State of the Practice of Long-Distance and Intercity Travel Modeling in US Metropolitan Planning Organizations and State Departments of Transportation

by

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A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, Alabama
May 4, 2019

Keywords: Long-distance travel, Intercity travel, Transportation, MPOs,
Statewide Models, Long-Range Transportation Plan.

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ABSTRACT

Long-distance and intercity travel represent a minimum percentage of total trips in the U.S, yet they represent a large percentage of total VMT. Long-distance trips represent an important travel market with over $317 billion in business-travel and $718 billion in leisure travel profits in 2017. Metropolitan Planning Organizations (MPOs) and State Department of Transportation (DOTs) are responsible for developing the Long-Range Transportation Plan (LRTP) and Statewide Transportation Plan, respectively. Within these plans, future infrastructure and funding investment is defined based on model estimation from past, current, and future travel and socio-economic variables. Currently, the lack of guidance in long-distance travel modeling has derived concerns among practitioners and scholars. Therefore, two national state-of-practice surveys on long-distance travel modeling were conducted among MPOs and State DOTs to gain insight in long-distance travel modeling among these agencies. The purpose of this thesis is to draw recommendation for future guidance on long-distance travel.

ACKNOWLEDGMENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

NHTS……………………………………………………………..National Household Travel Survey

MPOs…………………………………………………………Metropolitan Planning Organizations

DOT………………………………………………………………….Department of Transportation

US……………………………………………………………………………………….United States

VTM…………………………………………………………………………….Vehicle Miles Travel

NCHRP………………………………………..National Cooperative Highway Research Program

ATS……………………………………………………………………….American Travel Survey

ACS…………………………………………………………………American Community Survey

CHTS…………………………………………………………California Household Travel Survey

NTS………………………………………………………………………….National Travel Survey

FAST Act…………………………………………..Fixing America's Surface Transportation Act

FHWA…………………………………………………………….Federal Highway Administration

HPMS………………………………………………….Highway Performance Monitoring System

CTPP………………………………………………….Census Transportation Planning Package

BTS………………………………………………………….Bureau of Transportation Statistics

LSOT…………………………………………………….Longitudinal Survey on Overnight Travel

TDOT……………………………………………………Tennessee Department of Transportation

OD………………………………………………………………………………….Origin-Destination

GPS…………………………………………………………………………..Global Position System

ADT…………………………………………………………………………….Average Daily Traffic

DB1B…………………………………………………..Airline Origin and Destination Survey Data

AMPO………………………………………….Association of Metropolitan Planning Organizations

LRTP……………………………………………………………Long-Range Transportation Plan

UZAs………………………………………………………………………………Urbanized Areas

TMA…………………………………………………………….Transportation Management Area

TAZ………………………………………………………………………….Traffic Analysis Zone

WisDOT…………………………………………………….Wisconsin Department of Transportation

AADT…………………………………………………………………….Annual Average Daily Traffic

CHAPTER 1: INTRODUCTION

Long Distance Travel, defined as trips of 50 miles or more by the National Travel Household Survey (NHTR) 2001, is important for the Metropolitan Planning Organizations (MPOs) and State Department of Transportation (DOTs) because it represent an essential tool for planning and programming of congestion, economic growth, and quality of life at the state and metropolitan level. Long Distance Travel might not represent a large portion of total trips in the US, yet they account for a large proportion of Vehicle Miles Travel, VMT. Additionally, there is an important economic benefit from long distance trips. In fact, over 2.25 billion intercity person-trips were completed in 2017, resulting in over $317 billion in business-travel and $718 billion in leisure travel economic benefits (U.S Travel Association, 2018).

Unfortunately, MPOs and state DOTs lack detailed guidance on how to collect data and forecast Long Distance Travel. Therefore, some MPOs rely on simple scaling factors to estimate long distance travel or they may utilize a specific long-distance personal travel tour-based model. This make difficult for MPOs and state agencies to properly account for this travel. The main issue related to a poor long-distance travel forecasting is observed in the Long-Range Transportation Plan where most of future investment are defined. Without an entirely understanding of long distance travel the is an increase possibility of failures in future infrastructure capacity and investment allocation, especially for corridor planning.

Given the necessity to better understand and model long distance travel, this thesis objectives is twofold:

1. Summarize the state of the practice on Long Distance Travel at the MPOs and state DOTs level.

2. Based on main finding of the thesis, draw recommendation for future guidance on Long Distance Travel.

We achieve these objectives through two national survey on the state of the practice on Long Distance Travel. The first survey was distributed among a total of 405 MPOs, with 96 replies the response rate was 23.7%. The survey was sent through an anonymous link via email. The second survey focus on 34 DOT agencies with operative statewide models according to the National Cooperative Highway Research Program (NCHRP) – Synthesis 514 published in 2017. The total responses were 18 DOT agencies, which represent 52.9% response rate. This survey was conducted through phone call interview and e-mails. Both surveys were conducted throughout the year 2018.

This thesis is structured as follow. Chapter 1. A literature review that focus on how important Long-Distance Travel is, factors influencing Long Distance Travel, methods used by MPOs and state DOTs to forecast Long Distance Travel, and data requirements for Long Distance Travel. Chapter 2. Summarize the methodology, results, and discussion of the survey on the state of the practice on Long Distance Travel at the MPOs level. This chapter included topics on MPOs planning area, Internal-Internal and Internal-External trips, expected changes in traffic volumes, Long Distance Travel definitions, and MPOs planning process. Chapter 3. Includes a summary of results with a

discussion of main findings from the state DOTs survey on statewide models. Topic in this section include statewide modes, statewide trip purposes, external and internal zoning, methods for trip generation and distribution on internal and external zones, and data implementation on statewide models. Chapter 4. Provide the main conclusion of the thesis and some recommendations for future guidance develop on metropolitan and statewide Long-Distