questions	Inputs	Data Collection	Expected data	Expected Outcomes
• How have the historical contexts and directions of transportation policies influence practices? • What practices dominates the planning and modeling process? • What are the implications of discursive experts knowledge (e.g. transportation model) on the everyday travel experiences?	Experts Knowledge (Planning and modeling process in the DFW Metropolitan Area)	• Review of literature • Review of planning documents • Interviews with officials from the NCTCOG's Transportation Department	• Narratives and assumptions of the dominant transportation discourse • Production of knowledge about targeted population • Planners' and modelers' interactions in the modeling process	• The transportation modeling as a black-box • Knowledge about transportation needs is socially constructed • Case study of the DFW Metropolitan Area • Policy recommendations for inclusive planning practice and outcomes
• How does the inclusion of alternative knowledge considered in the transportation modeling process? • In what ways can there be mutual learning between experts and experience-based knowledge?	Experience-based knowledge (Daily travel data)	• Travel diary (data from GPS recorders, self-written form, and photographs) • Interviews with participants from Plano, Dallas, and Arlington	• Detailed travel experiences that do not conform to assumptions • Differences in accessibility and mobility	• Applications of qualitative methodology in transportation planning

3.1. Case Studies

This dissertation uses the case study as a methodological framework to explore how the various underlying assumptions of the Four-Step transportation model manifest in planning practices and consequently affect everyday travel experiences of the participants in the DFW Metropolitan Area. The purposes for using case studies are threefold. Firstly, to gain an in-depth understanding of the use of the Four-Step transportation model in making regional transportation decisions. Secondly, to compare the underlying assumptions used in the transportation planning and modeling process with detailed everyday travel experiences of participants. Thirdly, to investigate how both planning officials' expert-based knowledge and the experience-based knowledge of the targeted population can improve the planning and decision-making process.

One of the common concerns of case study as a research method is that individual cases cannot be used to draw generalization for theoretical development, and therefore case study is not a scientific research method (Flyvbjerg 2006; Yin 2008). However, lab experiments also consist of individual cases (Yin 2008) and are also subjected to a researcher's bias in explaining findings (Latour and Woolgar 1986). In a research that employs both quantitative and qualitative methods, a case study has been used to provide an example or to find variables for the statistical analysis. Yin (2008) argues that case studies are not meant to be representative "samples" that are then used to establish statistics generalization. Case studies as a methodological framework can be used to expand and generalize theories through a rich and interconnected process of case selection, data collection, coding process and analysis (Yin 2008). Case studies can be used to build or critique assumptions or hypothesis of theories by carefully selecting the case based on information from the literature (Flyvbjerg 2006). The in-depth approach of a case study is useful to build theoretical propositions that can be compared

with the observation from the case. For example, the finding of “a single black swan” can falsify the proposition that, “all swans are white” (Flyvbjerg 2006). Case study can provide in-depth information to dispute a general assumption, in other words, “either clearly confirm or irrefutably falsify propositions and hypotheses” (Flyvbjerg 2006, 231). The findings from the case study can become a basis for further inquiry into the existing theory and contribute to the accumulation of knowledge.

The use of transportation modeling is closely tied to the planning’s institutional decision-making context (Hatzopoulou and Miller 2009; Ortúzar S. and Willumsen 2011). Therefore, case study is useful to explore the transportation modeling process to provide an in-depth approach to gain context-dependent knowledge (Flyvbjerg 2006). Case studies can also put forward the daily travel experiences of target populations that are only represented by a number in the transportation modeling process. Case studies provide in-depth understandings of the complex interactions that occur in real-life phenomenon (Stake 1995; Yin 2008). Cases that show how various communities’ lack access foods, jobs, education, and other socio-economic opportunities can establish empathetic understandings of transportation problems that may not be captured by other methods. In addition, case study is an appropriate method for researches that require multiple sources of supporting evidence and data triangulation (Yin 2008).

One of the concerns about qualitative methodology, in general, including the case study method, is the presence of the researcher’s bias. Yin (2008), however, argues that bias is inherent in any research methods. The mixed-methods used in this research—GPS recorder, self-written form, photograph, and interviews—aim to triangulate the data to establish consistency. Triangulation is a process of comparing data through cross-checking the information through various sources (Schensul,

Schensul, and LeCompte 1999; Creswell 2009). Data in this dissertation are triangulated by comparing findings from the archival data, interviews, and travel diaries.

Thick description can also establish highly contextualized data because thick description allows for various perspectives that make the data more representative of the study (Creswell 2009). Thick description is an attempt to convey meanings of actions and events through a detailed description of individuals, settings, places, and cultural contexts (Geertz 1973). Thick description is useful to convey the experiences of participants in the research. Another way to triangulate the data is by discussing the interpretation with the participants as well as through a peer-review process. Interpretations of the data from travel diaries are presented in the exit interviews to clarify unclear data and discuss findings.

3.1.1. Dallas-Fort Worth Metropolitan Area

The DFW Metropolitan Area is selected as a case study because assumptions of both population growth and demographic changes are essential variables considered for the Four-Step transportation model. As a state, Texas is not only undergoing a significant increase in the Hispanic population as well as the foreign-born share, but now is considered a majority-minority state (Jimenez & Mattingly, 2009). According to the U.S. Census 2010, the DFW Metropolitan Area is the fourth largest and the fastest growing metropolitan area in the nation. In addition, the DFW-Arlington TX Metropolitan Statistical Areas population increased (23.4 %) from year 2000-2010. According to the Texas State Data Center (TxSDC), the Hispanic population of North Central Texas is projected to experience the largest increase by 60%, followed by Other (24%), and Black/African American (14%), and White (5%). Therefore, the DFW Metropolitan Area along with the state of Texas is likely to continue experiencing population growth with significant changes in socio-demographic characteristics.

Goetz, Dempsey, and Larson (2002) conduct a study that compare MPOs across the U.S. based on questionnaire given to staff, elected officials, and other stakeholders to measure correlation between collaborative process with successful regional planning. They find that the North Central Texas Council of Governments (NCTCOG) score consistently higher in collaborations between key players and the level of technical skills and knowledge. The NCTCOG develops and maintains the Metropolitan Transportation Plan (MTP) long-range transportation plan for the DFW region's transportation networks. According to the NCTCOG's website, the MTP identifies policies, programs, and projects for every 25 years as guidance for state and federal funding allocation. The responsibility of distributing state and federal funding into local projects and programs gives the NCTCOG some power to determine regional transportation policy directions and implementations. However, the DFW Metropolitan Area consists of various local governments that can have extremely different socio-demographic characteristics, as well as transportation accessibility. Therefore, a case study on the transportation planning and modeling practices at the NCTCOG can provide valuable information for other MPOs in the U.S that face similar challenges of population growth and demographic changes.

This dissertation focuses on the underlying assumptions of the transportation modeling process conducted by planners and modelers at the NCTCOG and its implications for the everyday travel experiences of participants from a variety of neighborhoods in Arlington, Dallas, and Plano in the DFW Metropolitan Area. Figure 3-2 shows the location of participants in this research. Participants living in one household or with addresses in close proximity are clustered together. Thus, the number of symbols does not correspond to the number of participants in the study.

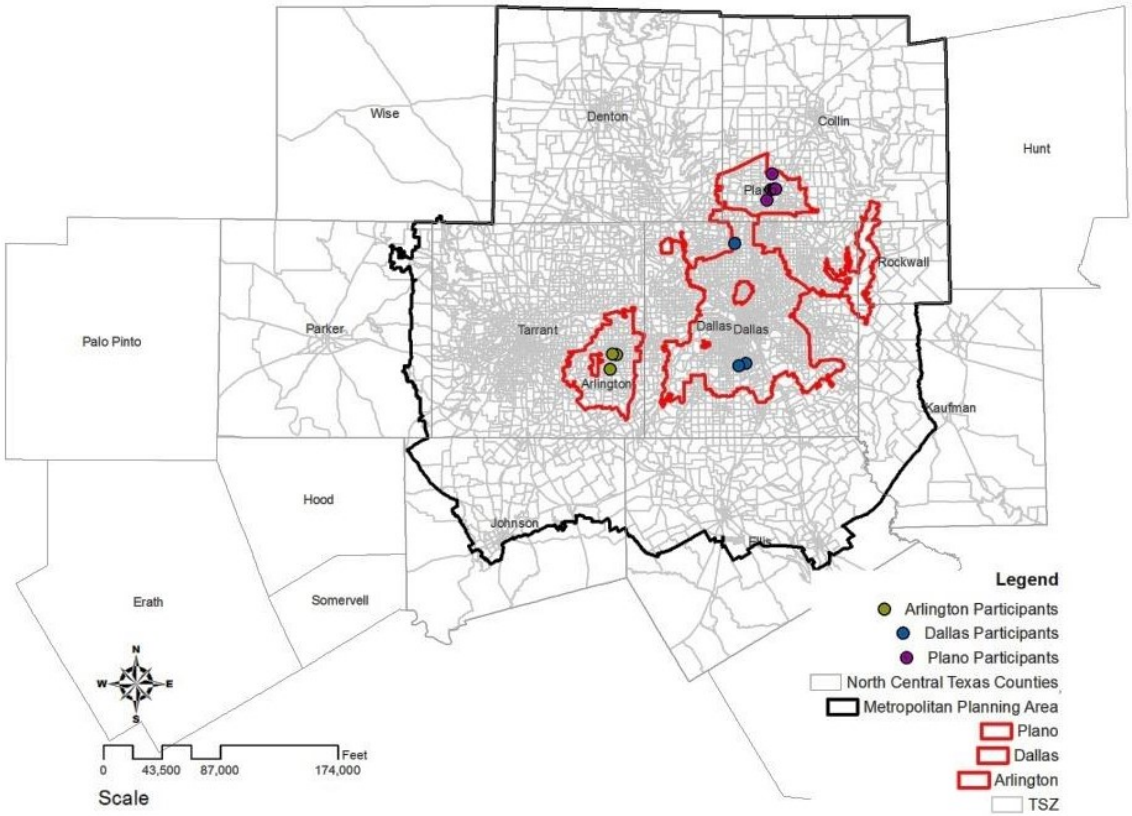


Figure 3-1 Dallas-Fort Worth Metropolitan Area and Location of Participants

The NCTCOG uses the Dallas-Fort Worth Regional Travel Model (DFWRTM) as its official travel demand model. The DFWRTM is developed based on the principles of the Four-Step transportation model and uses aggregated data derived from the socio-demographic characteristics of the population within the planning area (Ortúzar S. and Willumsen 2011). The aggregated data, while it serves the purpose of simplifying the model, assumes that individual travel behavior is predetermined by certain characteristics such as income, number of people in households (HHs) and education level. The DFWRTM uses a cross-classification method of households' income and size to calculate the number of trips taken by these HHs as input into the Trip Generation stage of the model. Figure 3-2 shows the household income distribution chart used to categorize

households. The household income distribution shows how many households are categorized into each income quartile for the Regional Area Analysis Zones (RAAs). The distribution of HHs into an income quartile group for the Trip Generation stage is based on the ratio of the zonal median income to the regional median income (North Central Texas Council of Governments 2007a). For example, if the ratio for a zone is one, then, HHs within the particular TSZ are categorized into about 35% Low Income, 35 % Low-Median Income, 20% High-Median Income, and 10 % High Income.

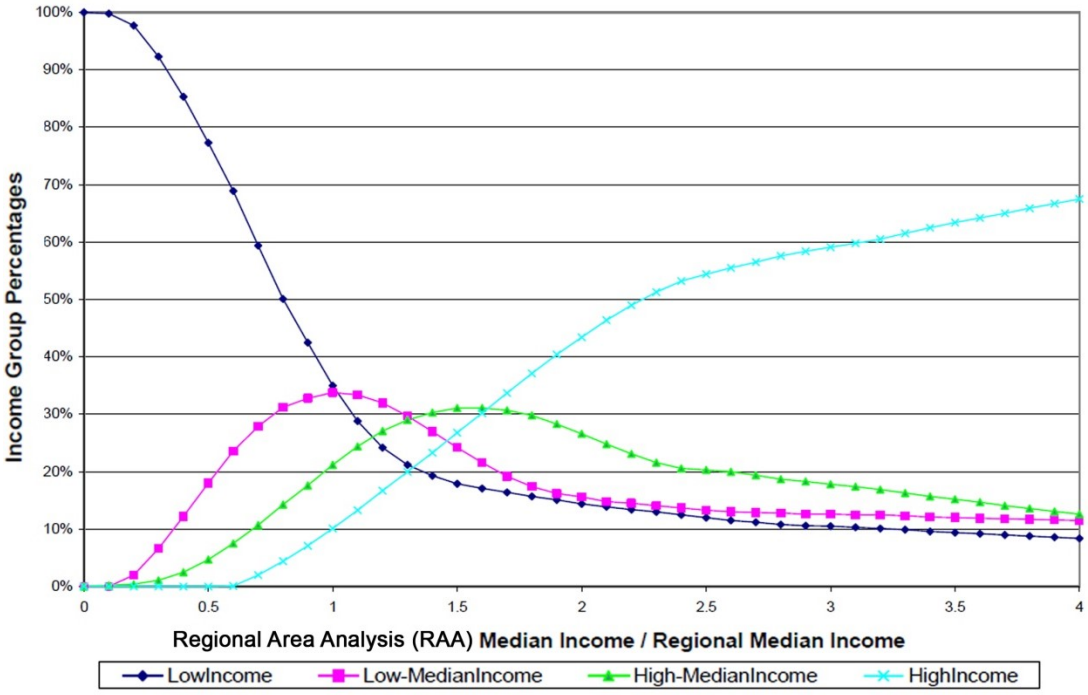


Figure 3-2 Households Income Distribution (North Central Texas Council of Governments 2007a)

Figure 3-3 shows the distribution of households based on average HH size for each TSZ with data from the 1990 Census (North Central Texas Council of Governments 2007a). For example, if a particular zone has an average of 3, then the HHs located in that zone would be distributed to 15 % HH size 1, 29 % HH size 2, 21 % HH size 3, 19 %

in HH size 4, 10 % in HH size 5, and 6% in HH size 6 plus (North Central Texas Council of Governments 2007a).

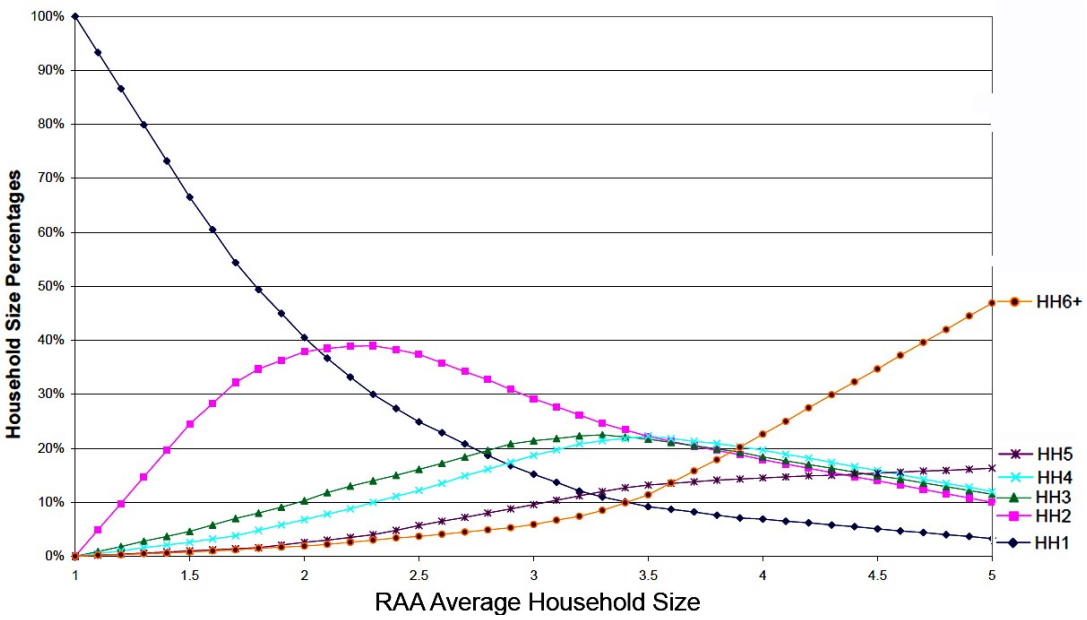


Figure 3-3 Households Size Distribution (North Central Texas Council of Governments 2007a)

Table 3-2 shows an example of a trip production rate table—defined as "the number of person trips per household" (North Central Texas Council of Governments 2007a,18)—for Home-Based Work (HBW) trips. The table shows how number of trips increases with HH size and income. For example, the table indicates that HHs of 6 persons located within Income Quartile 4 (High Income) have more than twice as many trips compared to HHs of 6 persons that are located within Income Quartile 1 (Low Income).

Table 3-2 Home-Based Work (HBW) Trip Production Rates (Reproduced, North Central Texas Council of Governments 2007a)

Income Quartile	Household Size					
	1	2	3	4	5	6
1 (Low)	0.87	1.347	2.082	2.354	2.003	2.003
2 (Low-Median)	1.288	1.916	2.491	2.583	2.908	3.524
3 (High-Median)	1.288	2.192	2.756	2.771	3.168	3.168
4 (High)	1.288	2.192	2.866	2.866	3.213	**4.458**

Data were collected from the travel experiences of participants located in three different cities: Dallas, Plano, and Arlington. The neighborhoods in Arlington and Plano were identified through the cities' neighborhood plans. The Oak Cliff Gardens neighborhood in Dallas were selected based a preliminary study conducted by the Dallas Habitat for Humanity on food desert where residents identified accessibility to transportation as one of the barriers to access healthy and affordable foods (Dallas Area Habitat for Humanity 2013). The criteria for selection and a brief overview of each neighborhood are as follow:

3.1.2. Dallas, TX

According to the U. S. Census Bureau, the City of Dallas has a population of 1,197,816 people with a median household income lower ($42,846) than DFW ($57,109). Based on the Household Income Distribution chart in Figure 3-2, the ratio of the HH median income for Dallas is about 0.7, therefore, about 60 percent of HHs are categorized Low Income, almost 30 percent Low-Median Income, about 10 percent are High-Median Income, and less than 5 percent are within the High-Income bracket. The U.S. Census ACS estimates that the majority of workers drive alone to work (77.4 %), carpooled (11.5 %), used public transportation (4.2 %) and walked (1.7 %). The mean

travel to work time for Dallas' residents is 25.1 minutes (See Figure 3-5). Fifty-eight (58 %) of the population is identified as households with families with the average family size of 2.57.

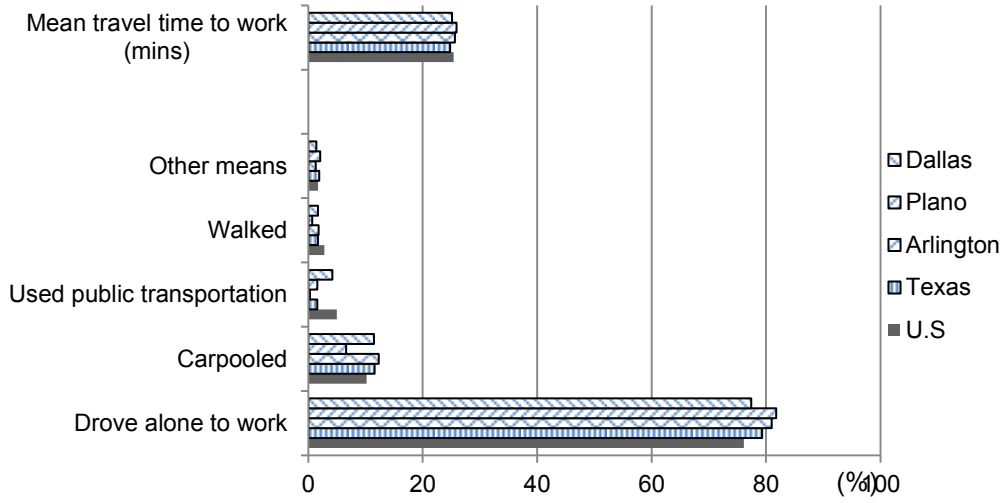


Figure 3-4 Travel to Work Mode (Source: U.S. Census Bureau - ACS report 2009)

The City of Dallas was selected because Dallas is one of the cities that have more transportation options compared to other cities in the region. Dallas is served by the Dallas Rapid Area Transit (DART) which connects Dallas with other cities in the region. Yet, a preliminary study on food deserts in Oak Cliff Gardens neighborhood, residents identified accessibility to transportation as one of the barriers of access to healthy and affordable foods (Dallas Area Habitat for Humanity, n.d.). The Oak Cliff Gardens is a neighborhood located in Southeast Dallas within the Census Tract 87.03. The neighborhood is located close to the VA Hospital and the Lancaster Corridor Transit Oriented Development (TOD) in Dallas, TX (Dallas Area Habitat for Humanity 2013).

Regardless, Dallas is extremely diverse, and Oak Cliff Gardens reflects this diversity. The neighborhood selected is part of the Dallas Area Habitat for Humanity

projects that consist of 2,462 residents where 63 percent are Black/African-Americans, and 34 percent are ethnically Hispanic (Dallas Area Habitat for Humanity 2013). According to Census 2010, the household median income of this neighborhood ($24,485) is far below the DFW Metropolitan Area ($57,109)and out of the whole population (2,462 people), residents with African Americans (63%) and Hispanic (34%) as the ethnic majority (Dallas Area Habitat for Humanity, 2013).

Travel demand models that use existing travel patterns, such as the Four-Step model employed in the DFW Metropolitan Area, have the tendency to reproduce differences in accessibility and mobility. Consequently, this tendency ultimately reinforces those that are predicted to travel more (e.g. HHs with higher income and car) compared to those that already have lower accessibility and mobility (Martens and Hurvitz 2011). Meanwhile, Jimenez and Mattingly (2009) find that Black/African Americans and Hispanics typically have fewer trips per households and lower car ownership compared to their Caucasian counterpart in Texas. Therefore, it is most likely that households in this neighborhood in Dallas do not resemble the aggregated assumptions of the Four-Step modeling process employed in the region.

3.1.3. Plano, TX

According to Census 2010, the City of Plano has a population of 259,841 people with a median household income higher ($81,475) than DFW ($57,109). Based on the Household Income Distribution chart in Figure 3-2, the ratio of median HH income of Plano to DFW is about 1.4. Therefore, roughly twenty percent of household in Plano are categorized low income; thirty percent are categorized low-median income; and thirty percent are categorized high-median income; twenty percent are categorized high income (See Figure 3-2). The U.S. Census ACS estimates that the majority of workers drive alone to work (81.8 %), carpooled (6.6 %), used public transportation (1.6 %) and

walked (0.7 %). The mean travel to work time for Plano's residents is 25.9 minutes (see Figure 3-5). Seventy percent (70.1 %) of the population is identified as households with families with the average family size of 2.61.

The City of Plano was selected because households in the city are most likely to closely resemble characteristics of the typical households considered in the modeling process. If there are cases in Plano where the assumptions do not hold—based on Flyvbjerg's (2006) preposition that the finding of "a black swan" can falsify the proposition that "all swans are white"— then these assumptions cannot be hold true in other areas. Participants were recruited from meetings for Park Forest neighborhood and a non-profit organization, the Plano Solar Advocates.

3.1.4. Arlington, TX

According to Census 2010, the City of Arlington has a population of 379,577 people with a median household income lower ($52,933) than DFW ($57,109). Based on the Household Income Distribution chart in Figure 3-2, the ratio of median HH income of Arlington to DFW is about 0.9. Therefore, over 40 percent of HHs in Arlington are categorized Low Income, about 30 percent is within the low-median income, almost 20 percent are within the High-Median Income bracket, and almost 10 percent are within the High-Income bracket (See Figure 3-2). Sixty-eight percent (68.4 %) of the population is identified as households with families with the average household size of 2.72. The American Community Survey (ACS) estimates that the majority of workers drive alone to work (81 %), carpooled (12.3 %), use public transportation (0.3 %) and walked (1.8 %). The percentage of people in Arlington who uses public transportation, (0.3 %) is significantly lower than Dallas and Plano.

The City of Arlington was selected because it had just shed its image as the largest city in the U.S. without public transportation when it began its pilot public bus

project, the Metro Arlington Express (MAXX) in 2013. Participants were recruited in two neighborhoods: the Heart of Arlington (HANA) and Rolling Meadows. HANA has been selected because the first bus stop is located within its boundaries as a result of a collaborative effort between the City of Arlington and University of Texas Arlington. Rolling Meadows neighborhood was selected because it is located within proximity of a regional shopping center, an elementary school, and Interstate Highway I-20. Thus, compared to other neighborhoods, Rolling Meadows has higher accessibility due to proximity to these places.

3.2. Experts-Based Knowledge

To explore the role of experts' knowledge, the underlying assumptions in transportation modeling were analyzed through analysis of text and images in regional planning documents and interviews with officials from the North Central Texas Council of Governments' (NCTCOG) Transportation Department.

3.2.1. Recruitment Process

Transportation officials from the NCTCOG were recruited via three ways: i) email provided in the NCTCOG's website, ii) snow-balling from contacts in the transportation department, and iii) contacts in the Civil Engineering Department and School of Urban and Public Affairs at UT Arlington. Although employees of the NCTCOG are considered public officials, participants were informed that they would be kept anonymous to encourage an in-depth discussion. However, they were informed that some discussions in the dissertation might refer to their specific job responsibilities and tasks.

3.2.2. Planning Documents

The document analysis evaluates the various ways transportation needs of various population groups are represented in the transportation modeling process through analysis of the following planning documents:

a. *The Metropolitan Transportation Plan (MTP): Mobility 2035* (North Central Texas Council of Governments 2014a)
b. *Mobility 2035-2013 Update* (North Central Texas Council of Governments 2014b),
c. *Dallas-Fort Worth Regional Travel Model (DFWRTM): Model Description* (North Central Texas Council of Governments 2007a)
d. *DFWTRM Performance Reports* (North Central Texas Council of Governments 2007b)
e. *NCTCOG Model Choice Model Estimation CSI* (North Central Texas Council of Governments 2014c), and;
f. Other supplemental documentations, available from NCTCOG's website.

For the purpose of this dissertation, I focus on the underlying assumptions stated in these documents for the following stages of the Four-Step transportation model: The Trip Generation stage and the Mode-Choice stage. The Trip Generation modeling stage predicts the total number of trips that is produced in each zone and attracted to other zones in the planning area based on factors like household's income, car ownership, family size, and household's structure depending on the structure of the model (Ortúzar S. and Willumsen 2011). Typically, the higher the household's income and size, the more trips it is predicted the household would make (please refer to Table 3-1).

The Mode Choice process performed by the NCTCOG uses daily person trip tables by purpose for trips that occurred within the NCTCOG region (North Central Texas Council of Governments 2014c). In general, the Mode-Choice stage's main assumptions are based on *random utility theory* where individuals are part of a homogeneous population, act rationally and possess perfect information (Ortúzar S. and Willumsen

2011). I investigate the underlying assumptions written in these documents on the availability of alternative mode and the ability of participants to access them.
The results from the document analysis also provide background for semi-structured interviews with planning officials at the NCTCOG as well as the participants.

3.2.3. Semi-structured Interviews with Transportation Planners and Modelers

Semi-structured interviews with NCTCOG's transportation officials investigate expert production of knowledge regarding people's travel behavior future travel demands and their approach and perceptions about the role of the model in practice, knowledge about people's transportation behavior and needs, as well as challenges to long-term regional transportation planning. All of the officials from NCTCOG were asked to provide a brief description of their roles, daily responsibilities, and their interaction with the Four-Step transportation model (see Appendix D for a list of questions).

Semi-structured interviews with five transportation planners from the NCTCOG's Transportation Department were conducted individually. Planners were asked about their level of confidence in the result of the model, how they communicate to elected officials and the public about the outcomes; and the challenges in public participation in long-term transportation planning. Other questions were directed to explore participants' view on significant changes in transportation decision-making witnessed within the agency and region. Furthermore, planners were asked for specific suggestions on how information from residents' daily travel experiences can inform future transportation planning, modeling, and policies. Information from the travel experiences of the participants were used as additional topic for the interviews.

The interview with the modelers on the other hand was simultaneously conducted with three members of the modeling team, to further investigate planning and modeling issues identified from the previous interviews with the transportation planners.

The members of the modeling team were asked to describe their educational and professional background and daily responsibilities. Questions were designed to allow flexibility in description of the modeling process to explore their thought process, i.e. preference over particular data collection, as well as their interactions with the planners (see Appendix D for a list of interview question). At the interview, a member of the modeling team stated that he expected different types of questions that are more related to, for example, the type of data collection methods and equations used in the modeling process. While the planners previously interviewed have no objections to the interview questions, a member of the modeling team seemed frustrated at the questions (See Appendix D for complete lists of interview questions). A member of the modeling team continued to either ask the questions to be rephrased or direct the interviewer to learn more about the Four-Step transportation model. The questions asked in the interview is used as an example by a member of the modeling team to illustrate how these questions—perceived as important to planners—are not relevant for the modelers.

Transportation planners at the local government level were not interviewed because cities are responsible for strategic transportation planning within their municipal boundaries. Furthermore, transportation planning at the local government level of scale typically does not directly utilize the output from the Four-Step transportation modeling process. However, interviews with participants suggest that travel experiences of those who do not commute to another city for work are directly affected by decisions local government make regarding the accommodations of alternative travel modes to car, traffic management practices, and road maintenance activities. Future studies might explore how transportation planners operate in relation to the effects of regional planning and modeling process in local transportation planning.

3.4. Experience-Based Knowledge

To explore the experience-based knowledge, data about detailed travel experiences were collected using the travel diary, semi-structured interviews, and photographs. Participants were asked to carry a GPS recorder to collect their daily travel data along with a self-written form containing: date, time, mode, destination route, whether or not they drive alone, and the cost for each trip (See Appendix A for the self-written form). Additionally, participants were asked to fill a background questionnaire that was collected when participants signed their written consent form (see Appendix B for a list of questions). Table 3-3 shows a summary of all participants. A total of sixteen participants completed at least one week of travel diary and one face-to-face interview, with the exception of one participant who was interviewed by phone. One participant recruited by snowballing process from one of the Plano's participants did not agree to do the second week of travel diary. The second week of travel diary was conducted by fourteen of the original participants and additional one participant who is the spouse of a participant from Plano. While the number of participants is lower than originally expected, participants' demographic characteristics are similar to that of the DFW population (Table 3-3).

Table 3-3 Summary of Participants' Characteristics

Alias	Area	Sex	Age	Educational attainment	Work	HH Income	Car/ HH	HH size	Race/ Ethnicity
Unique	Dallas	F	18-54	Other	Employed	<12,000	1	4	Black/African-American (AA)
Beatrice	Dallas	F	18-54	Master	Self-employed	no answer	1	3	Black/AA
Ashley	Dallas	F	55-67	High school	Employed	$12,001 – $24,000	2	2	Black/AA
Dahlia	Dallas	F	55-67	Master	Retired	$24,001 - $ 40,000	1	3	Black/AA
Mike	Plano	M	18-54	Master	Employed	$40,001 - $ 75,000	2	4	White
Richard	Plano	M	18-54	Bachelor	Self-employed/retired	> $100,000	3	3	White
Nita	Plano	F	18-54	Other, post grad	Employed	> $100,000	3	3	White
Debra	Plano	F	55-67	Other, some college courses	Employed	no answer	2	2	White
Karl	Plano	M	18-54	Bachelor	Employed	$40,001 - $ 75,000	2	3	White
Meagan	Plano	F	18-54	Bachelor	Employed	$40,001 - $ 75,001	2	3	White
Laura	Plano	F	55-67	Bachelor	Employed	$40,001 - $ 75,000	1	1	White
Jeremy	Plano	M	18-54	High school	Employed	$40,001 - $ 75,000	1	1	White
Rosa	Arlington	F	18-55	High school	Employed	$40,001 - $ 75,000	1	3	Hispanic
Lynn	Arlington	F	55-67	Bachelor	Employed	$40,001 - $ 75,000	2	2	White
Raymond	Arlington	M	55-67	Master	Employed	$40,001 - $ 75,000	2	2	White
Fiona	Arlington	F	55-67	Other, post grad	Employed	> $100,000	2	2	White
Total			44 % (18-54)	31 % (B), 31 % (M)	73% Employed	50% ($40-75K)	100%	2.5	69% (White)
DFW[1]			53% (18-54)	21% (B), 10%(M)	64%	$57,109 (median)	95%	2.8	65% (White)

[1] Source: American Community Survey (ACS) 2012 3 years estimate (U.S. Census Bureau).

3.4.1. Recruitment Process

Participants were recruited mainly from in-person communication and through snowballing from contacts in the cities' planning officials, schools, churches, and other institutions involved in the neighborhoods. The objective and descriptions of the study were presented at neighborhood meetings for Oak Cliff Garden in Dallas, Park Forest in Plano, and Heart of Arlington Neighborhood Association (HANA) in Arlington. Attendees were given the opportunity to ask questions regarding the study. Most participants who eventually participated in the research were given the package at the same time as the initial contact.

The Oak Cliff Garden neighborhood was identified in conjunction with a Walkability Study conducted for the Dallas Area Habitat for Humanity (DAHH). After an initial review of neighborhood plans in Plano and Arlington, several city planners were contacted for information regarding upcoming events or neighborhood meetings. All participants were informed of the study objective in the recruitment process, about the privacy risk concerning the use of GPS recorders when they signed the consent form. The privacy of participants is protected by keeping their names anonymous, and they are discussed here in alias.

In addition to presentation in a neighborhood meeting, participants from Plano were also recruited through snowballing from a participant who is also active in a non-profit organization, the Plano Solar Advocates. Therefore, the study was also presented at a Plano Solar Advocates meeting. The organization focuses on educational and support for the use of solar energy for residential homes in Plano. Those who participated in this research are also located in close proximity as participants from Park Forest neighborhood.

Recruitments for Rolling Meadows neighborhood in Arlington TX were conducted in two opportunities: an elementary school event and a pick-up time. The challenges to recruiting parents at a school environment include difficulties in getting parents attention because they already have a specific purpose and limited time when attending school events. Elementary school students may not cooperate and stay still long enough for parents to listen to the explanation of the research. Additionally, accountability is more difficult to establish because it is more difficult to determine whether those who attended the school events lived in the surrounding neighborhood. Language was also a barrier in the recruitment process in this neighborhood. Many parents speak only Spanish but I do not, which created a barrier to further collaboration.

During the recruitment process, people were asked to provide their contact information including their complete street address to be contacted later. This stage is intended to set up some measures for accountability to establish trust between participants and the researcher. Future studies should consider the time-span and duration of the research and ways to establish accountability and continuing relationship with participants. In this case, regular attendance at Oak Cliff Garden's Crime Watch meetings and involvement in their projects provide a continuous relationship where trust and confidence between the researcher and participants are established.

Participants were offered a compensation of $15 to complete the first week of travel diary and the initial interview; another $25 to complete the second week of travel diary and the exit interviews. Six participants received compensation for the first stage of the research; three participants received compensation for the second stage of the research, and the rest of participants refused to be compensated.

Initially, a total of 44 people expressed interest and provided their contact information. Ultimately 20 people agreed to participate in the research and filled the

background information. Out of the 20 participants, there are 16 participants that completed at least one week of travel diary from August 2013-December 2014. Out of those who resigned from the travel diary stage, a participant from Oak Cliff Garden claimed that she does not have transportation issues because she works close to home. One participant from Plano neighborhood volunteered to use the smartphone app and had concerns because the app was not recording the travel accurately in addition to feeling uncomfortable with being tracked. One participant from Arlington neighborhood cited conflicting schedule as the reason for resigning. After the first week of the travel diary, participants with a spouse were asked if their spouse would like to participate in the research. This process resulted in an addition of one participant from Plano. Therefore, there is a total of four couples (eight people) living in one household who participated in the research.

3.4.2. Travel Diary

This data collection process engages in mixed-methods data collection by a Global Positioning System (GPS) recorder, self-written travel form, and photograph images whereby these methods are referred to collectively as *travel diary*. The purpose of travel diary and semi-structured interviews is to explore how the various underlying assumptions of the Four-Step transportation model manifest in planning practices and consequently affect everyday travel experiences of the participants. The activity of recording participants' travel experience utilized ten sets of GPS recorder device (funded by the Civil Engineering Department at UT Arlington) and digital cameras. Each participant was given a package containing one GPS recorder, one USB charger, one digital camera, a copy of IRB Consent Form, a printed form for recording their travel (see Appendix A for the self-written travel diary form).

Household travel surveys are one of the types of data needed to forecast future travel demands in the Four-Step modeling process. The household survey typically investigates trips by all members of the household as well as their socioeconomic characteristics such as income, car ownership, family size and structure (Ortúzar S. and Willumsen 2011). Both the Trip Generation and Mode-Choice stages in the Four-Step transportation model use the data from households' survey. Thus, methodological flaws in this stage can have significant consequences on all consequent transportation planning processes because understanding of travel behavior is one of the most fundamental building blocks for assumptions in the transportation modeling process. Ortúzar and Willumsen (2011) recommend that travel behavior information should be contextualized, and activities should be examined as a whole to minimize errors in travel data collection.

One approach to collect travel data is by asking all members of households to keep a travel diary. This method requires the participants to write down their travel-related activities and mode of travel for every day including weekday and weekends, over a certain time period (Ortúzar S. and Willumsen 2011). The travel diary records participants' trip origins and destination, purpose, start and ending times, modes, and expenses for the trips. The purpose of this method is to be able to reconstruct travel patterns of the household's members and identify their motives for travel in terms of activities that produced or attracted the trips (Ortúzar S. and Willumsen 2011). Moreover, data should be triangulated by geocoding the travel locations, typically by the use of a GPS locator (Ortúzar S. and Willumsen 2011).

Participants in this study were given the choice either to use the provided GPS recorder or to use an Android-based app in their smartphone (See Appendix E for details of the app). The use of cell phones that have a GPS locator has been employed to

assess environments and travel pattern of adolescents (Wiehe et al. 2008). However, this option limited the range of participants because several potential participants neither had access to smartphones and internet service nor to the particular Android-based app. The use of individual's cellphone to track their GPS location also presents privacy issues and concerns raised in other studies using a similar method (Wiehe et al. 2008).

Issues of privacy were discussed at the recruitment process as well as at the time participants signed the consent form. Additionally, participants were asked to take pictures of their experiences when they encountered difficulties or easiness in their travel. The combined use of GPS recorder and digital camera assigns coordinates to pictures taken with a digital camera or a camera phone. Figure 3-5 shows an example of the software interface for the combination of data from the GPS recorder's and digital camera for one participant.

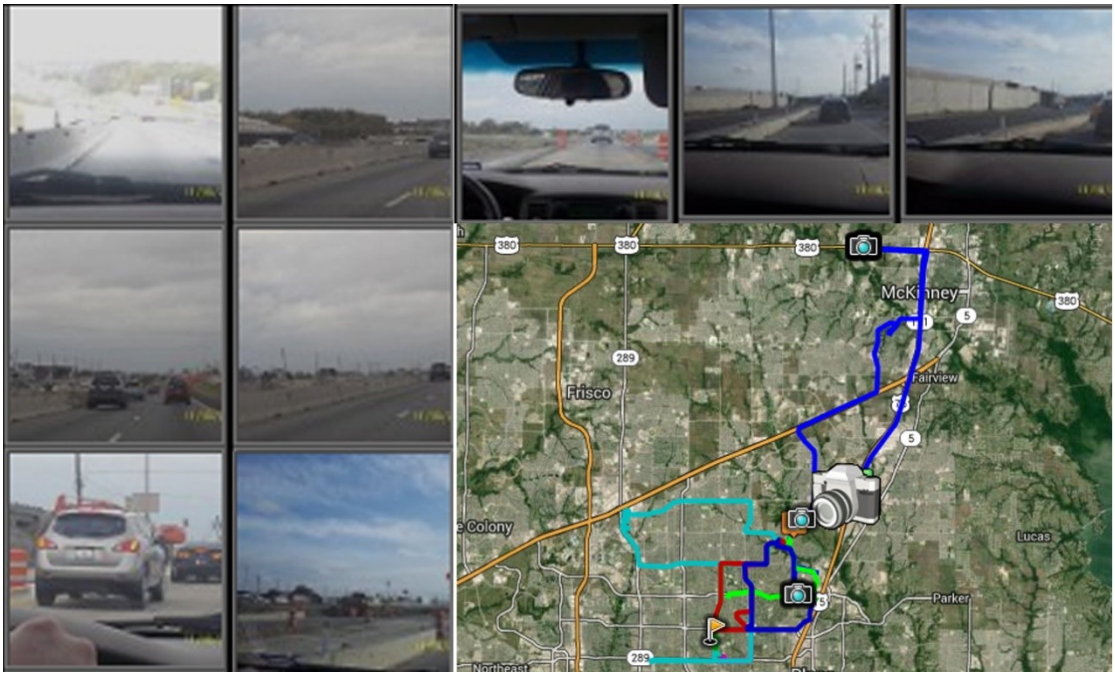


Figure 3-5 Example of a Participant's One-Week Travel Data from GPS Recorder and Digital Camera

Participation is determined by completion of at least one week of travel diary and one interview. The research was designed initially to collect two weeks of travel diary: one week in the first stage between August-December 2013 and one week in the second stage between May-August 2014. A total of fifteen people participated in the first stage of data collection. Each participant has been interviewed simultaneously at the time of collection of the data from GPS, self-written form, and digital cameras. Participants were asked to describe their travel experience in this initial interview. A total of 14 participants from the first stage participated again in the second stage. Data from a one-week travel diary of a participant's spouse has been added. The exit interviews have been conducted after the travel diary data have been analyzed—with the exception of one participant in South Dallas that insisted on having the exit interview when the GPS data were collected. Additionally, field notes were used to record decisions regarding methodology, as well as data collected in the research.

3.4.3. Travel Diary Limitations

The first limitation of the travel diary method—as defined in this research—is establishing accountability between participants and the researcher to allow documentation of participants' daily travel activities in detail and participation in a long-term research process. There are also differences in the quality of data depending on the diligence of the participants to carry out the required activities to document their travel related activities. Additionally, there are risks for technological failure due to the battery life of the GPS recorders and obstructions to GPS signals. Although the GPS recorders were tested to be able to withstand seven days of recording, data collected from GPS recorders are compared with data from the self-written form. For example, three participants' second week GPS data were not able to be downloaded due to technical errors. Similarly, one participant misunderstood the instructions and only turned on the

GPS recorder when taking pictures, and, therefore, the data from the GPS recorder contains gaps between locations.

A study with similar data collection method of using GPS enabled cellphone requires the participants to charge their cell phone daily and discuss unclear data with the participants (Wiehe et al. 2008). Another limitation is the availability of a GPS locator and digital camera for the participants to use in the study. For example, several potential participants were not able to participate in the research because all the GPS recorders were being used. Initially, the options for using a smartphone app or GPS recorders were provided to counter this limitation. However, the data collected from the smartphone app did not provide the time trips were taken and therefore participants who have opted for the app were asked to redo the research and use the GPS recorders instead.

3.4.4. Semi-structured Interviews with Participants

Interviews with participants and planners were conducted with an outline of predetermined questions from initial literature reviews but still have the flexibility when the interviews developed in a different direction. Semi-structured interviews with participants provide opportunities to explore detailed travel experiences, motivations, and challenges. The semi-structured interviews with residents were conducted when collecting the GPS data in the first-week of the travel diary. Questions include travel-related challenges and suggestions on how to improve their everyday travel experience (see Appendix C for a list of questions). The exit interviews were conducted after the collection of the second-week travel diary to clarify unclear data from both weeks and discuss interpretations and findings (Appendix C).

In the exit interviews, participants discussed their experience conducting the travel diary, travel experiences, and whether the recorded trips for the week(s) are typical or not. Participants also discussed transportation difficulties of either themselves or of

acquaintances. The interviews also explored motivations for participants' decisions regarding travel mode and housing location related to commuting experiences. Participants also discussed visions for future transportation system and infrastructures. Much probing was required to elicit detailed rresponses regarding long-term visions for the regional transportation system beyond participants' immediate travel behavior. In other words, most participants project their everyday self-experiences into what they foresee as necessary improvements for regional transportation infrastructures even when it was clarified that they should think about the next 20-30 years. Additionally, participants were asked whether they have the ability to influence changes in the decision-making process or policy directions particularly those regarding transportation issues.

3.5. Data Analysis

3.5.1. Discourse analysis

A discourse analysis interprets meanings that are conveyed through the construction of language, signs**,** and images situated within the discourse (Hall 2003). Meanings are communicated, appropriated, and re-appropriated within the discipline of the dominant discourse wherein a subject and object are located (Hall 1999), and therefore, rendering these meanings as "truth" or as "knowledge" according to its historical and cultural context (Foucault 1980). As a particular knowledge becomes to be seen as more "true" than others, other knowledges are excluded from the dominant discourse by various subtle coercive mechanisms that regulate the practice of everyday life.

One of the ways these subjugated knowledges are suppressed is through widely adapted disciplinary practices and, therefore, become institutionalized into a policy discourse. According to Healey (1997), a policy discourse that has been institutionalized becomes powerful and able to gain legitimacy to ignore other evidence, values and

claims in the policy agenda. The discourse, under which planning practices operate, affects the ways transportation needs are communicated and represented. For example, a dominant approach in transportation planning, “Predict and Provide” (Owens 1995), contains narratives such as ‘roads for prosperity’ and widely adapted practices such as forecasting and modeling techniques (Vigar 2002). The Predict and Provide—as a policy discourse—simultaneously produces these planning and modeling practices as well as the context where these practices are situated. Planning practices simultaneously shape and are shaped by the construction of knowledge about current and future needs of the targeted population. One of the power effects of a dominant transportation discourse is that it produces policies regarding urban development that affect spatial mobility and accessibility. The transportation model makes assumptions about travel behavior that resulted in output about transportation needs to inform subsequent transportation policies which became the basis for changing the environment.

The discourse analysis focuses on the constructions of knowledge about the targeted population in the Four-Step transportation modeling practices conducted by the North Central Texas Council of Governments (NCTCOG) as the Metropolitan Planning Organization (MPO) for the DFW Metropolitan Area. While the theoretical and philosophical limitations of transportation models, particularly those of the Four-Step transportation model, are widely acknowledged (Ortúzar S. and Willumsen 2011; Timms 2008), the transportation modeling process is embedded within the Predict and Provide discourse that accepts the modeling process as a legitimate source of knowledge about people’s transportation needs. Although this dissertation provides a critique of the underlying assumptions of the modeling process and how the output from the model inform planning practices, the quantitative analysis and computer programming techniques itself is beyond the scope of this dissertation.

3.5.2. Coding Process

Coding is an analytic procedure to draw out meanings from phenomenon observed in the data. Coding is a process where materials are organized into categories and assigned terms that represent the interpretation of the data (Creswell 2009).The coding process was conducted in two stages: a general and a focused coding process. Both stages of the coding processes were conducted using qualitative research softwares, *NVivo and Dedoose.* The first set of interviews was transcribed verbatim and analyzed to generate as many codes as possible to provide a detailed description of the participants, context of the data, and to generate subsequent themes in a more focused coding process. The exit interviews were transcribed selectively after themes were generated from the general coding process of the initial interviews.

The second stage of the coding process involved categorizing archival data, general codes from the interviews, field notes and travel diaries into a set of themes. The identification of themes in a focused coding process was conducted in a reiterative process where codes are added, removed, and renamed. The focused coding process analyzes themes individually and across cases to produce categories for developing key concepts (Emerson 1995). In this stage, data are categorized based on phenomena reflected by codes generated in the first stage of the coding process (Creswell 2009). A focused coding process is intended to develop theoretical connections with the various data collected in the research. For example, the relationships between the underlying assumptions of the Trip Generation and Mode Choice stage of the Four Step Model— such as household characteristics, attitude towards alternative transportation modes, and travel barriers— with travel experiences of participants were used as guidelines for the initial coding process. In the focused coding process, codes regarding people's travel choices were categorized into themes of "transportation exclusion" or "subjugated

knowledges." Table 3-4 shows the coding scheme and rules where codes generated in the first stage are categorized into several themes (highlighted): *expert knowledge, discursive practices, communicative practices, transportation exclusion, subjugated knowledge*, and *inclusive/deliberative practices*.

Table 3-4 Coding Scheme and Descriptions

Themes and codes	**Description**
Expert Knowledge	Codes related to underlying assumptions of travel behavior and future transportation needs.
Methodological Individualism	The practice of seeing individuals as a rational independent subject that makes decision based on all well-rounded information, underlying assumptions of "the universal, disembodied subject" (Hine and Mitchell 2001, 321) where travelers' social or biological characteristics are not considered resulting in disabled bodies.
Trip Generation: Assumptions	Underlying assumptions expressed about the number of trips and households characteristics
Mode Choice: Assumptions	Underlying assumptions expressed about travel mode or travel preference
Data-driven discourse	Narratives about the importance of data, methods, technology improvements in practices. The codes do not have any value associated with whether data-driven is a good thing over others. What experts mean when they mention valid data are distinguished from what participants mean when they think of the input.
Instrumental Rationality	Reliance on the transportation model as a technical foundation, as a tool to forecast
Predict and Provide	Assumptions, narratives, ways of representations of a dominant paradigm; Narratives that inform practices on "predicting" and "providing"
Discursive Practices	Codes related to practices wherein assumptions produce outcomes. Conducted by planners/modelers as well as by participants
Inversion	The process of exchanging and processing ideas until they materialize into an accepted form of "truth" or knowledge (Latour and Woolgar 1986)
Reification	The variety of ways experts separate themselves from data, process, technology (Latour and Woolgar 1986), and present output as "findings" or "knowledge" instead of "form of discourse" (Willson 2001)

Table 3.4—*Continued*

Black-boxing	The process of solidifying issues or practices that make challenging them difficult. Makes the inclusion of subjugated knowledges difficult/almost impossible (Latour and Woolga 1986; Vigar 2002)
Communicative Practices/communicative rationality	Practices of "institutions, interests, and 'world views' of actors to understand how certain types of information and knowledge are produced, acquired, accepted, or rejected" (Gudmunsson, 2011); also the ways information and knowledge is conveyed/represented
Representations	Ways information or knowledge is conveyed/communicated
Selective Representations	Ways planners practice communicative rationality by matching the ways they present information to the audience and the ways planners select which narratives to present.
Transportation exclusion	Ways people's travel needs (or concerns about travel) are being excluded from existing transportation system
Autonomy/control	Perceptions of control over one's bodies and movement
Perceptions of convenience	Perceptions of travel modes that seem to be more convenient, preference of one mode over others
Disabled bodies	Participants' inability to move through space or participate in activities
Crime and safety	Fear of crime and safety that excludes from taking public transit
Accessibility and Proximity	The disparity in travel experiences regarding accessibility and proximity to essential places
Subjugated knowledges--resistances	Needs, voices, aspirations, suggestions that are outside the dominant discourse--travel experiences that do not conform with assumptions; resistance to power that have a potential to become collective struggle; changes to travel behavior; unpredicted or outside of experts knowledge; choices people make that do not conform to assumptions
Attachment to place	The various reasons for choosing where to live and decisions to stay
Travel costs	Practices of participants to measure their travel costs and, therefore, affect decisions
Ideology and motivation	The various reasons for travel decisions on where to go, carpooling, energy efficiency car, trip-chaining
Travel commute	Commuting experience (past and presence) that affect other aspects of future travel and decisions on where to live (attachment to place)
Travel purposes	Ways that travel purposes are more about going from one destination to others

Table 3.4—*Continued*

Trip chaining or carpool	Resistances to the aggregated assumptions or methodological individualism
Trip Generations: Experiences	Everyday travel experiences related to income (ability to choose location/accessibility/proximity) due to income) and HH size (changes in HH structure, travel needs/number of cars)
Mode Choice: Experiences	Everyday experiences, travel decisions, behavior that are related to travel modes-car, public transit, bicycle, walking, carpool
Travel improvements	Participants' suggestions on how to improve their future travel experiences, in terms of their daily travel of future generations
Inclusive/ deliberative practices	expressed interests by experts to include alternative ways of knowing, or bottom-up aspirations/approach suggested by participants
Public outreach & engagement	Planners efforts to include more public participation and participants recommendations on how they can be reached out more to participate
Public participation challenges	Challenges to meaningful participation and inclusion of alternative knowledge as expressed by planners and participants. The act of identifying public participation challenges is also a form of deliberative practice by planners

3.5.3. Spatial Analysis

The mapping process of travel data from the GPS recorders uses Geographic Information Systems (GIS) in combination with Google Earth to understand how these travel experiences differ spatially. Data obtained from the GPS recorders were triangulated by matching them with the self-written form, as well as clarification of observed missing data in the exit interviews. The data were analyzed for each recorded trip for both one-week travel diaries (see Appendix E, Figure 0-6). Each of the trips was matched with the self-written travel form and annotated for discrepancies to be asked in the exit interview. Data collected from this method are number of trips, distance, and moving time. Each participants The exit interview—total and average of travel distance, duration, and purpose—were used to inquire whether participants are aware of their

travel behavior and constraints such as accessibility to places and availability of travel modes.

The written format complemented the GPS record by providing data on occasions where GPS signals were lost, or participants forgot to use their GPS recorder. Additionally, web-based mapping system such as Google and Yahoo map were used to provide information on distance and locations when needed. For example, a trip that begins or ends in the middle of a highway indicated that the GPS signal was lost. This particular trip was then matched with what is written by the participants and edited using GIS with distance information from a web-based mapping system such as Google Map. In cases where GPS data may be missing on a particular trip from home to work, but the trip is written on their self-written travel diary form, travel time and distance informationwas obtained from other days with a similar trip.

Data from the GPS recorders were saved as .kmz files and then converted into GIS shape files to allow analysis using the ESRI ArcGIS program (See Figure 3-6). The conversion was necessary because the GPS recorder computer interface does not allow comparisons of multiple users and does not show the scale unit of the trips. The mapping process in GIS is used to construct a travel map of participants with scale units and location of images (See Figure 3-7).

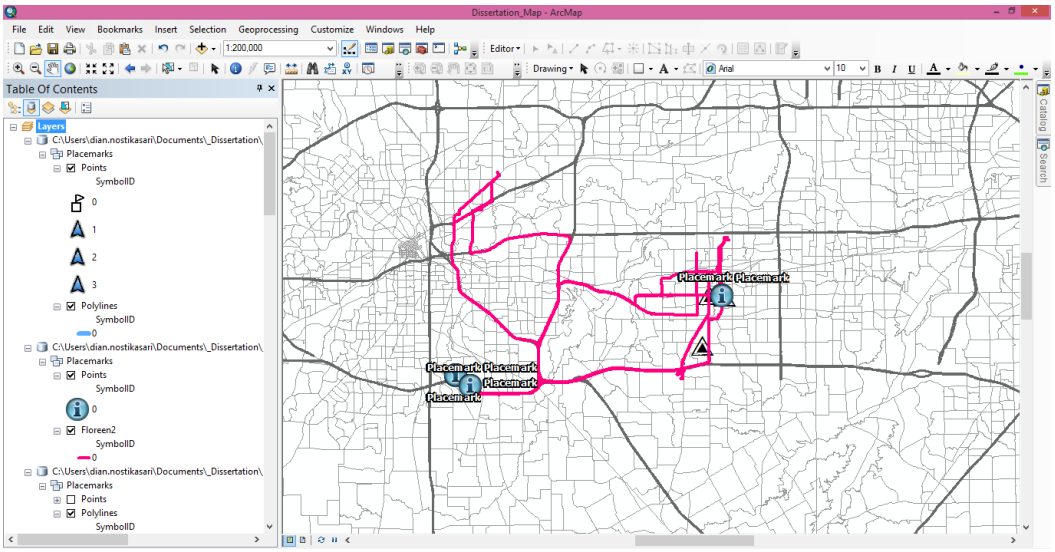


Figure 3-6 Converted GPS Data in ArcGIS Platform

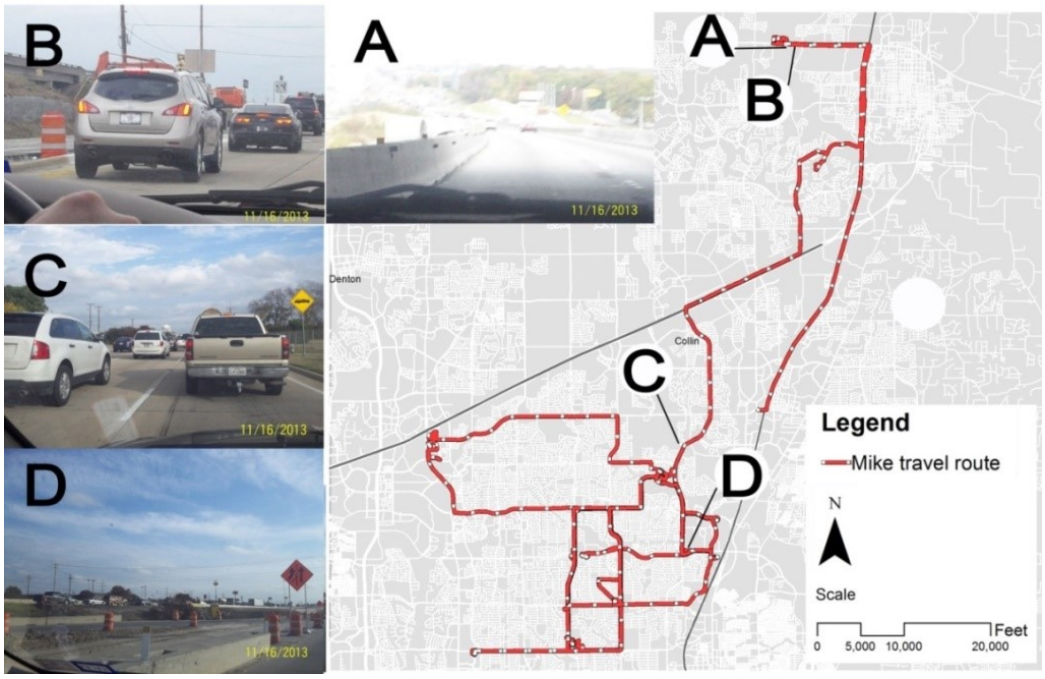


Figure 3-7 Example of a Participant's One Week Travel Map with Scale and Photo Locations

Chapter 4

REPRESENTATIONS OF EVERYDAY TRAVEL: ASSUMPTIONS AND TRAVEL EXPERIENCES IN THE DALLAS-FORT WORTH METROPOLITAN AREA

This dissertation focuses on the production of assumptions about travel behavior and needs in the transportation modeling process, interactions between planners and modelers, as well as interactions between the experts' knowledge with the model. The Four-Step transportation model used by the North Central Texas Council of Governments (NCTCOG) is called the Dallas-Fort Worth Regional Travel Model (DFWRTM). This demand-based model forecasts future transportation needs based on households' demographic characteristics as one of its underlying assumptions. Martens and Hurvitz (2011) argue that travel demand model has the tendency to reinforce inequality between households perceived to have high-mobility (high-income) with households perceived to have low mobility (low-income). The inequality increases significantly for low-income inner-city residents that experience a *"modal mismatch"* (186) wherein significant difference in travel mobility exists between those who have access to automobiles and those who do not (Blumenberg and Manville 2004).

This chapter does three things. First, it demonstrates that transportation modeling process is a form of *discursive practice—wherein its assumptions produces outcomes*—by investigating the role of the Four-Step DFWRTM in the planning process of the NCTCOG. Second, this chapter explores the interactions between planners and modelers, as those containing expert knowledge, to understand what knowledge dominates the transportation planning and modeling process. Third, the chapter illustrates what is at stake when the experts' knowledge dominates the planning process by comparing the latter with data from everyday travel experiences of participants from three different cities in the Dallas-Fort Worth (DFW) Metropolitan Area.

4.1. Transportation Planning and Modeling Processes as Discursive Practices: What Knowledge Dominates?

The interviews with planners and modelers from the NCTCOG's Transportation Department inquire about the use of modeling outputs in planning and decision-making processes, their confidence in the model, and the types of knowledge considered in making decisions about future travel demands. The interviews reveal that modeling is central to the transportation planning process at NCTCOG. Expert-based knowledge dominates through the preference of certain types of input for the model as well as the authority of the modeling team to determine what data collection and analysis techniques are valid. Additionally, planners rely on their professional experience when reviewing and validating the modeling output. There is also a distinct boundary between what planners do compared to what modelers do as well as what both consider as relevant knowledge about transportation needs.

4.1.1. The Black-Boxing and Reification Process

Transportation planning practices deal with technical, quantitative analysis to inform transportation policies on contested issues of funding allocation for transportation projects that affect people's travel behavior, mobility, and access to socio-economic opportunities. The Four-Step transportation model continue to be used by the majority of MPOs in the U.S., compared to those that utilized some type of activity-based or tour-based models and those that do not rely on travel demand modeling (Transportation Research Board 2007). Given the extensive use of the Four-Step transportation model in regional transportation planning practices, this section examines what kinds of knowledge are considered valid by experts as inputs into the long-term transportation planning and modeling process. The Four-Step DFWRTM uses various data collection methods

regarding households' demographic characteristics, travel behavior, travel patterns, land use as well as road and transit networks (North Central Texas Council of Governments 2007c). Therefore, the transportation modeling process, even though it is widely regarded as a technical practice, is also an attempt to quantify everyday life travel experiences that constitute social interactions with other people situated in the built environment.

Hatzopoulou and Miller (2009) find that not only does the role of transportation models in decision-making process increase with the advanced modeling process as well as the level of confidence in the model's output, but is also affected by planners' attitude on what kinds of knowledge are considered valid in the decision-making process**.** Interviews with the planners and modelers at NCTCOG reveal that the transportation model is embedded in various transportation planning practices in DFW Metropolitan Area. The DFWRTM's output is viewed as a legitimate source of knowledge and, therefore, is widely used in the transportation planning practices conducted by the NCTCOG, as illustrated in the following response by a planner:

> We certainly use our travel demand model. We call it the DFWRTM, I think they call it DFW X now. When I say "they," I mean the modeling team. They are the nuts-and-bolts of the model. They provide the model to us and then we are [on] the application side. We use the model to answer questions. It is a tool we rely on quite heavily for almost every single study that we do. (Interview with a transportation planner, May 2, 2014)

The interview with members of the modeling team provides insight into what types of knowledge are considered as valid in the transportation modeling process. Much of the conversation put emphasis on the importance of data as well as what Young (1990) refers to how bureaucratic authority is legitimized by "the ideal of impartiality" (115) wherein the modeling team is the producers of the model:

> They [planners] can't force [the modelers] to produce what they want to see. (Interview with members of the modeling team, September 11, 2014)

The interview with members of the modeling team at NCTCOG illustrates Timms' (2008) argument about how positivism and realism continue to be the underlying philosophy of all transportation modeling processes. Positivism can be defined as "epistemology of the fact" (Sprague 2005, 32) where "facts" are understood to be independent existence and to be the results of objective empirical observation. Thus, positivism centers on the idea of impartiality or objectivity that further provides legitimacy to bureaucratic authority (Young 1990). Positivism—importance of model validity using data—is inherent in transportation planners' and modelers' approaches to transportation planning issues in the DFW Metropolitan Area. Data is seen as the determining force of the modeling outputs as well as its interpretations. Data, according to a member of the modeling team, is "proof" and, therefore, have the final say on credibility given to the modeling process. It was explained by a member of the modeling team that data needs to be collected and updated with more recent data with the purpose to model "what is actually happening" (Interview, September 11, 2014).

Within this "data-driven" discourse, contested issues are black-boxed into the transportation model through a process of establishing validity, thus dominance, using what is considered as valid knowledge over issues such as determining future transportation needs for a population. One member of the modeling team exclaimed, "Show me the proof,"—meaning numeric data—when asked what would be the process if there were concerns raised about the transportation model's outcomes in public meetings. The cost of data collection is very expensive in term of monetary costs as well as producing outcomes that are seen as legitimate methodology. "The operation of black-boxing is made possible by the availability of credibility" (Latour and Woolgar 1986, 242). The black-boxing process significantly raises the costs—monetary and credibility—associated with finding alternatives to the black box. The following statement illustrates

the entrenched position of the transportation model in the transportation planning process:

> The [type] of data [used] is selected primarily based on the model structure that we have. So, the model is developed using certain data elements and certain definitions of data, and *it's structured around the model because the most difficult piece of all of that is to change the model* (emphasized by author). Because we only collect that data, maybe every 10-15 years, the model structure remains static for a period of 10 or more years. Moreover, so that is very difficult to change.(Transportation official, NCTCOG, July 18, 2013)

Once a transportation model is established—based on certain sets of data and assumptions—then the burden lies on those who raise concerns to provide different data. The transportation model as a black box in transportation planning goes through a process of what Latour and Woolgar (1986) call "reification" (242) wherein the model's outcomes becomes a "fact" and independent of the modelers who produce it. The reification process is an example of how the researcher claims objectivity on the subject-matter. Young (1990) refers to this process as an important element of the dominant scientific discourse that perceives rationality and knowledge as something separate wherein the researcher who "stands above, outside of, the object of knowledge" (125). Consequently, a reified statement is almost impossible to challenge once it is established that "reality is secreted" (Latour and Woolgar 1986, 243).

The modeling process, even though acknowledged as abstractions of reality, produces knowledge that is seen legitimate because it is based on a sequence of data collection and analysis outlined by disciplinary training. Thus, when a member of the modeling team states, "We [the modeling team] are at the mercy of data," that affirms the reified position of the model wherein, "Everything is data-driven facts, if data says it's not right, then, it's not right." (Interview, September 11, 2014). However, Latour and Woolgar (1986) illustrate how data collection and analysis includes an *inversion* process where ideas are discussed often amongst experts then reified into material reality. This data-

driven discourse guides the modeling practice where the modelers operate under the assumption that reality is outside of their domain, and their actions are guided by the selected data to convey objectivity. The modeling process operates in a similar manner as the economists observed by Greider (1989), that construct scientific theories about public behavior and test them against reality through the forecasting practice.

The reification process establishes legitimacy. Even if alternative data is collected, there is also the issue of whether new data sets will be considered valid by those who have established credibility in the existing planning and modeling process. When asked to confirm the definition of "accurate data" and whether there is such a thing, a member of the modeling team replied, "No, but some data are better than others" (Interview, September 11, 2014). Additionally, according to the modeling team, establishing and validating new data may take one year for collecting data, one year to analyze and one year to integrate the data into the modeling process. There is further insistence on what is considered as "proof" also needs to be validated by "proven methodologies." The following statement illustrates not only how the modeling process is dependent on the information collected from travel surveys but also what it takes to establish legitimacy for the data:

> [The model] is only as good as the information that comes into it because it is based on travel surveys, and some of these were done in the '90s. Right now, we are in the process of collecting workplace surveys and other things like that. [It] takes a lot of time to do and millions of dollars to collect. It is [based on] the sampling that you have: how many samples that you have, how many [samples] are valid that you can use. It all comes down to the statistics in the model. (Interview with a transportation planner, May 2, 2014)

4.1.2. Communicative Practices in Transportation Planning and Modeling

Willson (2001) argues that transportation planners mostly use the language of numbers that are often viewed as "unambiguous representations of reality" (p.1), yet the very nature of the problem/phenomenon that those numbers represent is inherently a

social and a communicative process whose meaning is always multiple and ambiguous. For example, the transportation modeling process uses household data in numeric format—e.g. income, family structure, and travel pattern— as input into the model. Furthermore, the underlying assumptions of households' characteristics are processed by the transportation model into aggregated outcomes that are considered representations of regional travel pattern. Once the model goes through a process of calibration and validation—in which the model's outcome is compared to the observed traffic pattern—then the outcomes of the model are communicated to the elected officials and the public in various forms of policy recommendations. The communicative process is highlighted in the ways transportation planners at the NCTCOG practice *selective representations* of transportation model's outcomes, depending on the audience. The communicative nature and *selective representations* in transportation planning are illustrated in the following response:

> When we work with, for instance, some local government staff, we'll show some of the detailed information. When we work with elected officials, we'll generally just summarize the information. We'll use more of the aggregate summaries, the performance statistics when we talk to elected officials whereas we'll show the actual traffic numbers or transit route ridership number when we talk to the local staff about that. For the public, we use a combination of both—we'll use aggregate statistics, but we usually draw up simplified diagrams of some of the traffic movements for the public. (Interview with a transportation planner, July 18, 2014)

Regardless of how it is presented, transportation model's outcomes are mostly represented as "findings rather than a form of discourse" (Willson 2001, 7). For example, this form of representation is clearly visible when the transportation modeling process is viewed as "data-driven" and "black and white" by members of the modeling team. Therefore, transportation models are at the heart of a data-driven 'Predict and Provide' approach that privileges quantitative and analytical data (Martens 2006; Martens and Hurvitz 2011; Timms 2008). The outcomes of the communicative process that occur in

this context are predetermined because the experts' knowledge tends to override other alternative types of knowledge:

> . . . . The planning process has typically undervalued public input mostly because we know that people are really talking about what their observation [is] today. I think people also tend to overestimate their reaction to future transportation conditions. If you tell somebody that there will be a Disneyland-type monorail in their neighborhood, [and ask] would you use it? [They will say,] "Oh yes, of course, I'll use it." But revealed preference tells us [the planners] that you do not. (Interview with a transportation planner, July 18, 2014)

The transportation model's outcomes, within the 'Predict and Provide' discourse, become "a story as to how the present becomes the future" (Timms 2008, 406) due to its use of observed existing travel characteristics to forecast future travel demands. This nature of demand-based transportation models—such as the Four-Step transportation model used in the DFW—also contributes to perpetuating social inequality because the assumptions have tendencies to reinforce population groups with high mobility (those with cars) and weaken population groups with low mobility (public transit users) (Martens and Hurvitz 2011). When asked about the discursive nature of transportation modeling—given the ability for discursive practices to produce the effects they assume—a planner acknowledges the possibility but contends:

> . . . . That is an issue not just here, but it is an issue with all aggregate travel models [because] the Four-Step travel models all have that same problem. They are calibrated and validated to existing travel characteristics. So, *the forecast is only as good as the assumptions that go into them* (author's emphasis). For instance, during the recession in the [year] 2007-2010 time frame we saw a reduction in the traffic on certain streets in the region. . . . But people did not move out of the DFW area, so that means people were making fewer vehicle trips or shorter trips. But the model itself will not capture that because it is calibrated on the travel characteristics from ten years ago. . . . because we are seeing our model slightly overestimated the amount of travel in the region. (Interview with a transportation planner, July 18, 2014)

4.2. Travel Diaries Results

There are 16 participants in this research each of whom has a complete set of at least one week of travel diary and one interview within the term of August 2013 – December 2015. The majority of participants are female (69%) with age within the range of 18-54 (44%); employed (73%) with income between $40,0001-75,000 (50%); has two cars in their HH (50%); and with HH size of 3 people (38%). The same percentage of participants has either a Bachelor's degree (31%) or a Master's degree (31%). Participants from the Dallas neighborhood are all Black/African-American compared to participants from Plano, who are all White. The race/ethnicity differences may be reflective of how some neighborhoods can be racially segregated in some parts of the DFW Region. Additionally, although Dallas and Plano have the same number of participants with graduate education (16%), participants from Dallas have on average a lower HH income (less than $40K) compared to those from Plano ($40 K and more). This income inequality is also reflective of the income inequality pattern of the DFW Region where lower-income population groups tend to be concentrated in the southern part of the region (Figure 4-1).

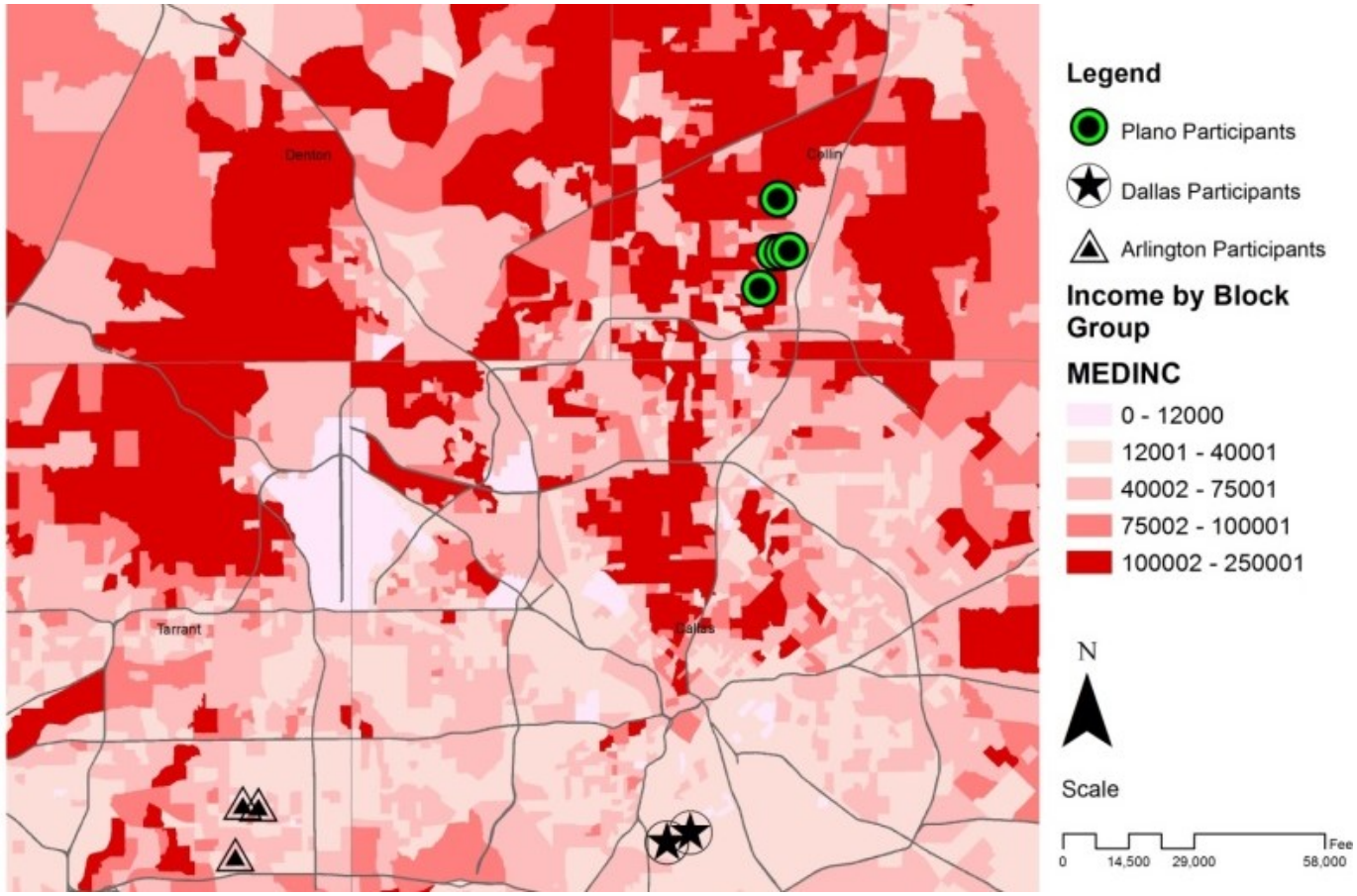


Figure 4-1 Income by Block Group (Source ACS 2008-2012)

Table 4-1 Summary of Participants' Characteristics (%)

	Dallas	Plano	Arlington	Total
Participants	4	8	4	16
Sex: F	25%	25%	19%	**69%**
M		25%	6%	31%
Age: 18-54	13%	38%	6%	**44%**
55-67	13%	13%	19%	31%
Race/Ethnicity				
African-American	25%	-	-	25%
White	-	50%	19%	**69%**
Hispanic	-	-	6%	6%
Education				
High school	6%	6%	6%	19%
College	-	25%	6%	31%
Graduate	**13%**	**13%**	6%,	31%
Other ……	6% (N/A)	6% (some college)	6% (post graduate)	19%
Employment				
Employed	6%	47%	25%	**73%**
Self employed	6%	6%	-	13%
Retired	6%	-	-	6%
HH income				
<12,000	6%	-	-	6%
$12,001 – $24,000	6%	-	-	6%
$24,001 - $ 40,000	6%	-	-	6%
$40,001 - $ 75,000		38%	13%	**50%**
$75,001 - $ 100,000	-	-	-	-
> $100,000	-	13%	6%	19%
no answer	6%	6%	-	13%
Car/HH: 1	19%	13%	6%	38%
2	6%	25%	19%	**50%**
3	-	13%	-	13%
HH size: 1	6%	13%	-	19%
2	6%	6%	19%	31%
3	13%	19%	6%	**38%**
4	-	6%	-	6%

4.2.1. Plano Participants

Participants from Plano consist of four females and three males of which two couples (Karl and Megan; Richard and Nita) live in the same household. The majority of participants have at least a college education, employed for wages with household's income range of $40,001-$75,000 and HH size of 3 people (see Table 4-1).

- Mike

Mike was recruited at a meeting for a non-profit organization that advocates the use of solar energy in Plano. Mike currently lives with his wife and two children in the current house since year 2004. Both children are in the driving age, and therefore, the household shared two cars. Mike is a high school science teacher and has very deep concerns about environmental issues. He stated, "I feel guilty every time I am [driving, and] burning fossil fuel" (Personal communication, November 26, 2013). Mike's attitude toward public transportation could be affected by his experience living Jakarta where public transportation in Indonesia is regulated by the government, but is also provided by small private companies that offer extensive bus services, jitneys, and affordable taxi services. During one recorded week, Mike made 32 trips and traveled approximately 146.85 miles, with a total moving time of 7 hours and 46 minutes.

- Debra

Debra was recruited at a meeting for a non-profit organization that advocates the use of solar energy in Plano. Debra currently lives with her husband after all their children have grown up and moved out. She lives less than one mile from her workplace and drives to work, but expressed that she could have walked to work. Her husband is one of the founders of a non-profit for solar energy. Thus, they are passionate about environmental issues and conscious about their energy use. These concerns over environmental issues manifest in their choices regarding traveling in the form of using an

electric vehicle, tracking mileage, and attempts to consolidate trips or carpool. During one recorded week, Debra made 29 trips and traveled approximately 130.45 miles, with a total moving time of 5 hours and 21 minutes.

- Richard and Nita

Richard was recruited at a meeting for a non-profit organization that advocates the use of solar energy in Plano. Richard, Nita, and their daughter have been living in their current house for 16 years earning a household income >$100,000. Their daughter is currently in high school and also drives. Richard is retired and is now actively promoting the use of solar energy in Plano. During one recorded week, he made 24 trips, traveled approximately 180 miles with a travel time of 5 hours and 31 minutes.

Nita commutes to Dallas, works at regular hours and, therefore, has a more consistent origin-destination-time of travel. Over one recorded week, Nita made 24 trips, traveled approximately a total distance of 170.53 miles with a total moving time of 5 hours and 7 minutes. The result of the travel diary surprised Richard because he did not expect to travel more than his wife. During the same recorded week, Richard made the same number of trips (24) but traveled slightly more and longer compared to Nita.

- Karl and Megan

Karl and Megan were recruited in a neighborhood meeting held by the City of Plano. They have been living in their current house for seven years with a young child who goes to elementary school and participate in a variety of extra-curricular activities. Karl's workplace is located in Plano while Megan initially commutes to Dallas when conducting the first week of the travel diary. Megan's second week of travel diary is not typical because she was working from home and preparing to change her place of work as well as being mostly in charge of taking her son to his baseball summer camp. Both Karl and Mary said that their travel patterns had significantly changed with an addition of

a child. During one recorded week, Karl made 21 trips, traveled approximately 97.8 miles with a moving time of 2 hours and 59 minutes. Meanwhile, Megan made 36 trips, traveled approximately a total of175.9 miles with a total moving time of 5 hours and 36 minutes. The significant difference between the miles traveled and travel time represent how Megan, described that her daily travel includes taking their son to school and most likely is also responsible for picking him up from school.

- Laura

Laura was recruited in a neighborhood meeting held by the City of Plano. She currently lives alone after her son, Jeremy, moved out to an apartment complex located near North Dallas and Plano. In addition to work, she is also active as a Girl Scout counselor, traveling to Richardson for their activities. She commutes to McKinney, which is located about 10 miles north and equivalent to a 15-minute drive. Over one recorded week, Laura made 27 trips, traveled approximately a total of 337.40 miles with a total moving time of 9 hours and 54 minutes.

- Jeremy

Being Lynda's son, Jeremy was recruited by snowballing from Lynda. He currently lives in the boundary between Plano and North Dallas and commutes to McKinney to the same workplace as Laura. He currently lives alone and over one recorded week, made 16 trips, traveled approximately a total distance of 187.73 miles with a total moving time of 4 hours and 12 minutes.

4.2.2. Dallas Participants

Participants from Dallas consist of four females of which two persons (Beatrice and Dahlia) live in the same household. Half of the participants have graduate education, but both are either retired or self-employed with a household income range of ($12,001-

$40,000. All participants, therefore, have a household income of $40,000 or below (Table 4-1).

- Unique

Unique was recruited in a neighborhood crime watch meeting. She has been living in her current house for eight years and is currently living with her daughter and grand-daughter. She considers herself as employed because she does home care for her granddaughter who has special needs. She actively watches over the neighborhood and is very concerned regarding safety and crime. She had the experience of being robbed on a bus and has traveled mostly by car since then. During one recorded week, Unique made eight trips, approximately a total distance of 29.8 miles and total moving time of 1 hours and 52 minutes.

- Beatrice

Beatrice was recruited in a crime watch neighborhood meeting. She has been living in the current house for about 30 years with her older sister, Dahlia, and their mother. Beatrice is currently self-employed, but she used to commute to Downtown Dallas for work using public transit. Over one week of recorded travel, she traveled approximately 102.01 miles with a total moving time of about 3 hours and thirteen minutes. Her second week of travel diary is not typical because they have been preparing for their mother's 100th birthday, and therefore it is not presented in this dissertation.

- Dahlia

Dahlia was recruited in a crime watch neighborhood meeting in which she is currently serving as secretary. She has been living in the current house for about 30 years with her younger sister, Beatrice, and their mother. Dahlia is currently retired and undergoes dialysis two days a week due to diabetes. According to her, the dialysis has significantly altered her travel behavior in terms of frequency and distance. Over one

week of recorded travel, she traveled approximately 101.74 miles with a moving time of about 3 hours and 17 minutes. Her second week of travel diary is not typical because in addition to preparing for their mother's 100 years birthday, she also damaged her wrist.

- Ashley

Ashley was recruited in a crime watch neighborhood meeting. She has been living in the current house for 34 years and currently lives with her adult son after her husband passed away three years ago. Her typical travel week includes a commute to North Dallas Mockingbird area with a distance of about 11 miles and travel time of approximately 24 minutes per one way trip. During one recorded week, Ashley made 13 trips, traveled approximately 112.67 miles with a moving time of 3 hours and 58 minutes.

4.2.3. Arlington Participants

Participants from Arlington consist of three females and one male of which one couple (Lynn and Raymond) lives in the same household. The majority of participants have at least a college education, employed for wages with household's income range of $40,001-$75,000 and HH size of 2 people (Table 4-1).

- Rosa

Rosa was recruited in an event at her daughter's elementary school. She currently lives with her two children one of which is a legal adult. She enjoys living in a neighborhood that is close to her daughter's school, a regional shopping center, a national grocery store, a hospital, and an interstate highway. Her son has special needs and is currently struggling to get to work because he has to go through an extra process to get a driver's license. During one recorded week, Rosa made 39 trips, traveled approximately 70.13 miles with a moving time of 2 hours and 44 minutes. Rosa's

average distance is 2.34 mi because a significant number of her trips' purpose is to take her daughter to elementary school.

- Lynn and Raymond

Lynn was recruited in a neighborhood association quarterly meeting and has volunteered her husband to also participate in the study. Both are active in their neighborhood association, and their children have all moved out. They have concerns about transportation accessibility and mode choice. They also know many people in Arlington with transportation issues. During one recorded week, Lynn made 39 trips, traveled approximately 270.61 miles with a total moving time of 9 hours and 35 minutes.

Meanwhile, in the same week, Raymond made 16 trips, traveled approximately 181.38 miles with a total moving time of 7 hours and 32 minutes. Raymond has been taking the bus to commute to work and expressed satisfaction with the service along with the reduced stress level and costs associated with not driving. Raymond's travel experience could be an example of how travel behavior is not fixed characteristics as the underlying assumptions of The Four-Step model suggests, and therefore provide opportunities for planners to pursue initiatives to encourage alternative travel modes when making policy recommendations.

- Fiona

Fiona was recruited in a neighborhood association quarterly meeting. She lives with husband after their children moved out. They have been living in the same house for 35 years, and Fiona, in particular, is very interested and invested in ways to improve her surrounding neighborhoods. Fiona enjoys traveling do and has visited cities that provide interconnected public transportation system. Therefore, she has a positive attitude towards provisions of public transportation. Fiona teaches at a community college 14 miles from home with an average travel time of 27 minutes. During one recorded week,

Fiona made 23 trips, traveled approximately 250.03 miles with a total moving time of 7 hours and 40 minutes.

4.2.4. Comparison between Participants

Table 4-2 shows a comparison of all participants for the average and range of the trip distance, moving time, number of trips, and speed. The average distance traveled for all participants is 160.42 miles with an average moving time of 5 hours and 29 minutes, and average 23 trips for the whole week. When compared across participants, the average trip distance range from 2.34 – 12.43 miles with an average of 11.93 miles. Meanwhile, the average moving time for each trip ranges from about 5 minutes to 49 min with approximately an average of 23 minutes.

Table 4-2 Comparison of Travel Diaries Results across Participants

Average Distance	160.42	(mi)
Average Moving time	5:29:38	(h:mm:ss)
Average Trips	23.06	
Average trip distance	Min	Max
Range	2.34	25.43
Average	11.93	
Moving time		
Range	0:05:15	0:49:22
Average	0:23:37	
Number of Trips		
Range	8	39
Average	23.0625	
Speed		
Range	19.07	39.46
Average	27.84	

Table 4-4 shows a comparison of the travel diaries' results from each city. The results reveal the disparity in terms of travel distance, time, and number of trips (Table 4-

3). Participants from Arlington on average travel the furthest (193.79 mi) and longest (6:53:10) and make more trips (28.25) during the recorded one week period. When comparing the average trip distance for each participant, participants from Dallas have the longest maximum trip distance (25.43 mi), travel further (14.7 mi), and longer average moving time (30:50 mins), but make much smaller number of trips (11.5 trips) compared to participants from other cities. The travel information reveals that it takes participants from Dallas longer and further to get to their destinations in their everyday travel experience as captured in their travel diaries. Meanwhile, participants in Plano and Arlington make more trips (average of 25.9 and 29.3 respectively). This disparity—as shown by the travel diaries results— indicates that participants in both Plano and Arlington have higher mobility and accessibility compared to participants from Dallas.

Table 4-3 Travel Diaries Result for Each City

	Dallas		Plano		Arlington	
Average Distance	86.56	(mi)	180.66	(mi)	193.79	(mi)
Average Moving time	3:05:21	(h:mm:ss)	6:00:00	(h:mm:ss)	6:53:10	(h:mm:ss)
Average Trips	11.50		26.25		28.25	
Average Trip Distance						
Range	7.11	25.43	5.44	17.76	2.34	22.55
Average	14.70		9.77		13.49	
Average Moving time						
Range	0:19:14	0:49:22	0:09:59	0:31:17	0:05:15	0:38:21
Average	0:30:50		0:18:39		0:26:22	
Number of Trips						
Range	8.00	15.00	16	36	16	39
Average	11.50		26.25		28.25	
Speed						
Range	19.07	30.73	19.58	39.46	20.74	37.11
Average	25.77		29.75		26.07	

In general, participants who are employed show consistent travel pattern during the study, even those who participated in two weeks of the travel diary process. Participants who are parents with children in elementary school exhibit different travel data between the two weeks of travel diaries. Additionally, participants who have different jobs during the research period exhibit changes in travel pattern due to changes in their workplace. As expected, participants who categorized themselves as self-employed or retired show a variety of Origins (O) and Destinations (D) during the study. Regardless, the trips for essential activities such as grocery shopping are mostly consistent.

On average, there is not much difference in travel distance for male participants (11.15 mi) compared to female participants (12.29 mi), and in the average moving time (22 min vs.24 min). However, Table 4-4 shows how female participants travel further (25.43 mi, 49 min) compared to male participants (15.64 mi, 37 min). Nevertheless, interviews reveal that in participants' female-male households, female participants tend make more trips. Studies have shown that women have more complicated travel pattern compared to men (Rogalsky 2010). For example, even though Megan works in Dallas and Karl works in Plano, Megan usually takes their child to school. Lynn drives more than Raymond due to the various errands and her self-proclaimed grocery shopping "hobby." Meanwhile, Raymond's travel diary results show consistent Home-Based-work (HBW) trips in both weeks of the travel diary.

Table 4-4 Travel Diaries Results (Male/Female)

	MALE (31%)		FEMALE (69%)	
Distance	Min	Max	Min	Max
Range	5.44	15.64	2.34	25.43
Average	11.15		12.29	
Moving time				
Range	0:09:59	0:37:45	0:05:15	0:49:22
Average	0:22:34		0:24:06	
Trips				
Range	16	32	8	39
Average	22		24	

4.3. What Is at Stake: Implications on Everyday Travel Experiences

The consequences of the dominance of expert-based knowledge in a 'data-driven' discourse are significant considering that planning practices and policies contribute to the production of space and is intertwined with the lived spaces where activities such as getting food, going to jobs, taking children to their school are being carried out. The stake for dominance of the expert-based knowledge is related to the discursive nature of the transportation model where the underlying assumptions produce its outcomes.

This section reviews some underlying key assumptions in the Four-Step transportation model —particularly that applied in the Four-Step model in DFW—explores how these underlying assumptions are manifested in everyday travel experiences of participants in the DFW Metropolitan Area. The assumptions under review are: 1) the assumption on households' characteristics and income as input for future number of trips produced in the Trip Generation stage, 2) the assumption on access to auto mode in the Mode-Choice stage, and 3) the assumption on availability of alternative travel modes in the region.

These three assumptions are basis to both the Trip Generation and Mode-Choice Stage of the Four-Step transportation model, wherein, the outputs of these two stages have the most significant impact on transportation policies' decision-making processes (Ortúzar S. & Willumsen, 2011). These underlying assumptions exert disciplinary power on the everyday travel experiences of participants. The generational effects of these implications reinforce differences in mobility and accessibility, sense of disabled bodies, illusions of choice in access to auto modes as well as the availability of alternative travel modes for travelers.

4.3.1. Trip Generation Stage: Representations of Household's Income and Future Trips

The first key underlying assumption in the Four-Step transportation model —that of households' income as one of the main variables to predict the future number of trips produced in Traffic Survey Zones (TSZs)—is typically represented by a statistical formula that uses households' demographic characteristics such as household's income and size as independent variables to determine the number of trips produced by households in a TSZ (Ortúzar S. & Willumsen, 2011). The Trip Generation stage is one of the first inputs into the modeling process where the outputs are number of trips per household in each TSZ. Therefore, the outcomes of this stage can have a snow-ball effect on the consequent Trip Distribution, Mode Choice, and Trip Assignment stages.

According to the NCTCOG (North Central Texas Council of Governments 2007c), household income categories are derived based on the ratio of the zonal median income to the regional median income, with range from income quartile 1 (low income) to income quartile 4 (high income) (See Figure 4-2). Furthermore, Table 4-2 shows an example of the trip rates for a variety of income quartile and household size for input into the Trip Generation stage.

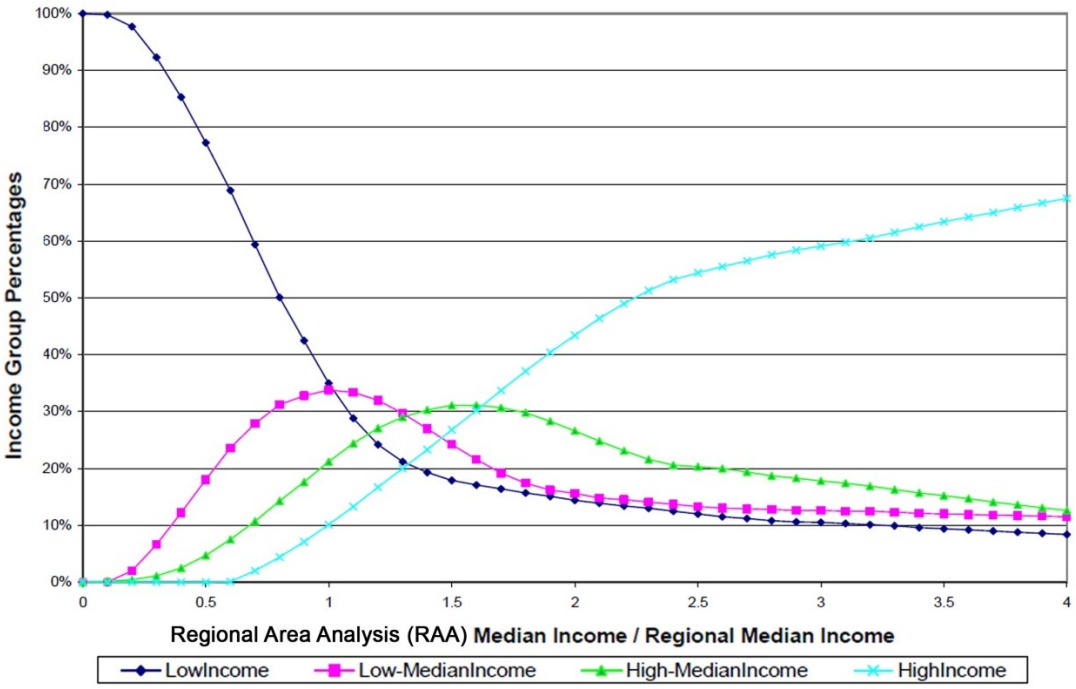


Figure 4-2 Households Income Distribution (North Central Texas Council of Governments 2007a)

Table 4-5 shows that for Home-Based Work (HBW) trips, for example, a six-person household in the Income Quartile 4 (High Income) is predicted to make more than two times more trips per day than a six-person household in the Income Quartile 1 (Low Income). This is an example of how transportation demand models have an inherent tendency to strengthen the mobility of high-mobile groups—often correlated with higher income—and, it is still difficult to measure to what extent policy considerations address the mobility and accessibility gaps for different population groups (Martens, 2006). Regional transportation planning practices utilize forecasts of future travel demands to make regional transportation policy recommendations, particularly those related to the development of transportation services and infrastructures (e.g. highway constructions).

Table 4-5 Home-Based Work (HBW) Trip Production Rates based on Households Income and Size (Source: North Central Texas Council of Governments, 2007, 18)

Income Quartile	**Household Size**					
	1	2	3	4	5	6
1	0.87	1.347	2.082	2.354	2.003	**2.003**
2	1.288	1.916	2.491	2.583	2.908	3.524
3	1.288	2.192	2.756	2.771	3.168	3.168
4	1.288	2.192	2.866	2.866	3.213	**4.458**

Meanwhile, Table 4-6 shows travel diaries results for all participants, including the household income, size, and number of trips. The table shows that there are many cases where the range of households' income does not entirely determine the amount of trips individuals make. Additionally, the amount of trips does not always translate to indications of transportation need. The table shows how information about accessibility can be discounted in an aggregated transportation modeling process.

Table 4-6 Summary of Participants Characteristics–Travel Diaries Results

Alias	Location	HH Income (Q6)	HH size	Total distance	Total time	#Trips	Avg. distance	Avg. moving time	Avg. speed	#Diary
Unique	Dallas	<12,000	3	29.81	1:52:04	8	7.11	0:22:25	19.07	2
Beatrice	Dallas	no answer	3	102.02	3:13:46	10	17.00	0:32:18	24.72	2
Ashley	Dallas	$12,001 – $24,000	2	112.67	3:58:04	13	9.27	0:19:14	28.58	2
Dahlia	Dallas	$24,001 - $ 40,000	3	101.74	3:17:28	15	25.43	0:49:22	30.73	2
Mike	Plano	$40,001 - $ 75,000	4	146.85	7:46:11	32	10.49	0:27:25	19.58	2
Richard	Plano	> $100,000	3	180.77	5:31:48	24	9.04	0:16:35	29.44	2
Nita	Plano	> $100,000	3	170.53	5:07:38	24	7.41	0:13:23	31.26	1
Debra	Plano	no answer	2	137.59	5:33:23	30	6.35	0:16:08	22.67	2
Karl	Plano	$40,001 - $ 75,000	3	97.90	2:59:40	21	5.44	0:09:59	31.36	2
Megan	Plano	$40,001 - $ 75,000	3	186.51	6:54:20	36	6.02	0:13:22	29.65	2
Laura	Plano	$40,001 - $ 75,000	1	337.40	9:54:14	27	17.76	0:31:17	39.46	2
Jeremy	Plano	$40,001 - $ 75,000	1	187.73	4:12:49	16	15.64	0:21:04	34.58	1
Rosa	Arlington	$40,001 - $ 75,000	3	70.13	2:44:16	35	2.34	0:05:15	20.74	2
Lynn	Arlington	$40,001 - $ 75,000	2	270.61	9:35:11	39	22.55	0:38:21	21.91	2
Raymond	Arlington	$40,001 - $ 75,000	2	181.38	7:32:56	16	15.12	0:37:45	24.53	2
Fiona	Arlington	> $100,000	2	253.03	7:40:17	23	13.96	0:24:06	37.11	2
AVERAGE			**2.5**	**160.42**	**5:29:38**	**23.06**	**11.93**	**0:23:37**	**27.84**	**30**

4.3.2. Implications on Everyday Travel Experiences

The first implication of this assumption on transportation policies—of future trips based on income—is that areas with higher household income continue to benefit as a top priority for transportation projects because of their perceived needs, while areas with lower income continue to be under-represented and underfunded. Transportation decision-making processes that do not involve adequate representations of transportation needs in lower income areas have long term and generational effects, including lack of mobility and accessibility to access socio-economic opportunities in the region.

Figure 4-3 shows the location of participants relative to the projected 2035 No-build congestion levels and Figure 4-4 shows the location of participants relative to households' median income by a 1-mile buffer of the Census Block Group according to the 2008-2012 data from the American Community Survey (ACS). As shown in Figure 4-4, there is a wide disparity of households' median income in the DFW Metropolitan Area, wherein Plano participants live in higher income areas while Dallas participants live in some of the poorest neighborhoods in the region. One of the many implications of this income disparity is reflected spatially through their visual narratives of what they see when traveling. The disparity as a consequence of this assumption on the everyday experiences is revealed through the photographs taken by participants.

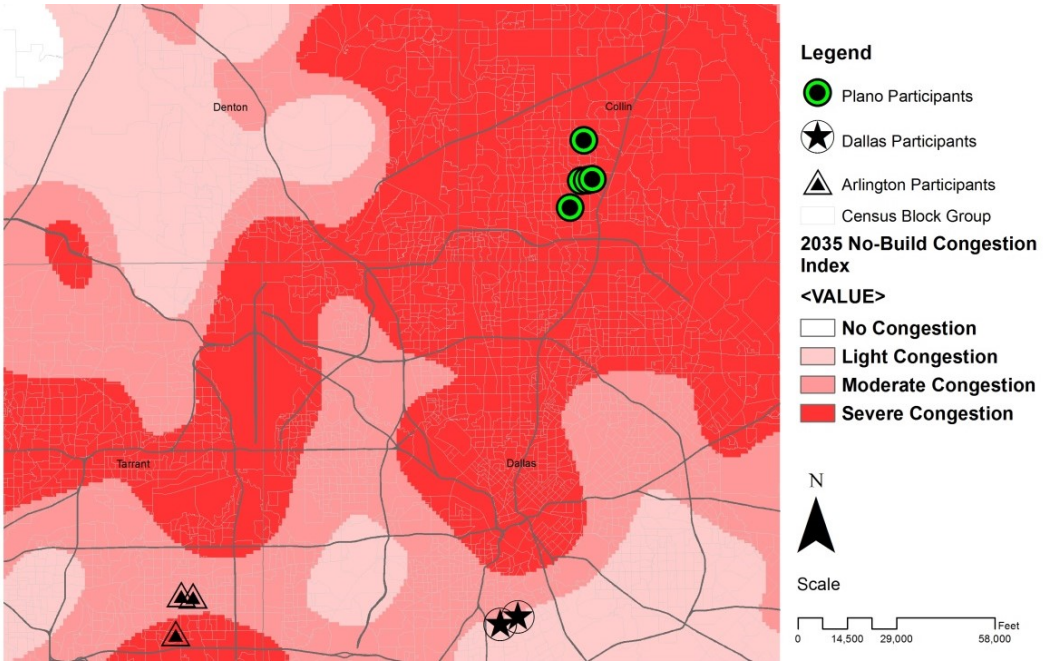


Figure 4-3 Projected 2035 No-Build Congestion Levels (Source: NCTCOG, n.d.a)

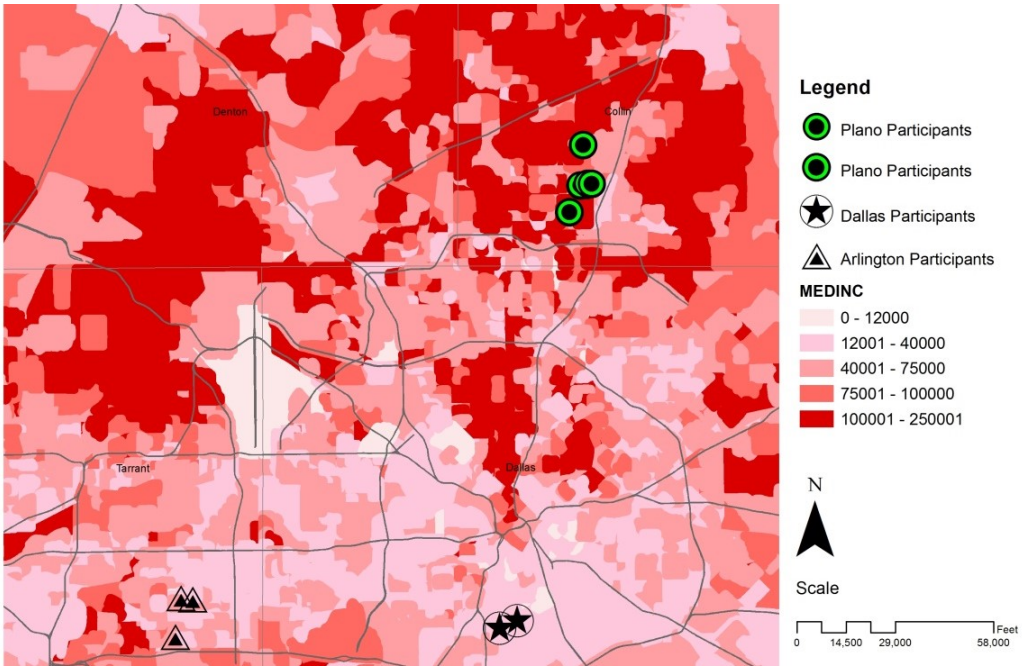


Figure 4-4 Participants/Household Median Income (Source: US Census Bureau, American Community Survey 2008-2012)

When asked to take pictures of their surroundings and experiences during travel, participants in Oak Cliff, Dallas, tended to take pictures of problem areas in their neighborhoods as portrayed in Figure 4-5. The photos taken by Unique, a middle-aged female participant from Oak Cliff Gardens in Dallas with an annual income of less than $12,000, represent the continuous issues faced by the neighborhood, such as illegal dumping, vacant houses, and barriers to walkability in the neighborhoods. Meanwhile, the photos taken by Mike, a middle-aged male participant from the City of Plano with an annual income of $40,000-$ 75,000, represent the transportation investments poured into the northern areas of the DFW Region through images of open roads and highway constructions encountered in his travel to work (Figure 4-6).

Figures 4-5 and Figure 4-6 show the disparity of investments in transportation networks in the areas surrounding the two different areas in the DFW Region, which is congruent with the projections of the region's congestion levels as part of the inputs to determine future transportation needs previously depicted in Figure 2-2. There are also significant differences in the quality of road surfaces and maintenance between Oak Cliff Dallas and Plano as depicted by the participants in these communities, for example, as shown in Figure 4-7 and 4-8.

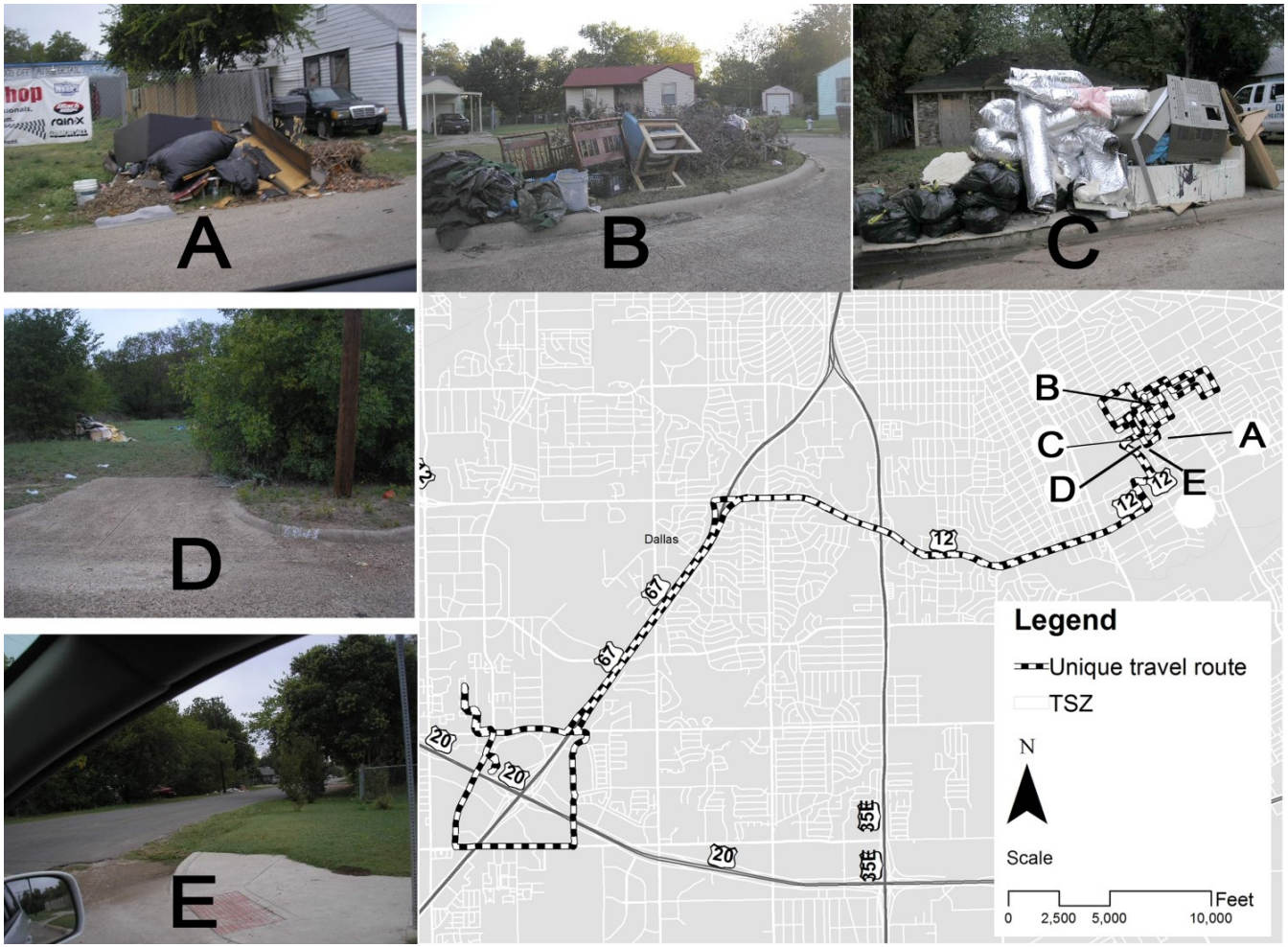


Figure 4-5 Unique's Travel Map, Dallas, TX

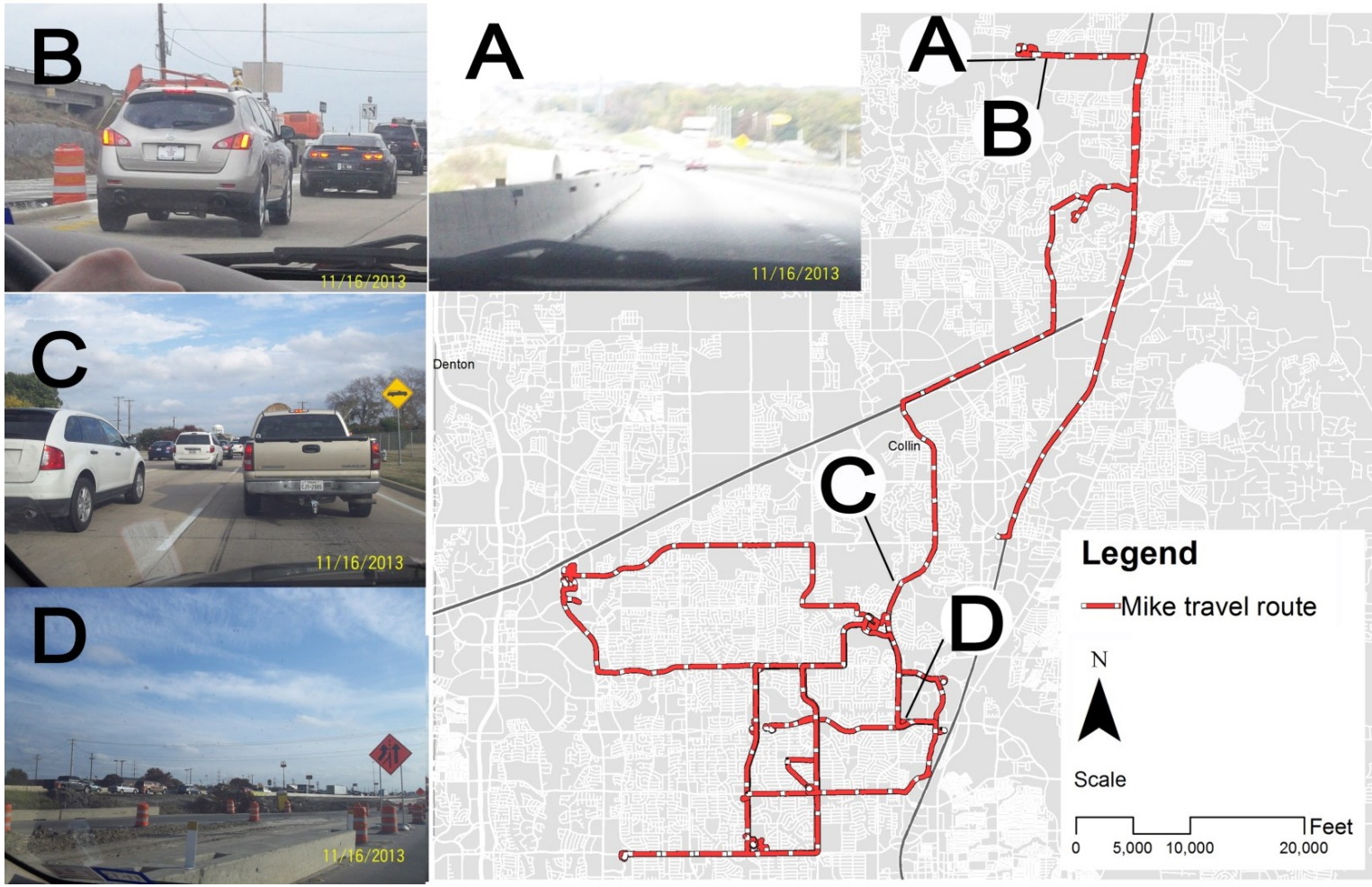


Figure 4-6 Mike's Travel Map, Plano, TX

Figure 4-7 Dallas Participant's Travel Experience

Figure 4-8 Plano participant's Travel Experience

The second implication of the underlying assumption regarding households' income and future trips is that communities predicted to have low travel demand continue to be subjected to the kinds of built environments that reinforce this assumption. Assumptions on the number of future trips generated from particular TSZs reinforce the current conditions of built environment. This is problematic because lower income minorities such as African Americans and Hispanic immigrants in Texas have significantly fewer daily trips and fewer vehicles per households compared to their Caucasian counterpart (Jimenez & Mattingly, 2009). Thus, lower-income minorities typically have lower mobility and lack of accessibility to socio-economic opportunities. If transportation investments are particularly directed to congested areas—e.g. building roads where there are higher travel demands—then many lower income and minorities households' daily travel struggle to access places are reinforced by their surrounding built environment.

The built environment then exercises "sovereign" power that enable mobility for some at the expense of others (e.g. car users have higher mobility by occupying public space therefore taking the space away from other users) (Sheller, 2008). Figure 4-9 and

Figure 4-10 show the spatial arrangements of retail and commercial uses in Plano and Dallas neighborhoods that influence participants' access to these places. Retail and commercial land uses for Plano participants in these neighborhoods are not only clustered along highways but are also located on almost every major road intersections in the city (Figure 4-9). Therefore, it typically takes about 5-15 minutes to drive to grocery stores for most participants in Plano. Meanwhile, many of the retail and commercial establishments within Dallas Oak Cliff are small convenience stores as mapped in Figure 4-10. Access to healthy food options is one of the many challenges for inner city neighborhoods where food sold in these smaller stores is limited and sold at higher prices (Cook, 2006; Walker, Keane, & Burke, 2010). Dahlia, an elderly retired female participant from Oak Cliff Gardens in Dallas, drives approximately 20 minutes one way from home to a national-chain grocery store. The same trip would take at least three transfers and approximately 1 hour and 30 minutes by public transit.

Beatrice, a participant in Oak Cliff Gardens in Dallas, also illustrates this lack of choice:

> I would probably say I don't shop in my neighborhood because there is, like, a limit. You know you have Minyard, that's a grocery store, and they are getting to have CVS drugstores. There's a new CVS that's open, and there is a Walgreens. But the things that I want to buy, maybe [in] Walgreens, the prices are going to be more than if I went to the Walmart because Walmart keep matching the prices. So I have a choice, but I know a lot of people don't have that choice. I guess that maybe if I don't have that choice then I would probably be forced to shop in my neighborhood. (Beatrice, personal communication, October 14, 2013)

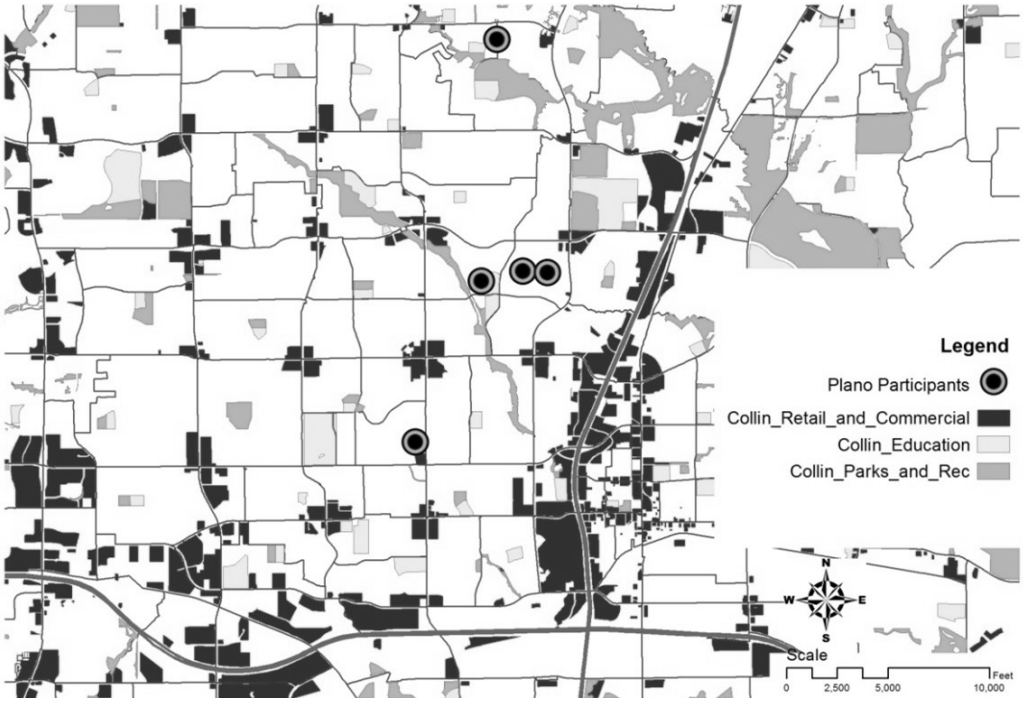


Figure 4-9 Land Use in the Surrounding Areas for Plano Participants

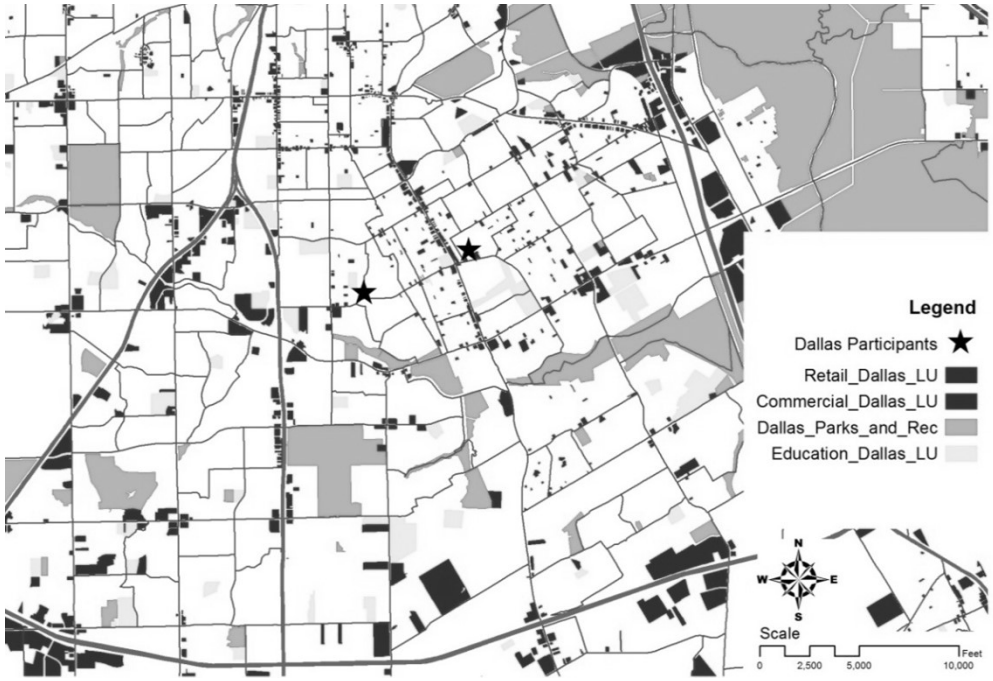


Figure 4-10 Land Use in the Surrounding Areas for Dallas Participants

4.3.3. Mode-Choice Stage: Representations of 'Choice' in Access to Auto Mode

The second key underlying assumption in the Four-Step transportation model—that of the ability for households to choose between auto trips and other travel modes in the Mode-Choice—is typically represented by the probability of households to choose between all available travel modes (Ortúzar S. and Willumsen 2011). The output of the Mode-Choice stage is the distribution of trips that are conducted by the various travel modes available in the planning area. As stated in the NCTCOG's Mode Choice document:

> . . . auto modes are available to all travelers; households without autos are assumed to be auto passengers; this assumption was borne out by the fact that HHs without cars made auto trips in the HH survey data set. (North Central Texas Council of Governments, n.d.-c, 9)

This assumption represents how in the modeling process, travelers are perceived to always have access to a car. An implication of this assumption is that future transportation needs will continue to be focused on car travel, particularly private cars. In contrast, participants in this study often expressed the lack of choices in travel mode and the impacts on their quality of life when no car was available. The disciplinary power of the transportation modeling discourse can be seen here in the *illusion of mobility*, particularly for participants from Dallas because people either have to allocate a significant amount of their income for buying a car or a significant amount of time for travel with public transit. When asked whether her car is reliable, Unique answers, "[a] car is where you invest your money."

The underlying assumption in the modeling process that auto modes are available to all travelers seems to superficially capture these experiences but does not reveal the diverse contexts and motivation of travelers. Participants express to some extent as having *disabled bodies* due to constrains imposed by the need to have a car. Unique uses the term "handicapped" to describe the effect of not having a car;

> I had a car, a truck from my brother, and somebody stole it. They *handicapped* me (emphasis added). I had to wait on people and (ugh) get a ride, and I do not like to take the bus, so I broke down and get a car. (Unique, personal communication, October 7, 2013)

Elderly, as one of the marginalized population groups, continue to be excluded from the ability to exercise capacity:

> . . . . the older I get its more convenient for me to get to places in the private vehicle because the places that I go to, there is no public transportation. . . . (Beatrice, personal communication, October 14, 2013)

4.3.4. Mode-Choice Stage: Representations of 'Choice' in Availability of Alternative Travel Modes

The third key underlying assumption of the Four-Step transportation model—that of the perceived availability of various travel modes—by categorizes trips as those conducted by:

> Auto - drive alone; Auto - two occupants; Auto - three or more occupants; Transit – Auto access; and Transit – Walk access. (North Central Texas Council of Governments, n.d.-c, 5)

This assumption represents alternative travel modes that are considered in the Four-Step transportation model when calculating the distribution of trips being carried out by each travel mode. The first implication of this assumption is the lack of *feasibility* rather than the availability of using public transit. For example, participants in Oak Cliff have access to public transit but have real concerns about safety and crime issues as well as physical limitations from old age and disabilities. People who live in areas where walking to transit is very difficult, due to safety and crime issues, would have little to no alternatives than travel by private auto. Unique uses the term "too much drama" to describe the situations that she might encounter when using public transit. Public transit is not seen as an option for elderly because of the many transfers it requires to get to a

destination. So, in effect, modal choice is limited in the everyday travel behavior of Oak Cliff Gardens' residents despite the assumptions of the model.

The effect of the disciplinary power of the transportation modeling discourse is evident in the way individuals perceive driving as the only option for travel mode. The assumption that alternative travel modes are available is not present when participants are asked about their reasons for choosing to drive compared to other modes. Ashley, who commutes to work from Oak Cliff Gardens to North Dallas, expresses her reluctance and the various barriers to using public transit:

> I prefer using a car. .. If I caught a bus, I'd have to get up much early to get out and catch the bus [sic]. And then if I have to transfer, I have to make sure that I have to be at that place, then, I have to get to my job. When I was younger it probably was OK but I'm old now. (Ashley, personal communication, October 16, 2013)

Participants from Arlington and Plano mainly see the potential of using public transit if their main destination is Downtown Dallas or across-region, but not as part of their everyday travel experiences. This is congruent with the function of the Dallas Area Rapid Transit (DART) as a commuter system to transport workers to central areas but not necessarily a viable public transit means to move in the region. Rosa illustrates this:

> I would [use public transit]. There are times that it would be a lot easier for me not to drive. . . . Especially if it's something that would connect a further distance within the metropolis, say, from here [Arlington] to Plano. That would save me a lot of money on gas, and I can read a book or crochet something while traveling, It is just not available. (Rosa, personal communication, November 25th, 2014)

Raymond, who uses the MAXX in Arlington to commute, says that using the bus to commute to work reduces his stress level and hidden costs of driving such as car maintenance. Even though he has the advantage of living within walking distance, he does not walk to the bus stop because he carpools with his wife to the bus stop on her way to work. However, when asked whether the availability of public transit affect their

decisions to locate in their neighborhoods, all participants except Beatrice from Oak Cliff Gardens (Dallas), respond that availability of public transit was not a consideration.

In conclusion, travel behavior is complex and interrelated with other aspects of an individual's life— as shown from the everyday travel experiences and interviews with participants—contrary to the underlying assumptions of the Four-Step modeling process discussed in this chapter. Applications of neoclassical economics' underlying assumptions to social issues by what Adam Smith calls the "man of the system" (DeMartino 2011), result in a particular spatial layout that constrains women, children, elderly and other minorities to move within the city according to the terms of the 'rational man. Furthermore, the notion of "the universal, disembodied subject" (Hine and Mitchell 2001, 321) has been central to formulation of transportation policies in which travelers are disassociated from their social or biological traits, consequently, fail to consider individual travelers as participants of different activities in different locations.

The findings discussed in this chapter demonstrate how the modeling process is central to the transportation planning process at NCTCOG. The preference of expert-based knowledge manifests in the disciplinary power over certain types of input for the model and authority of the planners and modeling team to determine legitimacy over transportation issues. There are significant distinctions between what planners do compare to what modelers do as well as what each considered as relevant knowledge to understand future travel demands. These differences result in the disconnection between the underlying assumptions with travel experiences of people in their everyday life.

Consequently, there have been increased mobility in the modern West but the ability to move through cities continues to depend on "forms of power that either enable or delimit forms of personal freedom of mobility" (Sheller, 2008, 28). The everyday lived spaces are the site of continuous subjugation at which of the implications of

transportation policies continue to “subject our bodies, govern our gestures, dictate our behaviors, etc.” (Foucault, 1980, 97). It is in these everyday lived spaces that the discursive structure of the Four-Step model contributes to the production of outcomes that perpetuate existing disparity in the DFW Region. Consequently, injustice not only concerns the unequal distribution of transportation resources but also as some population groups are marginalized from meaningful participation in social life within their everyday life (Young 1990).

Chapter 5

MAKING EVERYDAY TRAVEL EXPERIENCE MATTER: PRAXIS FOR INCLUSIVE TRANSPORTATION MODELING AND PLANNING

Chapter 4 makes explicit how underlying assumptions in the modeling process produce outcomes that are materialized into the built-environment and then act as constraints on everyday travel. Furthermore, the various mechanisms of this disciplinary power—black boxing and reification process—maintain the dominance of experts' knowledge over others. Planning and modeling processes that are dominated by experts' knowledge produce particular spatial layout and transportation infrastructures wherein the ability to move through cities results from these processes and differs based on socioeconomic status (Hine and Mitchell 2001; Sheller 2008).

Participants' travel experiences illustrate how the underlying assumptions of the Four-Step transportation model reinforce differences in mobility and accessibility, illusions of choice in access to auto modes as well as a lack of available alternative travel modes for travelers. For example, participants from Dallas engaged in the study have the longest maximum trip distance (25.43 mi), travel more (14.7 mi), and have longer average moving time (30:50 mins) but make much smaller number of trips (11.5 trips) compared to participants from other cities. Plano participants who are located in higher income areas of the region benefit from existing built-environment, mostly in their ability to go to places faster in distance and moving time, compared to other participants.

The dominance of expert knowledge shows how transportation planning is considered highly technical but is also weak in public participation (Khisty 2000). The findings in Chapter 4 demonstrate that planners exercise communicative rationality, but experts' knowledge—through the modeling process—dominates the transportation discourse, exercises disciplinary power to exclude, and, therefore, presents challenges

for inclusive planning practices. The recommendations discussed in this chapter are based on the applications of communicative rationality to allow transportation model's outputs to be viewed as one form of representation of transportation needs rather than as forecast, and therefore makes it possible to include other ways of knowing in the transportation discourse (Willson 2001; Khisty and Arslan 2005; Timms 2008). Critiques of communicative rationality warn that a normative ideal of communication put too much emphasis on planning process, therefore, separate ends-means as well as neglect the power relations that affect outcomes (Huxley and Yiftachel 2000; Fainstein 2010).

Chapter 5 is divided into three sections. The first section discusses forms of exclusion in two of the most important practices of regional transportation planning: forecast of future needs and the inclusion of communities. The transportation modeling process subjugates participation through the black-boxing contested knowledge into a normalized set of mathematical formulas and computer programming. Transport model, as a visualization tool, gains disciplinary power from its ability to visually communicate the world of science and technology to policymakers and the public (Pavlovskaya 2009).

The second section revisits applications of communicative rationality where transportation model's outputs are viewed as one form of representation of transport needs rather than as "scientific" forecast, and therefore allow other ways of knowing in the transport discourse (Willson 2001; Khisty and Arslan 2005; Timms 2008). Critiques of communicative rationality warn that a normative ideal of communication puts too much emphasis on the planning process, thereby, separating ends-means as well as neglecting the power relations that affect outcomes (Huxley and Yiftachel 2000; Fainstein 2010). I revisit applications of communicative rationality in transport planning not as a call for a comprehensive approach to planning where communication and language must be at the center. Instead, I draw on the analysis of language and images as a system of

representation (Foucault 1980; Hall 2003) and as a way to delineate areas where disciplinary power is exercised and where resistances to these disciplinary powers—collective struggle of subjugated knowledge— might be considered within the transport discourse.

The third section discusses potential praxis for inclusive transportation planning process and outcomes from distributive and social justice frameworks. Under the distributive justice framework, resistances take the form of explicit considerations of equity (Martens 2006) and integrated modeling approaches of the "disadvantaged population" (Duvarci and Yigitcanlar 2007, 188). The social justice framework engages with meaningful participation in a democratic decision-making process (Young 1990). Under the social justice framework, resistances might take the form of deliberative engagement practices through diverse data collection method and public outreach efforts. Resistances also take the form of decisions that residents make in their everyday travel experiences as well as the reflective practice of planners to seek out what these decisions could affect future transportation needs.

5.1. Transportation Modeling Process, Disciplinary Power, and Public Participation

The barriers to mutual learning process between experts and experience-based knowledge are connected with how disciplinary power is exercised in two fundamental elements of long-term regional transportation planning practices. Those two fundamental elements are the use visualization techniques, such as transportation models and the requirement for public input. Requirements to use visualization tools and public input are practices outlined in the Environmental Justice Executive Order of 12898 in 1994, Transportation Equity Act for the 21st Century (TEA-21) of 1998, and Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005 (Weiner 2008). Therefore, these policies have significant implications for regional

transportation planning practices of Metropolitan Planning Organizations (MPOs). These policies provide a platform to address grievances related to the unequal distribution of benefits and risks associated with regional infrastructure projects and planning (Bullard 1997; Bullard 2004). However, exclusion in everyday travel continue to be experienced by different population groups (Hine and Mitchell 2001; Grieco 2003; Rosenbloom and Altshuler 1977; Rosenbloom 2005; Sheller 2008; Blumenberg and Manville 2004; Blumenberg 2004). The combination of these policies provides openings where for collaborative efforts between different community groups might change policy directions in regional transportation planning (e.g. Rast 2006). Nevertheless, public participation remains as a challenge in transportation planning (Khisty 2000).

The first fundamental element in long-term regional transportation planning required by federal policies is the use of visualization techniques. In the 1950s, transportation planning emerged as a discipline along with developments in transportation modeling and large-scale urban modeling efforts (Kane and Del Mistro 2003). Furthermore, the federal government increased support for large-scale transportation studies on regional highway networks with emphasis on cost-benefit analysis (Weiner, 2008). By 1970s, the Federal government moves toward a system approach to planning that focused on the continuation of comprehensive and coordinated federal, state and local planning (Miller, 1973). The presence of a continuous, comprehensive, and coordinated plan becomes a prerequisite for MPOs that want to use the Urban Mass Transportation Authority's (UMTA) funding—currently known as the Federal Transit Authority (FTA) (Miller, 1973). By 1990s, states are required to have a continuous state-wide plan modeled in the metropolitan transportation planning plan and the SAFETEA-LU required MPOs to use visualization techniques for stakeholders and states for long-range transportation plans (Weiner 2008).

This requirement further cemented the position of transportation models in the transportation planning and decision-making process. Therefore, the long-term regional transportation planning process utilizes visualization tools such as transportation land use models and Geographic Information Systems (GIS). Figure 5-1 shows the role of transportation and land use models in the implementation process where after evaluation/recommendations, the outcomes are then implemented. Land use models are used to determine the distribution of projected population growth across the region based on households' population size and employment (Iacono, Levinson, and El-Geneidy 2008). Outputs from the land-use model serve as input for the transportation model for which outputs are often visualized spatially by GIS.

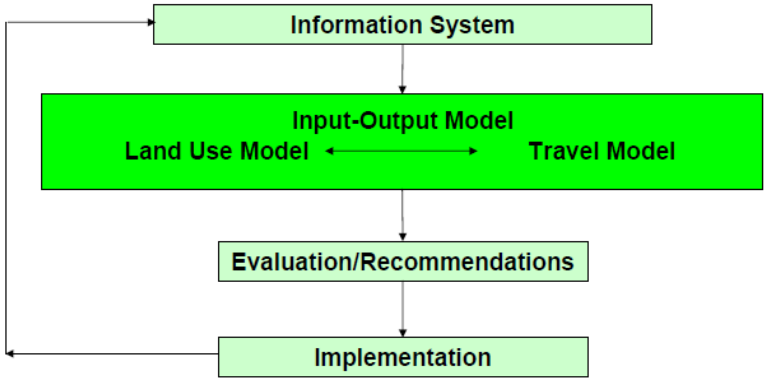


Figure 5-1 Role of Modeling in the Implementation Process (Source: North Central Texas Council of Governments 2006)

Spatial visualization techniques are powerful because of its ability visually to communicate the inaccessible world of science and technology to policymakers and the public (Pavlovskaya 2009). Additionally, credibility is given to the use of data that have been gathered by legitimate institutions such as the Census Bureau (Elwood 2009). The modeling outputs are considered as one of the many technical foundations for the decision-making process. The legitimacy of the modeling process hinges on the

relationship between rationality and power. Power is gained from the ability to provide rationality, or at least, the ability to provide a rationalization for a decision (Flyvbjerg 1998). The following statement from a planner interviewed for this dissertation illustrates how outputs from transportation model to explain and provide technical justifications when making recommendations to elected officials and the public:

> In planning, we are not the decision-makers. We make technical recommendations to policy boards, and politics is often what we do. We want the decision-makers to have *the advantage of having a technical foundation* (emphasis by author)**.** (Interview with a transportation planner, May 2, 2014)

Contrary to GIS, transportation model is a tool that is exclusive to "experts" in transportation planning. GIS are taught more in planning schools and are increasingly used across disciplinary boundaries. Additionally, GIS software is increasingly more accessible to be used in personal computers. Communities have been increasingly able to tap into the legitimacy given to GIS to provide alternative knowledge about their needs (e.g. Elwood 2009; Elwood 2006; Knigge and Cope 2009; Creswell 2009).

Meanwhile, transportation models are both expensive and complex to develop and to maintain. Most modelers are highly educated and specifically trained in this specialized knowledge. For example, members of the NCTCOG's modeling team interviewed for this research are highly educated and specifically trained in either engineering or computer programming. Therefore, the transport model is akin to a black-box. Arguments about issues are settled into a number of specific assumptions, mathematical equations, and computer programming that forms the black box (Latour and Woolgar 1986). Transport model as a black box becomes a very powerful tool for making decisions about who-gets-what-when-where, and even how these decisions are made due to its technical foundation. "It is unlikely, for example, that anyone will contest the wiring of the computer, or statistics on which the "t" test is based" (Latour and

Woolgar 1986, 242). Consequently, the black-boxing of contested issues in transport planning presents particular challenges for the inclusion of public input. The following quote from one of the planners interviewed illustrates how planners are puzzled over what to do if public input conflicts with outputs from the model**:**

> I've had many conversation [with members from the public outreach department] about how do we get people to be more involved in the [long term planning] process and sometimes they'll ask me, "Well what would you do with the information if you do have it?" And I'll be honest, I don't know what I would do with it if I had it, *especially if it's contradictory to what our, for instance, travel model is telling us what happened* (emphasis by author). I do not know what I would do with that information, to be honest, I do not know. (Interview with a transportation planner, July 18, 2014)

Another challenge for inclusion is the deliberate intention to keep the modeling structure constant. The practice of forecasting means that the transportation model operates under the assumptions of *ceteris parebus*—with other conditions remaining the same—an assumption viewed as essential to the modeling process due to the various complexities associated with the transportation modeling process (Timms 2008). The model's output represents fixed relations between assumptions about travel behavior based on a set of variables with future travel demands. According to a member of the modeling team, the transportation model is built based on data-sets. To evaluate how the model performs under a different data-set, there needs to be proof that the model needs to be re-calibrated. The calibration process involves the selection of parameters to achieve *goodness-of-fit* to the observed data. Meanwhile, the validation process involves comparing the model's output, typically base-year predictions, with observed behavior of the transportation system (Ortúzar S. and Willumsen 2011). Once the model is calibrated using the new data set, it is then re-validated to check the forecast if it is still able to model observed travel behavior. Thus, the modeler attempts to control this process:

> For each step of changes, I [need to] know where the changes are and have to make sure all the side effects are controlled [by only changing one input at one time and keeping other elements constant]. Everything has to be calibrated. It is a whole process. (Interview with a member of the modeling team, September 11, 2014)

Consequently, the long-term planning document, the Metropolitan Transportation Plan (MTP), currently Mobility 2035, is intentionally kept constant and only gets updated based on new data but not necessarily based on input that are brought up by a public participation process. As a visualization tool, this fixed quality provides the ability to analyze the relationships between the data and policy changes (Wilson 2009). The model then is able to show, for example, how a construction of a highway affects changes in other variables in the surrounding area. Although *ceteris parebus* is considered necessary, the question of *what* are kept constant *is* contested knowledge (Timms 2008). Data collection, categorization, and analysis always involved decisions about what variables or factors are "significant" to be included or excluded.

The implication of this deliberate attempt to remain constant is a predetermined future in terms of the types and particular transportation projects that ultimately get built for the next 20-30 years' time span. Hence, when reviewing the underlying philosophy of transportation models, Timms (2008) argues that, "Due to the mathematical nature of the model, the story is *closed (author's emphasis)*: i.e. given exogenous factors and a starting point, the future is fully determined" (Timms 2008, 406). Additionally, transportation model outputs are often represented as "findings" instead of a form of communication in a discourse (Willson, 2001). Thus, participation are limited to providing input on issues that are predetermined and more often are already decided on (Khisty 2000; Quick and Feldman 2011). Public meetings are structured so that people have the opportunity to comment on further actions based on the outcomes, but not on the assumptions that produce the outcomes:

> We really don't get into the technical modeling just because, the public, I don't think, understands that we're assigning based on census demographics and survey information where we think people will go in the future. So it [the public meeting] really won't cover that but it is more about the goal, the type of projects that they'd like to see, the financial assumptions that we are making. [For example] if nothing changes, more projects will have to come out from the plan. . . . So, that is really what you talk to the public about, "how do you afford these transportation projects?" (Interview with a transportation official, June 18, 2014)

The position of the model as a black-box and attempts to get the public to participate more in the decision-making process are contradictory because the two are disconnected. The monetary cost and resources to challenge the black-box—transportation model—are impossibly high (Latour and Woolgar 1986). For instance, there are various stages to be considered to contest the outputs of the transportation model. The first stage is to identify the underlying assumptions of the modeling process that produces the undesired outcomes. The second stage is to identify what data needs to be collected again. The third stage is to collect data that requires access to financial and human resources. An example of this third stage is the travel diary method used in this research which is a long process of finding participants, making sure the equipment operates, collecting and triangulating data, analyzing data, and organizing into meaningful information about each participant's travel experiences. The data still need to be represented in a manner that is considered "valid" by the experts in the existing institution even if communities can gather resources to collect alternative data. The fourth stage—if the new data set is considered as legitimate data—is to go through the process of calibration and validation of the model's output with the most current observed travel behavior. Neither of these stages is easily accessible for community groups that might raise concerns over implications of future travel forecasts on their ability to have improved transportation access. A successful attempt to change long-term regional transportation planning directions includes collaborative efforts between groups and

experts to produce maps and report about spatial mismatch and inner cities decline (e.g. Rast 2006).

Interviews with transportation planners reveal that transportation planners continuously deal with complex issues and the political nature of planning (Willson, Payne, and Smith 2003; Innes and Gruber 2005). When knowledge is contested, there can be intentional reliance on the discursive 'expert power' of computer visualization (Elwood 2009, 69). The potential to use transportation model's outputs to establish authority on issues where knowledge is contested is higher when expert knowledge dominates the planning process. A transportation planner interviewed for this dissertation discusses how the transportation model's output is used in a contested issue such as a community group's demand to tear down a part of the I-345 highway that goes through Downtown Dallas (see Kennedy 2013):

> The model does come in handy when we do talk to some community groups [that demanded to tear down a section of I-345]. But it is an education to help them understand that the model is sensitive to these types of things [referring to how traffic is distributed into road networks]. (Interview with a transportation planner, July 18, 2014)

This 'data-driven' discourse produces planning practices and policies that contribute to the production of built environment in which daily activities such as getting food, going to jobs, taking children to their school are carried out. Our bodies, gestures, and behaviors are then subjected to the disciplinary power of the built-environment in these everyday lived spaces (Foucault, 1980). Interviews with transportation planners at NCTCOG reveal that although public meetings are regularly held, there is a lack of participation in long-term transportation planning process. Consequently,

> Certainly there can easily be a mismatch between their needs and what [is] perceived to be their needs. We are not even actively getting to the people about the public meetings for the input. We get nothing. (Interview with a transportation planner, May 2, 2014)

Another fundamental component of long-term regional transportation planning is public participation**.** Transportation planners interviewed in this research expressed a desire for more public participation but are ambiguous about how to include public input into the planning process. The increasing emphasis on public participation in transportation policies allows plans to be considered as programs that need to be executed, and to some extent, can be seen as a binding agreement between various stakeholders and the government (Weiner 2008). Therefore, public participation process adds another layer of legitimacy to the planning process. In their study of planning processes in San Fransisco MPO, Innes and Gruber (2005) identify that four different planning styles—technical/bureaucratic, political, social movement, collaborative—have different attitude towards public participation. Each planning styles operates under a set of visions and goals that affects how each approach views public participation. They find that collaborative approach best applies to situations where there is high diversity and of interests as well as interdependence amongst stakeholders. However, collaborative approach faltered when lack of inclusion often initiate oppositional movements (Innes and Gruber 2005). Out of the four planning styles, the technical/ bureaucratic and political planning styles tend to benefit from the lack of public participation. In general:

> . . . . The [transportation] planning process has typically undervalued public input mostly because we [planners] know that people are really talking about [when they provide input is based on] what their observation today. I think people also tend to overestimate their reaction to future transportation conditions. If you tell somebody that there will be a Disneyland-type monorail in their neighborhood, would you use it? [They would say,] . . . of course I'll use it but revealed preference tells us that you don't. (Interview with a transportation planner, July 18, 2014)

The way public participation process is conducted can increase mistrusts between government organizations and population groups (Quick and Feldman 2011). The dominance of technical/bureaucratic and political planning styles encourage lack of public participation, by institutionalized practices that only treat public hearing as one-way

informational sessions and to add legitimacy to already decided projects (Innes and Gruber 2005). Arnstein refers to this as “tokenism” on her ladder of citizen participation (Arnstein 1969, 217). Even worse, public participation can be a site of manipulation and therapy where those in power see it as an opportunity to “educate” or “cure” misguided participants. Various forms of exclusions are subtle but discourage meaningful participation through the manipulation of languages and images where issues are presented in terms that most people are not familiar with (Young 2004). When asked whether participants feel that their input can affect the decision-making process based on their experience participating in local government’s public meeting, Karl responded:

> I do not know if there is any one time where they actually took our feedback. Mostly [they provide] information. (Karl, personal communication, September 11, 2014)

When asked what happens when concerns are raised about the modeling output in a public meeting, a member of the modeling team insists on “proof” and seems to perceive questions about the model’s output as challenge to the validity of the modeling process. Additionally, when responding to questions about mode-choice, a member of the modeling team said that the model does not concern *how* people get to work but *whether or not* people go to work. Therefore, the model will only be altered if there changes to, what they refer to as the “core assumptions” of the model, demographic forecasts regarding HH size, e.g. if everyone in Dallas-Fort Worth decided to have 5 children in the next five years. Therefore, public input is not considered in the transportation modeling process because it is considered as situated outside of the modeling process.

If the model is viewed, however, as a system of representation, public input can be used to pinpoint areas where the models may not be sensitive to. For example, if presented at community meetings where assumptions and implications of these

assumptions are laid out, public input can take the form of pointing out areas where communities would be most disadvantaged by the modeling output. The planning process can be reiterative in the sense that it takes a closer look into these areas and address the potential disparity with other policies.

5.2. Revisiting Communicative Rationality in Transportation Planning

Transportation planning practice is still largely dominated by the use of instrumental rationality (Willson 2001; Khisty and Arslan 2005; Innes and Gruber 2005). Rationality is seen as having an independent existence and only brought into the process as instrument to achieve the objectives in an ends-means process by utilizing scientific knowledge and technology to inform decision makers. Transportation infrastructure projects are typically large-scale, long-term, require large fixed capital investments, and coordination between institutions (Ortúzar S. and Willumsen 2011). Consequently, the "Predict and Provide" approach where the main objective of transportation planning is to predict future travel demands and accommodate by building infrastructures has been dominant because of its reliance on science and technology (Owens 1995; Vigar 2002; Willson 2001).

Institutions have the capabilities to produce 'official data' with a specific purpose of making some claims to 'truth' through aggregated representations of reality (Knigge and Cope 2009). This claim to truth evokes Max Weber's famous caution about how too much reliance on scientific knowledge and technology signals the emergence of another type of elite that can disempower citizens and decision makers (Schneider and Ingram 1997). The ability to produce and choose types of data to present produces knowledge that is exclusive and is only circulated in closed networks of those who can understand them (Foucault 1980; Schneider and Ingram 1997; Flyvbjerg 1998). As a result, decision makers and citizens are disempowered either because they are not able to understand

the information or feel that their knowledge is not important. For example, Debra reflects on her experience giving input for a comprehensive planning process in Plano:

> It's difficult to feel like you have the knowledge to even participate, to project that far into the future. . . . Seems like you have to have training and education to know how to project that far out. (Interview with Debra, September 14, 2014)

Planning practices based on communicative rationality have been criticised as emphasizing a democratic planning process but not necessarily on equitable outcomes (Fainstein 2010). Planners are often situated amongst political interests, forces that systematically violate Habermas' communication rule, and the lack of power of planners to make decisions or set the rules on dialogue (Fainstein 2010; Innes and Gruber 2005). Inherent inequality in society means that there is inherent inequality in power when parties engage in dialogue and the various forms of exclusion in the decision-making process (Young 1990; Young 2004). Often decisons are already made when it reaches public hearings where expertly-conceived options are already laid out (Fainstein 2010; Fischler 2000; Talvitie 2001; Arnstein 1969). In summary, critiques to applications of communicative rationality are directed to the various forms of how power is exercised to exclude meaningful participation in the decision-making process. Exclusion not only takes the form of physical restraints but also in the the use of language, signs, and images that are incomprehensible to particular audiences (Arnstein 1969). The use of disciplinary jargons can exclude those who do not understand them. For example, the term "discrete choice" (i.e.an individual's decision to choose from a finite set of alternative travel modes, see Ortúzar S. and Willumsen 2011), may invoke confusion in public discussions. In this sense, power is exercised by the various forms of disciplinary practices in a discourse (Foucault 1980).

Suggestions to explore applications of communicative rationality in transportation planning stem from persistent transport inequality and lack of public participation due to

the heavy reliance on instrumental rationality (Khisty and Arslan 2005; Khisty 2000; Willson, Payne, and Smith 2003; Timms 2008). Therefore, communicative rationality that is situated in the transportation discourse needs to find ways to integrate beliefs about strong technical foundation and inclusive public participation. Willson (2001) delineates six areas where applications of communicative rationality provide an alternative framework for engaging in transportation discourse (see Table 5-1). These alternative frameworks provide a guideline for deliberation yet practice may prove to be more difficult as transportation planners continue to answer demands for accountability and technical foundation. In analysis/modeling process, knowledge continues to be defined as that of resulting from a particular set of data and gained from a particular type of empirical study.

Although there is a general agreement on the need for transportation planning to adopt an alternative paradigm, Talvitie (2001) contends that frameworks based on communicative rationality do not provide explicit suggestions to changes in planning practices, in everyday experiences of people, or in travel behavior. Similarly, the assumptions of ideal communication between stakeholders disregard the role of ideology and cultural practices in shaping actions (Whittemore 2014). These critiques recognize the way everyday practices contribute to issues explored by Willson (2001): the role of planner, the purpose of planning, planning process, communication, problem framing, and analysis/modeling process.

Table 5-1 Instrumental and Communicative Rationality in Transportation Planning

(Source: Willson 2001)

Issue	Instrumental Rationality	Communicative Rationality
1. Role of the planner	Expert/analyst. Often a specialist (e.g., modeling, community affairs, finance, etc.) Official role is objective, but usually plays a political role.	Communicative expert with technical knowledge and skill. Plays multiple roles--process design, activist mediation, education and technical roles. Self discloses roles.
2. Purpose of planning	Problem solving and optimization, with a rational decision-maker as the client. Finding the best solution for a fixed and known set of ends.	Reaching an understanding that facilitates action. Increasing capacity for reasoned deliberation and democratic decision-making.
3. Planning process	A sequence of linear steps (with feedback). Assumes that facts and values can be addressed separately. Action follows knowledge.	Recursive process: fact, value and discovery are interlinked. Emphasizes learning and consensus building. Is invented/modified as part of the planning activity. Action and knowledge are simultaneous.
4. Communication	Planners' communication is assumed to provide accurate representations of facts and values; has standard meaning outside of action.	Communicative processes produce meaning and linguistic "action". Planners seek to improve the validity with which claims are made, e.g., truthfulness, legitimacy and sincerity.
5. Problem framing	Problems can be defined and bounded in a single frame; problems can be broken into pieces and recombined; problems can be defined in the absence of solutions; problems can be "solved".	Multiple problem definitions and frames are acknowledged; problems are broadly bounded. Planning actively engages multiple problem frames, seeks creative redefinition.
6. Analysis/ Modeling	Reductionism, reliance on data and models as forms of inquiry. Knowledge is empirically established.	Quick-response models used along with other forms of knowing. Modeling claims are part of discourse.

Healey (2008) argues that communicative planning practices have pragmatic views that emphasize different world views without disregarding in-depth understanding of the substantive issues at hand. Similarly, pragmatic communicative action allows for understanding of theory ". . . . as a kind of practical reasoning rather than a kind of

template or primal rationale" (Hoch 2007, 279). Furthermore, these pragmatic approaches highlight the importance of constructing and acknowledging a variety of knowledge claims and reinforce "human capacity to invent, create, and transform" (Healey 2008, 281). Thus, much of the theoretical underpinnings based on communicative rationality contains pragmatic traits that emphasize the interconnectedness between theory and practice (Healey 2008).

A pragmatic communicative action integrates scientific knowledge with inclusive planning practices where the planning process includes describing future consequences, utilizing models and analysis of causal-relationships, along with narrative and images (Hoch 2007). In this sense, changes to existing practices might occur when frameworks of issues are highly contextualized to identify new relationships. Therefore, the planning process focuses on telling narratives, exploring existing case and instances where collective struggles lead to a shift in power relations (Fischler 2000).

5.2.1. Transportation Modeling Process as a System of Representation

This section revisits the discussion of transportation modeling as an institttuionalized and discursive practice. I make the argument that the discursive nature of the transportation modeling process allows for expanding the modeling process from a forecasting tool into a system of representation. A model, as an aggregated representation of reality is, in that sense, always wrong because it can never fully capture the complex nature of human interactions, but it can be useful to explore alternative scenarios when underlying assumptions are clearly laid out (Klosterman 2013). In this sense, the transportation model's outputs become one of the many ways to understand transportation needs. The difference between technical planning and collaborative planning is that in the latter, values are explicit (Innes and Gruber 2005). Therefore, the role of transport model shifts from being a tool to forecast travel demands into a system

of representation where numbers that represent future travel demands can be explored along with other forms of inquiries.

A system of representation—as "an essential part of the process by which meanings is produced and exchanged among members of a culture" (Hall 2003, 15)—acts as the vessel in which what is considered as knowledge can be shaped and reshaped by members of the transportation planning discourse. As a system of representation, the transportation modeling process acts in tandem with other forms of knowing because the model's output is seen as one of the many ways transportation needs and capacities are communicated. I propose three changes to view the model as a system of representation rather than as a forecasting tool.

The first change in the transportation discourse to view the transportation modeling process as a system of representation requires a form of, what Marcuse (2010) calls *reflexivity*, as being aware that world views are shaped by historical and dominant forces of societies to reinforce existing conditions. Therefore, the underlying assumptions that go into the modeling process are evaluated as a product of historical context and the dominant discourse in the transportation planning discipline.

The modeling process, then, is based on understandings that knowledge about travel behavior is also affected by history, identity and culture, in addition to utility considerations (Willson, 2001). The practice of modeling is a result of a variety of transportation policies arises out of particular economic, social, and political contexts. Additionally, transportation policies are interconnected with other aspects of urban development. Transportation decisions in the Dallas-Fort Worth Metropolitan Area are not the result of the model per se but the result of a variety of historical, political and disciplinary traditions.

The transportation modeling process is institutionalized into the transportation policy discourse since the emergence of the transportation planning discipline in the 1950s (Kane and Del Mistro 2003). An institutionalized pollicy discourse means that underlying assumptions are deep-rooted in the discipline and institutional practices (Vigar 2002). An institutionalized policy discourse exercises disciplinary power that operate in subtle mechanism considered as normal practices. The transportation modeling process is a mechanism of the 'Predict and Provide' policy discourse that also produces narratives such as as 'road for prosperity' (Vigar 2002). Within this discourse, planning practices utilized instrumental rationality that relies heavily on scientific knowledge and technology. The transportation model is a product of this discourse that are costly to build and maintain. Statistical analysis often treats 'outliers' as 'anomalies' so that the data can be abstracted and aggregated to simplify the modeling process. The model is a tool to visualize human behavior and its relationships with the existing built environment. The model and the computer programming are products of specialized knowledge and interdisciplinary practices wherein both are applications of partial knowledge about human behavior as its underlying assumptions (Pavlovskaya 2009).

The transportation model is socially constructed. In this sense, the modeling process acknowledges that numeric outputs from the transportation model can only be made meaningful by the use of representations—a set of signs, images, and language that conveys meanings within a discourse (Hall 2003)—and therefore are not privileged over alternative knowledge. Martens and Hurvitz (2011) conclude that although the Four-Step transportation model has a tendency to generate higher travel demand for higher mobility groups (high-income and car owners), but the ways these modeling outputs are communicated for policy recommendations have the potential to neutralize this tendency. Planners might increase awareness of the underlying assumptions and stress the need to

provide alternative policies for populations that are disadvantaged (lower mobility groups). Hence, stressing the importantance of representations through the deliberate use of images and languanges to provide a context for the numerical outputs. The production of knowledge in transportation planning and modeling process is not what a transportation modeler exclaimed in the interview as "black and white" but is discursive—and is contested knowledge—and therefore requires an explicit communicative process between modelers-planners-elected officials-the public.

The second change in the transportation discourse to view the transportation modeling process as a system of representation is to widen the scope of the transportation modeling process. As a system of representation, the scope of the transportation modeling process not only consists of quantitative analysis and computer programming but also includes interactions between planners' and modelers' world view with the model *and* with each other (Timms 2008), as well as the process of representing and communicating the model's output to a variety of different audiences. In this sense, the the transportation model produces knowledge about activities of people between places based on a set of underlying assumptions. The transportation model shifts from being a *tool to forecast* travel demands into *a system of representation* where numbers that represent future travel demands can be explored along with other forms of inquiries.

The inclusion of alternative knowledge occurs if these assumptions are disclosed and, therefore, allow communities opportunities to compare these assumptions with their experiences and desires about future transportation system. Figure 5-2 illustrates the various elements in conceptualizing the modeling process as a system of representation.

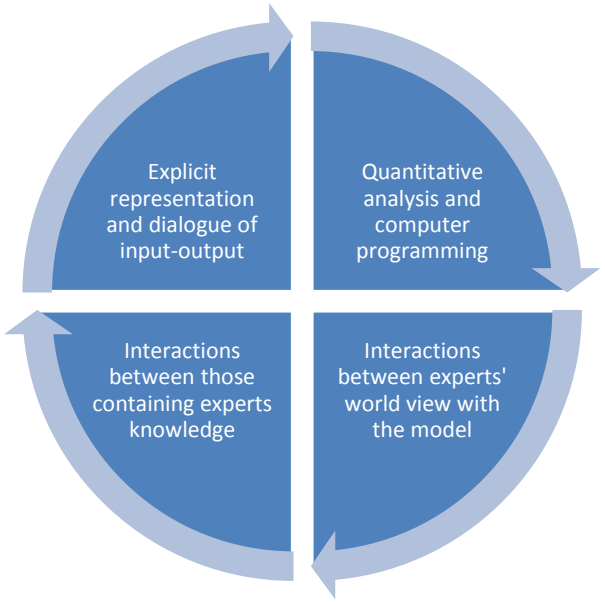


Figure 5-2 Transportation Modeling Process as a System of Representation (Source: drawn from Timms (2008)

Furthermore, the use of communicative rationality in transportation planning posits that if there is doubt about the result of the modeling, then these doubts should be disclosed in the planning process (Timms 2008). Planners and modelers should acknowledge that the integration of planners' and modelers' perceptions of how the world works in the modeling process contributes to the production and interpretation of the modeling outputs. Thus, planners should disclose their confidence in the modeling outputs (Willson 2001; Timms 2008). Relationships between variables are determined by exploring probabilistic relationships but not based on certainty. Rasouli and Timmermans (2012) contend that, "a model is nothing but an expression of the researcher's beliefs about the relationship between theoretical constructs" (57). A senior transportation planning official describes this process:

> I think experience is the only way [to determine whether the model's output is reliable or not]. . . . Whenever you look at a forecast, you also have to look at what the calibration or the validation looks like. You can not just look at the forecast and say "that's what it is". Every model has areas that it does not do very well at, so I always tell people that you have to show me the current forecast for the validation along with traffic counts that are there today. So, I can see if the model is replicating today's traffic very well and if it is not, then we have to question the forecast. (Interview with a transportation planner, July 18, 2014)

The following statement by a planner illustrates the discursive structure of the Four-Step transportation model and how, as a system of representation, the model produces outputs that ceased to be meaningful when there are changes in people's travel behavior that were not anticipated when the model structure was created:

> [For example], Downtown Dallas used to have 2000 to 3000 people that lived there, but now there are 20,000 to 30,000 people there and a lot of them are not driving. They are either taking transit or walking to work. Whereas if we try to model 10,000 people in Downtown Dallas, the model is still going to try to send them 25 minutes away from Downtown Dallas because the model was calibrated on a trip length that says work trips typically travel 25 miles or 25 minutes. So the model is not sensitive to the changing policies that encourage a more urban lifestyle. (Interview with a transportation planner, July 18, 2014)

The third change for an expanded understanding of transportation modeling processes is that those containing expert knowledge must be reflective on how existing practices include and reinforce particular structure in society as well as exclude others. Both planners and modelers should recognize the implications of the discursive nature of underlying assumptions used in the modeling process. Particularly because it is difficult to determine the extent to which policies that address transportation exclusion can mitigate how the Four-Step modeling process reinforces travel demands based on households' income levels (Martens and Hurvitz 2011). Therefore, Willson (2001) suggests that modelers need be involved in participatory activities with communities so modelers not only can understand the various motivation for travel but also the implications of their technical analysis. Therefore, modelers might be able to understand

how current underlying assumptions reinforce existing uneven development patterns in a metropolitan region. Particularly, the relationships between mobility mismatch between those who have cars and those who do not, with access socio-economic opportunities (Blumenberg and Manville 2004). Interviews with planners and modelers suggest that planners understand the political reality of competing interests but rely on modeling outputs to provide a technical foundation for policy recommendations.

Understanding the transportation modeling process as a discursive practice—that it produces what it assumes—makes it possible for a different outcome when there is a mutual learning process between expert and experience-based knowledges. According to Willson (2001), modeling and research should be a continuous process that is reactive to policy questions instead of a distinct step to provide estimates for policy recommendations. Table 5-2 summarizes the three changes as conditions for an expanded understanding of the transportation modeling process as a system of representation.

Table 5-2 Three Changes for an Expanded Understanding of the Transportation Modeling Process

Proposed Changes	Conditions
As an institutionalized practice	• Reflective of the historical, political, and disciplinary traditions • Socially constructed knowledge • Discursive and contested
Scope of the modeling process	• Quantitative analysis and computer programming • Interactions between experts' world view with the model • Interactions between those containing experts knowledge • Explicit representation and dialogue of input-output
As a discursive practice	• Benefit higher mobility groups (higher income) • Disadvantaged lower mobility groups • Reinforce existing structures of inequality

As a system of representation, the transportation model can be viewed as beyond a tool to forecast future travel demands and, instead, as a mean to understand relationships between travel behavior, the built-environment, and implications for decisions about transportation needs. Therefore, the transportation modeling process is used to visualize these relationships. The ability to visualize the relationships between human interactions and the built environment that is situated in the intersections between science, technology, and visual communication is powerful (Pavlovskaya 2009). Power is exercised by presenting a particular set of reality about travel behavior, transportation needs, and what can be done to address those needs. As other visualization tools (e.g. GIS) have been made more accessible to provide opportunities for communities (Elwood 2009), so might transportation modeling tap into this power to provide alternative narratives about communities and their needs.

Understanding the trasnportation modeling process as a system of representation allows for including public input to pinpoint areas where the models may not be sensitive to. For example, if presented at community meetings where assumptions and implications of these assumptions are laid out, public input can take the form of pointing out areas where communities would be most disadvantaged by the modeling output. The planning process can be reiterative in the sense that it takes a closer look at these areas and address the potential disparity through the utilization of other policies.

Transportation planning practices that specifically focus on how particular projects and policies impact potentially disadvantaged populations has the potential to open discussion about ways underrepresented communities can be empowered to place their subjugated knowledge in the discourse. For instance, interview with a planner

reveals the role of transportation model in Environmental Justice analysis where the model has the potential to be viewed as a system of representation:

> [The model] helps link what we know is going on anecdotally, [for example,] we kind of know where a lot of the EJ [Environmental Justice] populations typically live in the Dallas-Forth Worth area. The model helps us link [between the locations of these populations to] what does that mean in future travel pattern. [For example] Wether some areas [and roadways] are going to remain [the same] or be more congested; and how can we relate that [analysis] to potentially vulnerable population groups. (Interview with a transportation planner, May 2013)

The challenge remains that transportation modeling process is still a highly elusive process in the eyes of elected officials and most people. Even the communicative process between planners and modelers might be problematic because depending on the culture of the institutions, both planners and modelers might have different perceptions of the role of the transportation model in the decision-making process (Hatzopoulou and Miller 2009). The difference between technical planning and collaborative planning is that in the former, values are hidden under the guise of science and objectivity, while in the latter, values are explicit (Innes and Gruber 2005). Therefore, expanding transportation modeling as a discursive practice requires more collaboration between planners and modelers to address the limitations of the modeling process. There is further need to overcome different understandings of what is considered relevant to the modeling process, as raised in the interview, "Planners look for gray areas, for us it's black and white" (Interview with members of the modeling team, September 11, 2013).

5.3. Praxis for Inclusive Transportation Modeling and Planning Practices

Quick and Feldman (2011) argue that there is a distinction between public participation practices and inclusion practices. Public participation includes efforts to increase public input to respond to specific programs and policies. In contrast, inclusion

practices include continuous efforts to develop a community that is involved in "coproducing processes, policies, and programs for defining and addressing public issues" (Quick and Feldman 2011, 272). In Arnstein's ladder of participation (1969), this understanding of inclusion includes the three highest level of public participation, respectively, as partnership, delegated power, and citizen control. This section discusses how different frameworks of justice affect approaches to inclusion of alternative or subjugated knowledge. The distributive justice framework focusses on ways to include explicit considerations of what is considered as disadvantaged population groups into existing methodologies of the transportation modeling process. The social justice framework focuses on ways to develop meaningful inclusion of experience-based knowledge in the decision-making structure.

The potential ways for inclusion discussed in this section arise out of identifying "resistances" to the disciplinary power of transportation model. The disciplinary power of the transportation modeling process affects both the decisions people make in their daily travel and planners' daily practices. However, individuals carry out actions to resist this power from shaping their life that arises out of fulfilling their everyday needs. In carrying out resistances to disciplinary power, society is really engaging in living their life (Friedmann 2011). Often the term "insurgencies" is preferred to "resistances" as these resistances manifest in the way society shapes and reshapes the city space in which they live to serve their needs. Such insurgencies might be carried out when appropriating public spaces to serve the needs of marginalized populations even through illegal actions (see Holston 2008). In this dissertation, the term resistances refer to individuals' reaction to power carried out by either planners or residents in their daily life. These resistances are yet to be mobilized into insurgencies. However, these resistances, collectively and

overtime, might provide openings for subjugated knowledge to be included within the transportation discourse.

5.3.1. Inclusion under the Distributive Justice Framework in Transportation Planning and Modeling

Under distributive justice frameworks, resistances take the form of explicit considerations of equity (Martens 2006) and integrated modeling approaches for the "disadvantaged population" (Duvarci and Yigitcanlar 2007, 188). Therefore, suggestions to address the shortcomings of the Four-Step model include the development of more advanced models with different techniques of forecasting and allocating future travel demand. Table 5-3 illustrates how transportation equality is seen as outcomes of the methodology and techniques for measuring equity and distributing transportation benefits under this framework.

Table 5-3 Key Components of Distributive Justice Framework and Practical Application to the Analysis of Transportation Demand Modeling (Source: Martens 2011)

Key elements	Description	Application to transport modelling
Benefits and burdens	The 'things' that are distributed (shared, divided, exchanged, dispersed) in society	– Transport facilities – Accessibility
Members of society	Recipients of benefits or burdens divided into groups based on characteristics that are relevant for the distribution of the benefit or burden under discussion	– By car availability – By income
Distributive principles or criteria	Principles that determine which distribution is just	– Equality/equalisation

Martens (2006) shows that transportation demand models have "built-in tendencies" to strengthen the mobility of high-mobile groups often correlated with higher income and car ownership. In general, transportation policies and strategies have been used to address the needs of disadvantaged population groups (Grieco 2003). While

policy considerations may include other factors than household income, it is still difficult to measure in what ways these other factors mitigate the tendencies of the transportation models to widen the mobility and accessibility gaps for different population groups (Martens and Hurvitz 2011). Therefore, the extent to which these policies address the inherent inequality of the modeling process continues to be difficult to measure.

Shortcomings of the transportation models to understanding future travel demands are widely acknowledged (Ortúzar S. and Willumsen 2011; Duvarci and Yigitcanlar 2007; Martens and Hurvitz 2011; Lee 1973; Timms 2008; Rasouli and Timmermans 2012; Zhao and Kockelman 2002; Willson 2001; O'Sullivan and Haklay 2000). However, efforts that have been conducted in Europe, particularly UK—to focus on accessibility and mobility justice for individuals—largely been ignored through the continuous use of travel demand modeling process in the U.S. (Transportation Research Board 2007). The continued use of the Four-Step modeling process shows how practices gain disciplinary power once it is institutionalized through educational trainings, researches, and governmental institutions (Vigar 2002).

Martens (2006) explores the possibility of integrating considerations of equity into the transportation modeling process. Instead of a trip-based model, Martens proposes a need-based model with three main components. The first component is the use of a matrix of transportation needs based on different population groups (for methodology to identify disadvantaged population and to compare their travel behavior see Duvarci and Yigitcanlar 2007; Dodson et al. 2010). The second component is the use of accessibility standards based on travel time, costs, and number of opportunities within each Traffic Survey Zone (TSZ). The third component is a travel demand model that is considered still necessary due to its ability to determine the capacity of existing transportation networks.

Critiques of approaches under distributive frameworks relate to the underlying philosophy of the model itself wherein underlying assumptions continue to be unchallenged (Timms 2008; O'Sullivan and Haklay 2000). Furthermore, there is a positive relationship between the complexity of the model and the degree of confidence in the ability of transportation models to assist in the decision-making process (Hatzpopolous and Miller). Various actors in the decision-making process benefit from viewing forecasts as objective rather than as arguments for a certain position (Klosterman 2013). Political planning styles benefit from the appearance of technical foundations, and technical planners benefit from the appearance and neutral technical experts (Innes and Gruber 2005). The scope of distributive justice is limited to allocation of materials where people are seen as consumer of goods and resources, and tend to overlook equally important issues such as decision-making power (Young 1990). Nevertheless, distributive justice approaches have the potential to contribute to the development of practices that can include explicit considerations of equity into transportation modeling process.

5.3.2. Inclusion under the Social Justice Framework in Transportation Planning and Modeling

The question of whether there is a need to provide explicit considerations of equity in transportation modeling focus only on outcomes. Therefore, there is a need to expand the framework of justice not only regarding a person as consumer and owner of goods (or access to transportation benefits and resources) but also including explicit focus on the decision-making structure that "operates to reproduce the distributive inequality, the unjust constrains on people's lives" (Young 1990, 23). Fainstein (2010) reiterates that a focus on just outcomes guides a just process, and, therefore, both are important frameworks for planning practices.

Focus on the decision-making power is exemplified by explorations of communicative rationality in argumentative, participatory, deliberative, and collaborative planning practices (J. Friedmann 2008; Healey 2008; Healey 2003; Forester 1980). However, emphasis on equitable processes does not translate into equitable outcomes (Fainstein 2010). Conflicts in planning styles and cultural practices of transportation planning, such as the black-boxing of contested issues, are key barriers to collaborative decision-making process (Innes and Gruber 2005). Therefore, decisions are the result of highly contextualized practices.

Interviews with the transportation planners and modelers reveal how disciplinary power is exercised by drawing distinct boundaries between what planners do compared to what modelers do. According to a member of the modeling team, their job is to create tools for planners. For example, planners may ask to see the historical traffic counts and to classify them. The application of the transportation model involves impacts of changes in the transportation network—e.g. construction of a highway— on how forecasted travel demands are distributed into existing transportation system. A member of the modeling team makes the analogy of the relationships between website developers and their clients. The website developer help makes changes to the web interface based on the client's request. The following response illustrates how drawing disciplinary boundaries reinforces the reification process where the output is separated from the process:

> I like to believe because we keep the modeling team separate from us, I don't have any control over what necessarily goes in to the equations of the model or the behavior of the model. . . . As long as we keep [the modeling process] at certain people's hands and not [have] one person control everything. (Interview with a transportation planner, May 2, 2014)

The exercise of disciplinary power is also prevalent in the everyday practices of planners regarding public outreach and engagement. Resistance to this disciplinary power includes the ability to identify practices in participation *and* to articulate knowledge

excluded from the decision-making process. Planners' resistance might begin with a form of deliberative public outreach and engagement efforts by NCTCOG. Interviews with planners reveal that planners simultaneously desire more public inputs but are also bewildered when the inputs contradict the transportation model's outputs. To address this, I redefine the transportation modeling process as a system of representation with assumptions that are communicated alongside with its outputs (please refer to Figure 5-1). The scope of the transportation modeling process is expanded beyond quantitative analysis and computer programming to include the communicative practices between planners' and modelers' world view with the model and with each other. To do this, the notion of participation is expanded into inclusion in decisions regarding programs, projects, and plans (Quick and Feldman 2011). Participation is defined as practices to gain public input on particular programs and policies, while inclusion is defined as practices to engage communities in "coproducing processes, policies, and programs for defining and addressing public issues" (Quick and Feldman 2011, 272). Distinct openings for inclusive practices in transportation modeling process discussed in this dissertation might be achieved through two focuses: data collection and public outreach and engagement process.

5.3.2.1. Data Collection

The preference for certain data collection methods over others is also a form of disciplinary power. The current Four-Step modeling process uses data from surveys that are sent out randomly to households. The validity of this data is measured by thresholds in achieving minimum sample errors. According to a member of the modeling team, "we sent out the survey, it is their choice whether they want to fill it in" (September 11, 2013). The assumption that the random survey is more credible or less bias contributes to the indifference on whether or not the public participates in the survey.

In a data-driven discourse, legitimacy is established through the validity of data, scientific method, and technology (Pavlovskaya 2009; Wilson 2009). Therefore, data *is* public input. In this sense, households' surveys sent out to residents in the metropolitan region should be considered as public input. By considering households' survey as public input, these travel surveys might be circulated to the various community groups meetings in the region and, therefore, provides more chance to get rich contextualized data. Community groups meetings are mobilized based on shared interests. For example, the recruitment process for this dissertation includes attending meetings held by a neighborhoods' crime watch group, a city-based neighborhood programs, sustainability event, community gardens, non-profit environmental groups, and elementary school events. Because these meetings are organized based on shared interests, people who participated in these meetings are from a variety of socio-economic background.

One of the strategies to integrate alternative knowledge is to use participatory data collection methods (Innes and Booher 2010). Corburn (2003) shows how training and providing local communities with accessible devices to gather air quality data are able to articulate issues that otherwise would be subjugated by existing data collection methods to measure air pollution. Similarly, the use of user-friendly GPS recorders can be used to collect travel data of particular population groups.

For example, participants from Dallas in this research are those who are typically left out of the current underlying assumptions in the Four-Step transportation modeling process: the working poor, retired, and disabled. They are not considered high-mobility groups and, therefore, their needs—narrowly define as travel demands—are assumed to be accommodated in provisions of transportation infrastructure that is designed based on future travel demands of high mobile groups (Martens 2006). Therefore, planners could

train communities to use GPS recorders to further understand transportation needs of these lower-income communities.

The travel diary method used in this dissertation is an example that it is possible to get residents to be involved in the production of knowledge about their travel needs. At the very least, the use of GPS recorders provides opportunities for residents to exercise their ability to gather data about their own travel experiences. Additionally, the use of GPS recorders provides a platform for representation of their travel needs in a narrative form with tools that are typically considered as quantitative and analytical. While data from GPS recorders reveal travel patterns such as trip-chaining and travel mode, interviews provide an explanation about motivations for activities such as trip-chaining and carpooling.

Another method that can be effective to include experience-based knowledge is participatory mapping (Innes and Booher 2010). This method provides the opportunity for communities to relate their transportation issues with their surrounding built-environment. Participatory mapping includes processing travel data using GIS to produce some type of maps that represent the relationships between people and the built-environment. Elwood (2009) finds that community organizations rely on "the discursive 'expert power' of GIS" (70) to invoke a sense of legitimacy because powerful actors and institutions often treat these maps "as illustrations of what is real or true about a place, and as evidence of an expert (and therefore, legitimate) portrayal of that place" (70).

An example of how alternative knowledge can be included in transportation planning process and outcomes is the Walkability Study conducted by the Dallas Area Habitat for Humanity (DAHH) in Oak Cliff Gardens neighborhood (Dallas Area Habitat for Humanity, The Build Louder Dallas Blog, entry posted September 13, 2014). The study utilizes phone enabled GPS to determine routes and needs (broken sidewalks, lack of

sidewalks, and illegal dumping or other obstructions to walking) to develop an inventory of the existing sidewalks. The results are then presented in a participatory mapping process where residents are asked to provide information about their daily activities and most traveled streets. The report outlines daily travel needs that are not being met. The outcome is made possible by the collaborative efforts to present studies in local and regional governments that have resources to pursue the agenda. Consequently, the City of Dallas, Dallas Councilmember Dwaine Caraway, and the North Central Texas Council of Governments contributed to provide funding to build sidewalks for the community (Dallas Area Habitat for Humanity, The Build Louder Dallas Blog, entry posted October 8, 2014). For example, the NCTCOG provided $1 million for sidewalks construction in the neighborhood. Similar studies could be conducted to address transportation needs of local communities. Although the scope of the project is highly localized, these types of initiatives could contribute to the overall long-term accessibility in the regional scale.

Personal travel experiences could also be considered as a form of data. Survey methods are typically close-ended questions and serve a particular narrow purpose. Residents, particularly those of lower income and minorities, typically attend public meetings to tell their problems. This form of public input tends to leave technical planners baffled because they do not know how to process open-ended input (Innes and Booher 2010). Nevertheless, planners are more receptive than modelers when questioned about public participation and the type of inputs that can be useful for the modeling process. The following statement by a transportation planner interviewed for this dissertation shows how the types of questions that planners ask require further inquiries than a close-ended random survey:

> I would like to understand the ideologies of people relative to their life and is there a way to apply that to transportation. (Interview with a transportation planner, July 18, 2014)

This particular transportation planner recognizes the importance of understanding the relationships between how people make decisions in their daily life with transportation needs. Additionally, travel behavior is not determined only by demographic characteristics of households' income and size. Travel behavior is shaped by daily decisions affected by one's belief—e.g. in environmental sustainability or family relationships—and consequently shapes the assumptions about transportation needs.

5.3.2.2. Public Outreach and Engagement

Transportation planning is considered to have a high technical foundation but lack of public participation (Khisty 2000). One of the challenges to public participation is that those who participate tend to do so with considerations only of their own interests (Fainstein 2010). For example, narratives of not wanting to pay additonal tax to provide public transit are used to justify the underlying motivation to exclude in Arlington, Texas. Participants from Arlington reflected on decisions about voting against public transit. Lynn, Raymond, and Fiona talk about their acquaintances, now in need of public transit due to their age and increasing inability to drive, and who now regretted their vote against public transit when they had the opportunity:

> Their biggest reason they don't vote for [public transportation in Arlington] is not the money. The biggest reason we've ever had people telling us is that they don't want the type of people that come into a town when there is public transportation. And we just look at them and like, do you think Arlington doesn't have it already?" (Lynn, personal communication, January 10, 2015)

This example of how narratives in a discourse are used to support exclusion of people from transportation system is a reason that transportation planning practices need to include explicit considerations of disadvantaged population groups. The following statement by an official from the NCTCOG's Transportation department that deals with public outreach programs illustrates some of the challenges in public participation:

> It's very hard these days to get people to come out to a public meeting. You have people who are very distrustful of government right now, and it's just not a priority for people. So that's why we're looking at different ways as opposed to just regular public meetings to try to get out to people and get their input and try not to make seem like they're just coming to a public meeting giving input to a government agency that will never get [heard]. (Interview with a transportation official, June 18, 2014)

The lack of public participation is attributed by transportation planners interviewed for this dissertation to three factors: 1) limited understandings of the role and planning scope of North Central Texas Council of Governments (NCTCOG), 2) competition with daily schedules, 3) the relevance of long-term transportation planning process on daily travel needs. Firstly, most participants are not aware that regional transportation planning and projects are coordinated through the NCTCOG. Similarly, participants are not aware that the practice of forecasting their future travel needs is based on socioeconomic characteristics, particularly households' income and size. A transportation planner echoes this concern:

> When they [the public] are thinking about transportation needs, those are maybe something that are more immediate or something that we [regional government] can't necessarily solve by ourselves. (Interview with a transportation official, June 18, 2014)

To address this limited understanding of the role of NCTCOG, the agency might benefit from aggressively pursuing events in local communities. Participants also suggest a media campaign, such as billboard, to make the NCTCOG and transportation issues visible in their everyday spaces. The agency might also benefit from increasing partnership with local governments to connect regional transportation issues to those of the local communities.

Secondly, planners also attributed the lack of public participation to the competition between public meetings with schedule and activities in daily routine. Planners can be deliberate when designing public meetings to include services to make participation easier. As such, Karl and Megan, who have a ten year-old child and both

work, remark that decisions to come to public meetings are made easier when meals and child care are complementary. The following statement by an official from the NCTCOG's Transportation Department shows the importance of reaching out to the public in their daily routine:

> So getting to people in their daily routine, where they're at, is I think the most important thing we could do. (Interview with a transportation official, June 18, 2014)

When asked whether participants feel that they have the ability to influence the decision making process or policy directions, most participants respond positively to the idea that their participation matters. Most of those recruited in either community-based meetings like OakCliff crime watch, Plano Solar Advocates, and HANA, or meetings organized by the city such as Love Where You Live meetings for Plano, are homeowners who have interests in improving the quality of their neighborhoods. Participants from Plano, especially those involved in the non-profit environmental group are more optimistic because they are more progressive in participating in various level of government. They consistently look for ways in which their interests can be accommodated within a variety of institutions' mission and funding structures. However, Karl and Megan, who participated in neighborhood meetings organized by the local government feel that many activities in the meetings tend to be informational, and the most interactive process is filling in surveys. A participant echoes this concern:

> I think it takes more than just "here when we're having our planning meetings." I think it's sometimes doing some of the outreach stuff, doing some of the things like Live Green, maybe the government [can be] a part of that.. talking to people about it . . . and getting people to realize that if I voice my opinion then maybe things we'll change. (Nita, personal communication, September 14, 2014)

Thirdly, planners attribute the lack of participation to the difficulty of making connections between the impacts of long term planning projects with people's everyday life. Disadvantaged groups, such as those of lower income and minorities, typically

struggle in meeting more immediate priorities such as food and health care (Innes and Booher 2010). As a result, transportation needs discussed by residents in public meetings often are not related to the various transportation projects presented at the meeting. Public input might be too narrow (e.g. a stop sign at an intersection) compared to the larger scope of regional transportation needs (e.g. the construction of a highway).

Therefore, interviews reveal that while public participation in long-term regional planning is lacking, planners are also reluctant about putting more weight into public input. This could be addressed by providing more interactive activities that provide the knowledge of linking transportation planning with everyday life. For example, it might be beneficial to explore their reactions to the map presented by NCTCOG—in a focus group where all participants can come and participate in a deliberative visioning process. Additionally, public engagement could mean providing incentives to try alternative transportation modes or educational session about existing public transit options. Public outreach could also take the form of including community leaders to gather public input.

> I think they need to go out to neighborhoods, they have a network of volunteers and if those volunteers can host a meeting for their neighborhood on [a topic]. So, perhaps if the NCTCOG can partner with local municipalities especially those who have these kinds of programs. To me the outreach of actually going to people might make them feel less threatened, and they are maybe more inclined to participate. (Mike, personal communication, September 16, 2014)

5.3.2.3. Integrating Alternative Knowledges into Institutional Planning and Decision-Making Process

Inclusive data collection and public outreach efforts are ultimately tools to achieve a more equitable distribution of transportation benefits. The nature of transportation infrastructure projects that require large-scale investments indicate that its planning process is likely to continue to involve existing powerful government and other institutions. Given how the gap between technical knowledge and experience-based

knowledge tends to hinder public participation, Klosterman (2013) argues for a modeling process with explicit assumptions about present conditions and future alternative policy directions through a scenario-building approach rather than the traditional forecasting method.

Banister and Hickman (2013) discuss alternative approaches to forecasting—e.g. the Four-Step Travel Demand Model—wherein these approaches have been used to construct future directions in long-term transportation planning. Alternatives to forecasting are "future-oriented exercises" (Timms et.al. 2014, 82) that tend to include some combination of the "backcasting/ visioning" and "exploratory" approaches where these approaches begin with "one or more images of the future and 'work backwards' to understand how they might occur" (80). The exploratory approach involves the formation of one or several possible futures that might arise from external conditions that are out of the control of the existing organizations. Thus, these possible futures may or may not be desirable but are given a set of scenarios on how they might unfold (Timms et.al. 2014). Meanwhile, the backcasting/visioning approach mainly involves the identification of a desired vision or goal and the construction of strategies to achieve such vision. Figure 5-3 shows a diagram of the backcasting/visioning approach that might be adopted by institutions as an alternative to the forecasting approach.

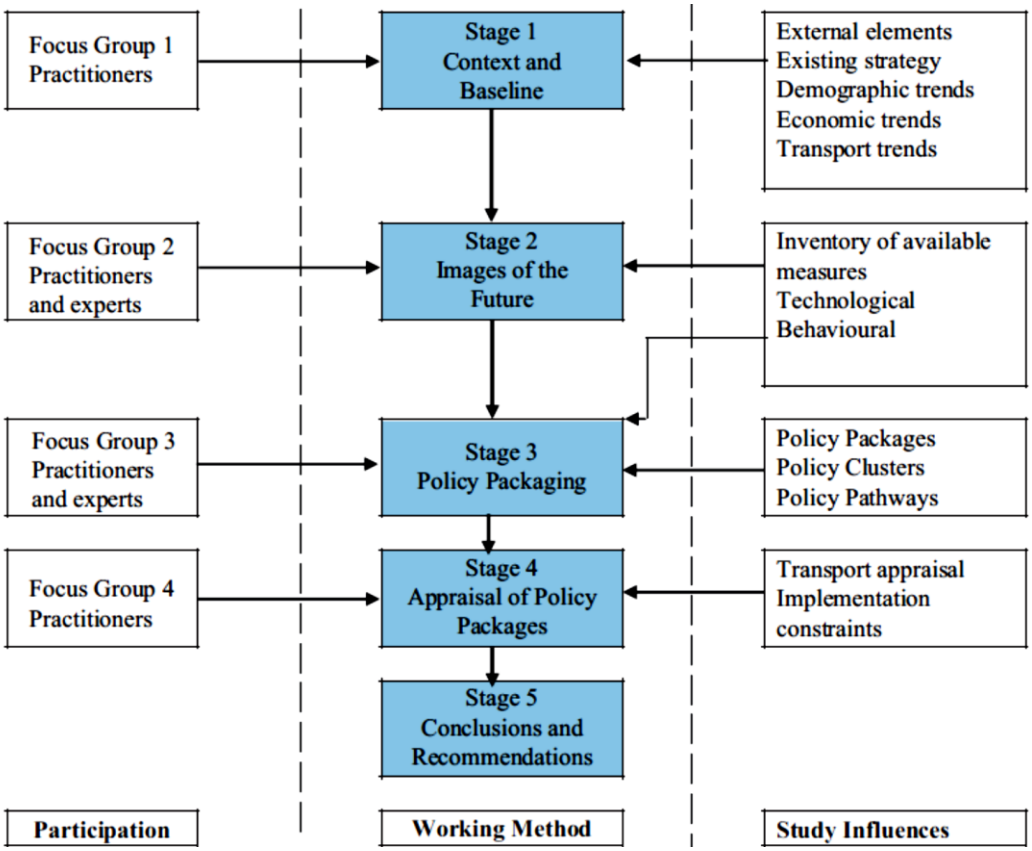


Figure 5-3 The Backcasting/Visioning Process (Source: Banister and Hickman 2013)

In the backcasting/visioning approach, the outcomes of each stage are evaluated by participants to achieve more understanding of the directions and its consequences, thus, both the decision-making process and engagement in these stages mattered as much as the outcomes (Banister and Hickman 2013). In Stage 1, existing strategies as well as economic, demographic, and transport trends are part of the discussion that leads to Stage 2 where desired visions for the future are constructed. Therefore, there can be a "layering" of the planning process where the use of forecasting practices—such as transportation modeling—is considered simultaneously with a participatory visioning process. Inclusion in data collection and public engagement ideally can occur in all of these stages. A discussion about a desired future transportation projects can result in

decisions about what type of data needs to be collected and potential strategies to achieve the goal. Simultaneously, an exploratory approach might be carried out to discuss external factors that can alter the desired future directions of transportation planning and policies.

The form of public participation process within these backcasting/visioning and exploratory approaches can draw from works in participatory budgeting (e.g. Wampler 2000; Cabannes 2004; Baiocchi and Lerner 2007; Goldfrank 2007; Sintomer et.al. 2008; Pinnington, et.al. 2009). The Participatory Budgeting Project highlights the need for access to data as an important element of inclusion in a participatory planning process (www.participatorybudgeting.org). Participation of communities in the production of knowledge about their needs involves several goals: to make sense of the data, to generate alternative data, and to represent these alternative data without high technical expertise (Participatory Budgeting Project blog, entry posted April 28, 2015).

In conclusion, inclusion defined as co-production of knowledge might be achieved through a combination of alternative data collection method and deliberative public outreach and engagement efforts. Therefore, communities interested in producing alternative data might organize using low-cost tools such as *vojo.co* and *Ushahidi* for their projects. An interactive data and mapping tool such as *Healthy City* for communities in California might be developed for particular regions like Dallas-Fort Worth. The National Priorities Project also provides a *Local Spending* tool that provides information on how federal funding for local projects.

Planners who are interested in particular population groups or particular areas in the region might collect in-depth travel diaries and engage the public by showcasing and engaging the public with these travel experiences in interactive platforms. The public may be asked to review significant issues showcased in a website or public meetings. Design

charrettes that is typical to the New Urbanism might provide a template on how to represent complicated planning jargons into images and narratives that can be a platform for mutual learning process between planners and experience knowledge of its participants. Stakeholders can engage in dialogue about future transportation infrastructures and possible scenarios and develop strategies to achieve that vision. These participatory processes can be integrated into the institutional decision-making process through the combination of the backcasting/visioning and exploratory approaches that is layered with existing transportation model forecasting practices.

Chapter 6

CONCLUSION

This dissertation investigates how understandings of various communities and residents' transportation needs get produced and incorporated into transportation planning, modeling, and decision-making process; the implications of different understandings about transportation needs on the process and outcomes of the transportation planning and modeling. To address these questions, the discussion on the competing narratives transportation discourse in the U.S. focuses on how the Predict and Provide becomes a dominant paradigm and practices such as transportation modeling are institutionalized (Vigar 2002). Using the Dallas-Fort Worth (DFW) Metropolitan Area as a case study, the research utilizes mixed-methods of discourse analysis and spatial analysis in GIS to analyze data collected from travel diary, interviews, and planning documents.

The dissertation also discusses what knowledges are dominant in the transportation and modeling process at NCTCOG, by exploring how planners use the Four-Step transportation model's output in the transportation planning process through interviews and review of planning documents. The underlying assumptions used in the Trip Generation and Mode Choice stage of the Four-Step model have been compared with travel experiences of participants using data from travel diaries and interviews. Additionally, I demonstrate how these assumptions produce outcomes that reinforce existing inequality in accessibility and mobility of participants in the DFW Metropolitan Area.

Chapter 5 reemphasizes that the transportation modeling practice is a discursive practice and the need to expand understanding of a transportation modeling process as a system of representation. I revisit discussions about changes to planning practices when

planners deliberate in communicative rationality. Additionally, I discuss approaches to inclusion when justice is viewed either as a thing under the distributive framework or as social relations under the social justice framework. The former typically produces approaches to improve methodologies in the planning process, while the latter typically address inequality in the decision-making structure.

Transportation planning has always relied on instrumental rationality where the use of transportation model is considered as a normal practice (Kane and Del Mistro 2003; Timms 2008). Finally, the recommendations in this dissertation are largely based on my attempt to "problematize" these normal practices by identifying areas where disciplinary power is exercised, resistances to these actions, and how might everyday travel experiences—the collective struggle of subjugated knowledge—be included within the transportation discourse.

6.1. Summary of Findings

Transportation planning practices have been criticized due to its claim to objectivity due to the utilization of technology and science, and, therefore, reinforce exclusions of other ways of understanding transportation issues in an increasingly complex world. Although transportation planning goals not only focus on providing increasing mobility but also include environmental concerns and accessibility of different population groups, there are still much debate on the implementations of these different goals (Kane and Del Mistro 2003). Historical overviews of U.S. transportation policies show how the continued dominance of the ‘Predict and Provide’ paradigm results in the requirements to use visualization techniques to receive federal funding (Weiner 1982; Weiner 2008; Miller 1973; M. D. Meyer 2000). The requirement to use visualization techniques results in reliance on transportation models for regional transportation planning.

This dissertation provides in-depth understanding of how expert knowledge dominates the transportation planning and modeling process, as conducted by the NCTCOG. The findings of this dissertation demonstrate the Four-Step transportation model as a black-box where the underlying assumptions regarding input (demographic information), and output (forecast of travel demands) produce outcomes that reinforce existing transportation inequality in the DFW Metropolitan Area. The travel diaries show that on average, participants from lower income households travel further and longer to reach their destinations, compared to participants from higher income households. Consequently, the existing built-environment the spatial layouts of the built-environment exert disciplinary power by limiting the choices people make when they travel from one place to another. Therefore, the transportation modeling process is a discursive practice—wherein its assumptions produce outcomes—as shown in the disparity in travel distance and moving time from participants' travel diaries.

The disciplinary power of the transportation modeling process is also exercised in planners' daily practices as they make policy recommendations based on the outputs of the transportation model. Transportation planners often have to "play catch-up" when existing demographic trends, such as increased downtown population, are not in accordance with what the model previously predicted (Interview with a transportation planner, May 2, 2014). Faced with a funding structure and MTP that is deliberately kept constant under *ceteris parebus,* transportation planners may face challenges on "how to sell" justification for these demographic changes and how it may affect recommendations for funding allocation.

Even though regional transportation planning process is required by the federal government to include the use of visualization tools and public participation, the research reemphasizes the disconnect between these two elements. On the one hand, public

participation process provides a sense of legitimacy where plans can be considered binding agreements for future projects (Weiner 2008). On the other hand, planners are more concerned with providing "technical foundation" for policy recommendations. The planning process does not put much weight on public input gathered in public meetings. Planners contend that most residents bring up issues that are either too localized (e.g. issues about potholes or stop signs) or require significant collaboration with other agencies (e.g. transit improvements). Another benefit of concentrating on the technical foundation is that policy recommendations can be seen as objective and above political conflicts (Goetz, Dempsey, and Larson 2002b; Innes and Gruber 2005; Klosterman 2013). At best, planners may address comments in public meetings but not as considerations for different policy recommendations. At worse, public input is non-existent in the modeling process as shown in the context of the Four-Step model in DFW. However, this is not particular to the transportation modeling process in DFW but rather is the challenge for the use of modeling in planning practices (Klosterman 2013). Nevertheless, considering that transportation modeling and public participation are fundamental elements in long-term regional transportation planning, the black-boxing of issues into the transportation model presents significant barriers to inclusion. The dominance of expert knowledge signifies the continued need to look for ways to include experience-based knowledge in the transportation modeling practices.

6.2. Summary of Recommendations: Praxis for Planners

The disciplinary power of transportation model is derived from its position as a techno-rationality where science and technology are merged into a visual communication tool (Wilson 2009). One of the planners' role is to identify resistances to this disciplinary power—one that subtly coerces our actions— and locate lines of weakness where these resistances might be included in the discourse (Foucault 1980). These resistances may

be as subtle as acknowledging that transportation planning process in not rational (Interview with a transportation planner, May 2, 2014); or persistent as the way participants engaged in democratic participation in various levels of government knowing that their input hardly gets heard.

Resistances both carried out by planners and participants in everyday life spaces are representations of subjugated knowledge. Resistances, Friedmann (2011) argues, are practices that society carries out in being "for itself" (122). For planners, resistances take the form of selective representation and deliberative practices when validating outputs from the transportation model. Planners may not have the specialize knowledge and trainings on transportation modeling process, but they have the capabilities to understand and validate the output, and capabilities to communicate to officials, and thus the way they choose to communicate and things they choose to represent is essential to the decision-making process. As a system of representation, the transportation modeling process is critically examined based on how its underlying assumptions exclude particular population groups. Planners can explicitly identify these population groups and make policy recommendations that mitigate the inherent inequality in the outputs of the Four-Step model. Planners have openings when they engaged in the revalidation of the model and asserted how the model's outputs disregard a phenomenon.

For participants, resistances take the form of daily travel decisions like trip-chaining and carpooling. Collectively, these daily decisions can alter the way planners think about future travel demands when engaging with the transportation modeling process. An example of this is the decisions to move closer to downtown Dallas. Individual decisions about housing choice may seem insignificant in the short-term. However, collectively and over a long-period of time, these individual household's choices to live in downtown would affect the data used for the modeling's input.

Transportation planners interviewed in this research take notice of the increased population and employment in Downtown Dallas and Fort-Worth. These planners are then engaged in another inversion process where ideas are exchanged and materialized into different assumptions about future transportation needs. The mutual learning process occurs when planners communicate alternative knowledge to find ways how the modeling process could reflect these changes. Klostermann (2013) argues that modeling process can be useful to explore scenarios instead of forecast future needs. To do so is to understand the transportation modeling process as a discursive practice where its assumptions produce outcomes. Therefore, the underlying assumptions are laid out on the table where planners and modelers engage in a communicative process about the modeling process with other stakeholders.

Disciplinary power may again be exercised with the insistence on "proven methodologies" to justify the collective change, e.g. the increased population and employment in downtown Dallas and Fort Worth. According to a transportation planner, the DFWRTM Four-Step model currently takes 20 hours to run and, therefore, limits its ability to be responsive to alternative assumptions. Nevertheless, technology can potentially be used in the co-production of knowledge about future transportation needs rather than inhibit meaningful participation (Klosterman 2013). Thus, simplification of the modeling process that allows underlying assumptions to be clearly communicated might be useful in developing future scenarios about the regional transportation systems.

Additionally, the use of GPS recorders and the ability to analyze and visualize large-scale travel data might provide an alternative to the current data collection methodology. Studies have shown the potentials of using similar methodologies in understanding travel pattern of particular segments of the population (Wiehe et al. 2008; Rogalsky 2010; Division 1997). The use of GPS recorders have been explored as an

alternative to traditional self-written form (see Wolf, Guensler, and Bachman 2001). Studies have also explored ways to analyze data from GPS recorders (Bohte and Maat 2009; Bricka et al. 2012). Planners might identify areas with rapid demographic and travel behavior changes and collect data on a smaller scale.

Additionally, planners may engage in the more aggressive campaign for public outreach and engagement. The focus of these efforts could shift from gathering input to engaging the public in the data collection process. The overall purpose should be to learn from experiences of residents in the region rather than insisting on public meetings. Planners might develop a public outreach and engagement process that begins with a regional-wide media campaign. Participants suggest that if getting to people is the issue, then perhaps the public outreach efforts can reach people as they travel and conduct their daily activities. Most participants express interests in engaging with a visioning process. Karl form Arlington expressed that transportation is the one topic that he would be interested to get involved in. Participants also suggest the use of billboard and image branding to increase awareness about transportation issues.

Innes (2010) notes the importance of speaking in terms of needs in the everyday life with marginalized population groups rather than future goals or visions. Similarly, participants in this research typically refer to their daily needs to go to the workplace or grocery shops and needs for safer neighborhood and public transit system when asked about future transportation needs. Therefore, issues should be presented in language that avoids jargon and relate to people's experiences as they make decisions about their daily activities (Whittemore 2014). In some ways, planners may not specialize in modeling process but they have the capabilities to understand and validate the output, and capabilities to communicate to officials, and thus the way they choose to communicate and things they choose to represent is essential to the decision-making

process. Planners who are concerned about a particular population group or particular area of the region might engage the public by collecting travel diaries and showcase travel experiences in various media, e.g. an interactive website. Planners could intentionally avoid jargons and use images and narratives to explain complicated planning concepts.

6.3. Limitations and Future Research Directions

This research situates the everyday travel experiences of 16 participants in the aggregated analysis of the transportation modeling process. As a case study, this research is an attempt to explore issues as it occurs in a particular context of the transportation and modeling practices in the DFW Metropolitan Area. As a qualitative study, this research challenges works in transportation that is mostly dominated by quantitative data analysis. While the number of participants is lower than originally expected, participants are mostly similar to the profile of the larger DFW population (please refer to Table 3-1). The research reviews planning documents and interviews planning officials about how the modeling's outputs are used and communicated in public meetings, but future research would benefit from either reviewing minutes or videos or conducting participatory observation of these issues in public meetings.

Some of the most significant challenges in the research is organizing time between participants and the devices, scheduling interviews, finding ways to retain participation, and analyzing the GPS data. Future studies might consider collaborating with local and regional governments to establish legitimacy and accountability. Additionally, future studies should consider the different ways people use language and communicate the purpose of the study in a way that is easy to understand. Overcoming barriers to communication is important, more so in the recruitment process. As Texas population increasingly becomes more diverse, it is more important to understand the

differences to travel behavior of minorities population (Jimenez and Mattingly 2009). Public outreach and engagement need to address potential language barriers to participation. In this research, participants who are well-informed about the purpose and the significance of this study provided more detailed information about their travel experiences.

The research initially was designed to capture two-week of travel diary, however, considering that most participants travel pattern are not affected by changes in academic calendar, future studies might consider only requiring one week of travel diaries (e.g. Rogalsky 2010). However, studies utilizing travel diaries should also consider households with non-driving children and/or grandchildren because participants do note decrease in the number of trips taken when children have all grown up and/or moved out of the house.

Future studies should also consider allocating enough time to analyze GPS data to be able to triangulate results with participants. The data in this research have been triangulated by confirming with participants about their trips, writing field notes, and doing peer-review. However, the study has been conducted by one researcher and, therefore, does not have the external control of a collaborative research. The GPS data have been analyzed by matching with the date, time, and destinations information in travel diary form but the quality of data largely depends on the discipline of participants in using the GPS recorders and writing down their travel information. In general, it takes at least 40 minutes for each participant to ensure that all trips have been accounted for. Institutions such as the NCTCOG might find the rigorous time required for in-depth analysis to be impractical but necessary, particularly, to understand disadvantaged population groups. Future large-scale studies might benefit from other studies that use algorithms to analyze

GPS data (Bohte and Maat 2009; Bricka et al. 2012; Wolf, Guensler, and Bachman 2001).

Finally, future studies would benefit from comparative case study analysis of other metropolitan regions in the U.S. as well as other countries. Similar inquiries need to address two of the most important practices of regional transportation planning: forecast of future needs and the inclusion of communities in these regions. The methodology utilized in this dissertation might be expanded to explore how differences in social and political structures affect transportation planning discourse and its implications on the practice of everyday life, with the following objectives:

- to investigate explicit considerations of inclusion in the regional transportation planning and modeling process and outcomes;
- to utilize both quantitative and qualitative studies of the relationships between long-term regional planning practices with the practice of everyday life, for example, the relationships between ideologies on issues such environmental sustainability with travel behavior; and,
- to investigate the role of technologies such as GPS recorders and Geographic Information System (GIS) in the production of knowledge in transportation planning and decision-making process; and,
- to identify and develop forms of participatory planning practice—as alternative knowledge— that can be institutionalized into the planning and policy decision-making process.

Appendix A

Self-Written Travel Diary Form

Table A-1 Self-written Form

Date	Start Time	End time	going from (approx. location)	going to (approx.location)	purpose	mode	Route (enter: street-street-street)	Alone (Y/N),if N says how many	costs
	8:14 AM	*8:47 AM*	*Home, Green oaks blvd Arlington*	*Nedderman Dr, Arlington*	*work*	*car*	*six flags dr-I-30 frontage-center st-abram*	*N, 3 persons*	

Appendix B

Background Questions for Participants

Please choose one of the following answers:

1. What is your approximate address?
2. Sex: F/M
3. What is your age:
    a. 18-54
    b. 55-67
    c. 67 above
4. What is your education level?
    a. High school
    b. College
    c. Graduate
    d. Other: …….
5. Are you currently…?
    a. Employed for wages
    b. Self-employed
    c. Out of work and looking for work
    d. Out of work but not currently looking for work
    e. A student
    f. Military
    g. Retired
    h. Unable to work
    i. Other: ……..
6. What is your approximate **household's** income:
    a. <$12,000
    b. $12,001 – $24,000
    c. $24,001 - $ 40,000
    d. $40,001 - $ 75,000
    e. $75,001 - $ 100,000
    f. > $100,000

Contact information:

- Email:
- Phone:

Appendix C

Interview Questions for Participants

Initial interview Questions

1. Counting yourself, how many people including children live in your Household?
    a. How many children?
    b. Do you take them to school?
2. Do you or does someone who lives with you own a car? How many cars are there in your Household? Is the car reliable?
3. How do you identify yourself to the Census regarding your race/ethnicity?
4. Do you have any physical limitations or disabilities that prevent you from going anywhere??
5. Do you have responsibilities at home that limit how far you can be away from home?
6. (If yes) can you share what responsibilities?
7. How long have you lived in your current home?
8. What were the two most important reasons when you choose to live here?
9. Did you think about being able to walk or bike to bus stops and/or commuter rail station when you moved?
10. Approximately how much time do you normally spend traveling on a typical day, week?
11. How much of those are work related?
12. Where do you get your groceries?
13. How do you go to work? What are the places that you mostly go to in a week, month, year? Do you have problem getting there?
14. Would you make a rough sketch map of places (grocery stores, etc.) near your home and workplace as if you are describing it for someone asking for directions? It is alright if it's not accurate and detailed drawings but a rough sketch or diagram is enough (make note of the sequence of drawing).
15. Please describe in detail your daily travel activities while you put it on your map? If you travel using different mode of vehicles, can you write it on the map or tell me as well? (Probe for detailed description).
16. Do you go outside a lot in a week other than for work purposes?
17. What are three things that will improve your daily travel experience?

Adapted from: www.expandingactivity.org and (Lynch 1960)

Exit Interview Questions

1. Can you take a look at the information that I put together from your travel diary and describe it to me? Please let me know if there is missing information or discrepancies? (Show their map and probe for details)
2. What travel experiences would you like to share with authorities that can help them improve transportation facilities and services in your neighborhood and/or the city? (Probe for examples and specific travel mode)
3. When you were filling out your diaries, were you surprised of any travel behavior that you did not expect?
4. What type of events would you likely to participate ? Do you think that you have the ability to change decision-making process?
5. Do you know of anyone who has transportation difficulties?
6. What kinds of transportation options would you want to be available for your children in the future that you don't have now? How are you encouraging them?
7. Have you heard anything from younger generations that have helped you make some decisions about your travel behavior?
8. Are you doing anything to try to influence their travel behavior?
9. Is there anything you would like to propose on how you can be included in long-term transportation planning process?

Appendix D

Questions for NCTCOG's planning officials

Background Information

1. Can you tell me about your position at the COG and the responsibilities?
2. What is the duration of employment in the current position:
3. Can you explain your position's responsibilities? (probe for differences in the job description vs. daily work activities)

The Travel Demand Modeling Process

4. Can you tell me what you know of the transportation modeling process at the NCTCOG?
5. How do outputs from the transportation model's affect your job activities?
6. Can you explain your interaction with the Four-Step transportation model and/or other type of models for planning purposes? (probe for details)
7. What is the benefit of the current model compared to other modeling process?
8. How was the data for the model collected? (probe)
9. How often is the data updated?
10. What assumptions do you use to select which data to use and categorize the data? (probe for assumptions used for the data processing)
11. How significant is the role of the Four-Step transportation models for decisions in either short or long term planning? (probe for details when using the output in decision-making context)
12. How confidence are you of the outcomes of the modeling process, in terms of whether the output is reliable for 20-35 years of planning?
13. How is the validity of the model established? When do you know if the model is reliable?
14. Can you tell me how you use output from the model so it can be understood by stakeholders or other department? (Probe for examples, specific cases)

Public participation

15. What kind of public participation process does NCTCOG go through when doing long term planning?
16. How does result from public input do into the model?
17. Are you concern about lack of participation?
18. Have you considered studying more detailed travel experiences of residents?
19. Can you give suggestions on how residents' input can be included early in the planning process? (Probe for examples)
20. Can you explain some of the changes in policy directions or planning practices that you have seen in the years you have worked here?
21. How do these changes affect the assumptions for the transportation planning process? (Probe for general policies, strategies, and applications in the modeling process)
22. Do you have any suggestions on questions I should ask participants that may help you?

Appendix E

Proposed Travel Diary Method

Smartphone users

Participants who own a smartphone were asked to download a free application (app) for Android cell phone called *FollowMe*. The app allows participants to include notes, pictures and videos while they are traveling. Participants were informed on how to activate and deactivate the app (Figure 1); and what data are collected by the app (Figure 2). They were also be shown an example of the final product of the app (Figure 3).

The information of a route they took along with any pictures, notes and videos can be shared via email. The participants can send the data containing route, pictures, notes and videos via email daily. Therefore this app does not give real time information unless the participants choose to. The data were mapped using ArcGIS explorer (Figure 3). Because I plan to ask the participants to send their daily route, I sent an email reminder if they lapse behind for more than one day.

Figure E-1 FollowMe Interface

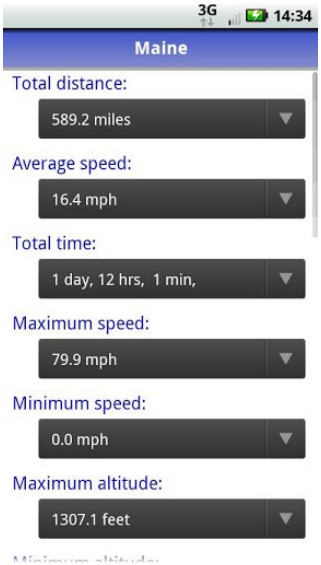


Figure E-2 Data Collected by FollowMe

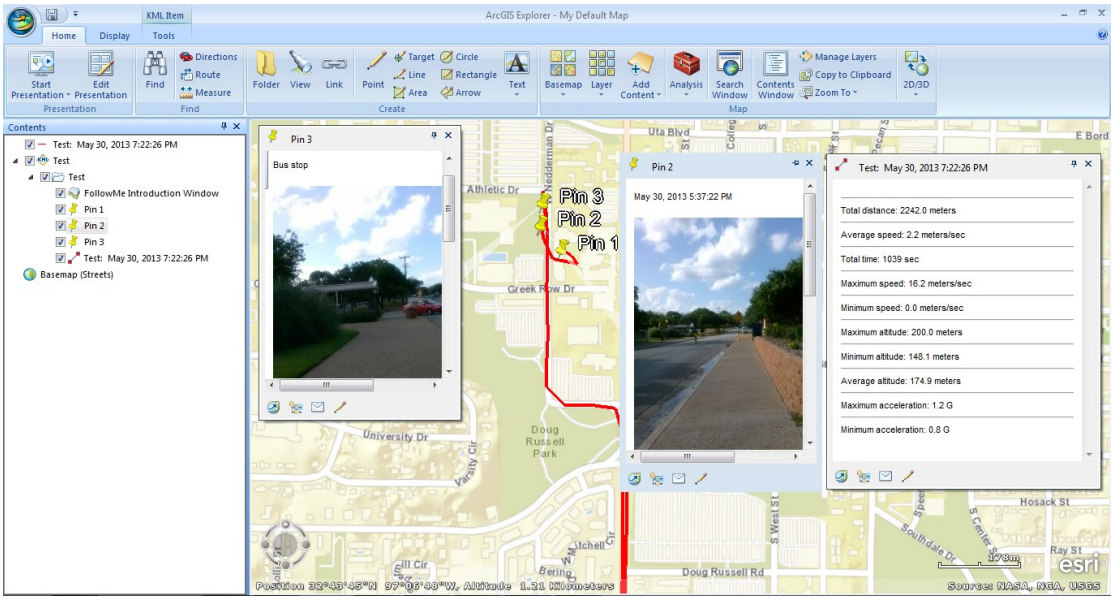


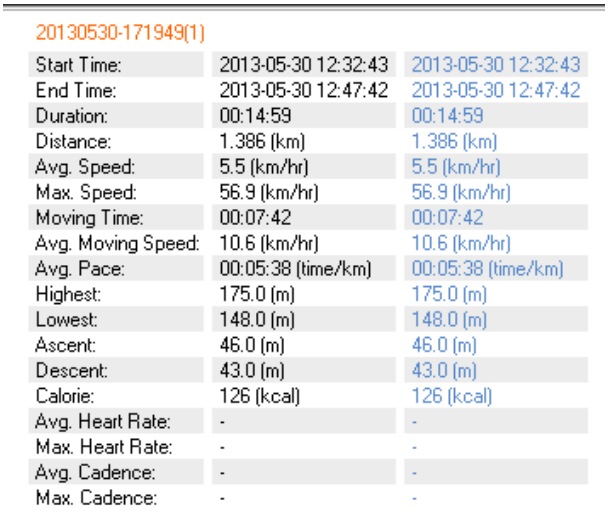
Figure E-3 Route recorded with "FollowMe" and mapped with ArcGIS Explorer

GPS Recorders (Non smartphone users)

This project used the “i-gotU USB GPS Travel & Sports Logger - GT-120” in conjunction with either a stand-alone digital camera or mobile phone camera. The GPS

logger collect information using GPS on participants' location and travel route that is collected into the device when it is turned on and connected to a satellite. Figure 4 shows the detailed information on the movement and distance traveled.

The participants were either sent an email reminder or called on one day before the study begins and one day before the data collection. They were asked to turn off both the GPS logger and the camera when not in use. Data were collected at the end of the week. The data were extracted by connecting the GPS logger into a computer and downloading it into the memory drive. This device comes with its corresponding software *@trip PC* (Figure 4) and *Sports Analyzer* (Figure 5) to process the data. Data were mapped using the device's software or with ESRI ArcGIS.



20130530-171949(1)		
Start Time:	2013-05-30 12:32:43	2013-05-30 12:32:43
End Time:	2013-05-30 12:47:42	2013-05-30 12:47:42
Duration:	00:14:59	00:14:59
Distance:	1.386 (km)	1.386 (km)
Avg. Speed:	5.5 (km/hr)	5.5 (km/hr)
Max. Speed:	56.9 (km/hr)	56.9 (km/hr)
Moving Time:	00:07:42	00:07:42
Avg. Moving Speed:	10.6 (km/hr)	10.6 (km/hr)
Avg. Pace:	00:05:38 (time/km)	00:05:38 (time/km)
Highest:	175.0 (m)	175.0 (m)
Lowest:	148.0 (m)	148.0 (m)
Ascent:	46.0 (m)	46.0 (m)
Descent:	43.0 (m)	43.0 (m)
Calorie:	126 (kcal)	126 (kcal)
Avg. Heart Rate:	-	-
Max. Heart Rate:	-	-
Avg. Cadence:	-	-
Max. Cadence:	-	-

Figure E-4 Data Collected

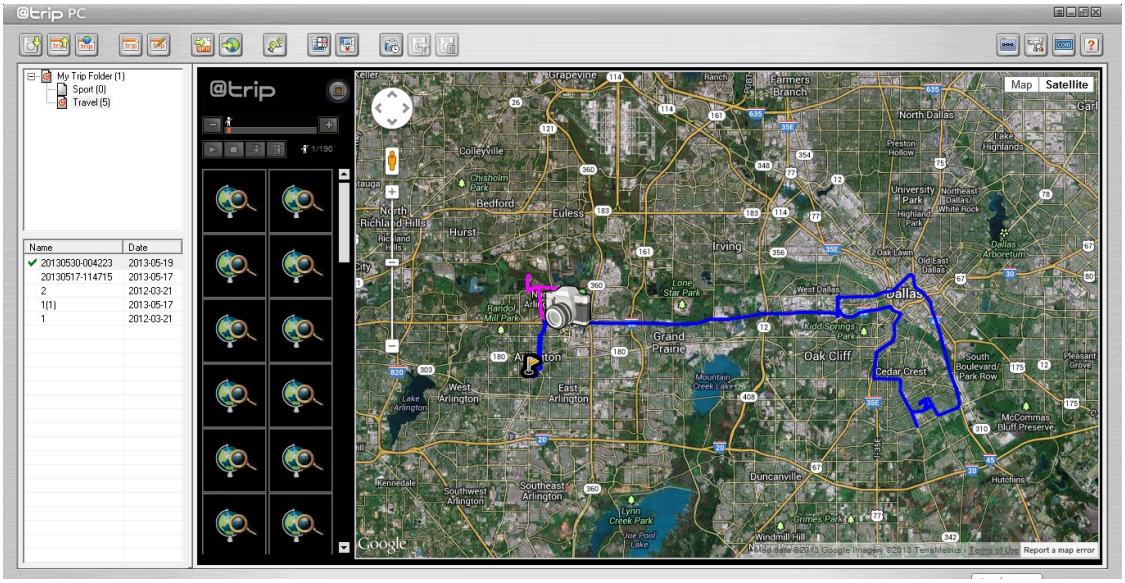


Figure E-5 Screenshot of @Trip PC, Route Recorded with the GPS

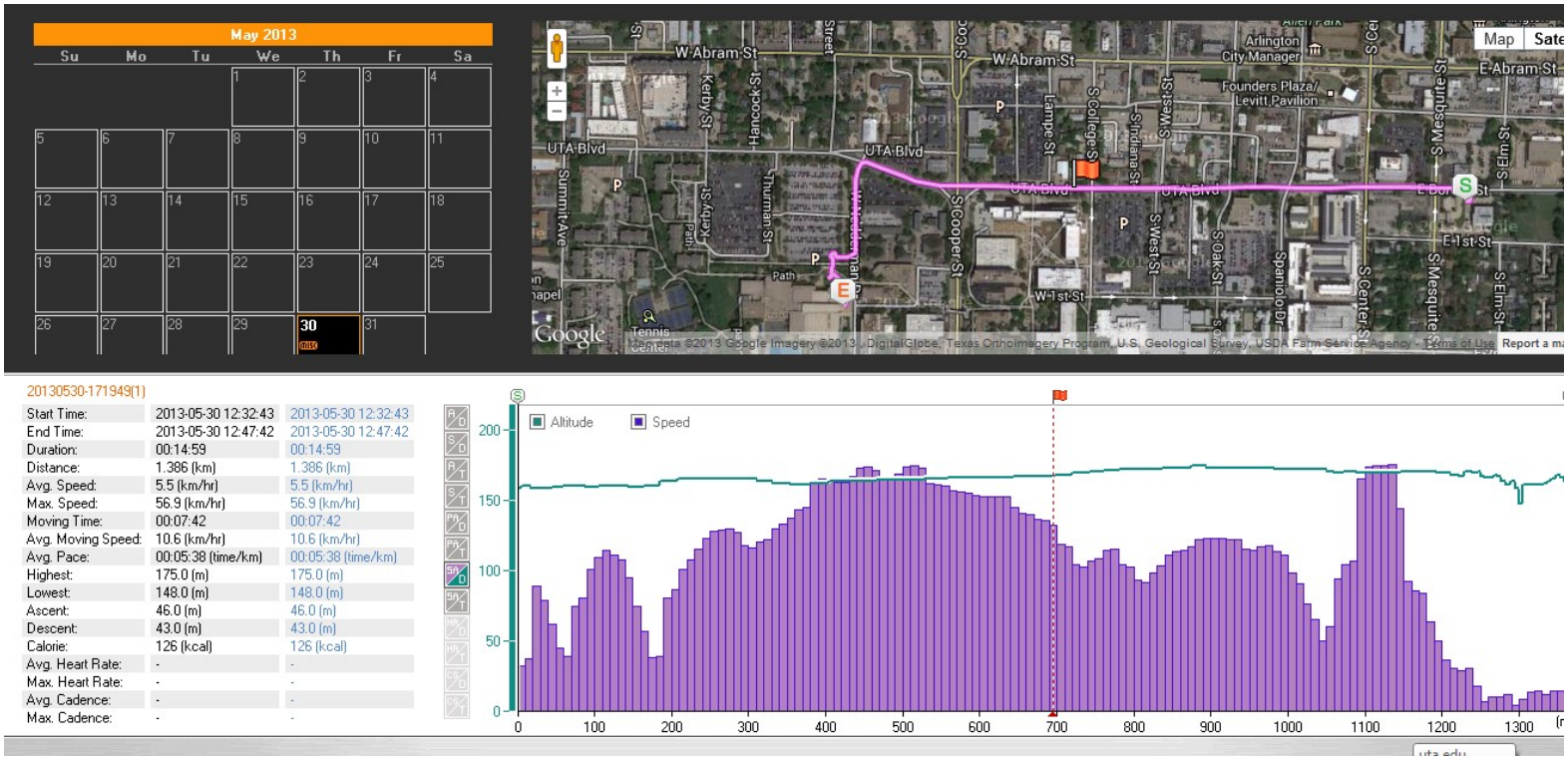


Figure E-6 i-Got U Sport Analyzer interface

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Biographical Information

Dian Nostikasari was born in Garut, Indonesia. She earned her Bachelor in Architecture from the University of Indonesia (UI) in 2002. During her study, Dian worked as assistant to an editor to edit and translate English architectural books to Bahasa Indonesia. After seven years of practice as an architect and interior designer, Dian began her graduate study in 2008. She earned a Master in City and Regional Planning from the University of Texas Arlington in 2010. Dian received the Enhanced Graduate Teaching Assistant (EGTA) scholarship while pursuing a doctorate in Urban Planning and Public Policy. Her dissertation challenges studies that largely rely on quantitative approaches to travel behavior and forecast of future travel demands without considering how the dominant discourse informs underlying assumptions in the planning practices. Dian's collaboration with the Dallas Area Habitat for Humanity in a Walkability Study in South Oak Cliff, Dallas led to over $1 M investments from the North Central Texas Council of Governments and the City of Dallas for sidewalks constructions in the neighborhood. In Summer 2014, Dian developed and taught an undergraduate level course entitled "Urban Food Deserts" that explores how access to healthy food options is related to identity, poverty, political economic relations of power, and capitalism. She looks forward to expanding her research to other metropolitan regions in the U.S. as well as other countries, particularly those in the Global South such as Indonesia.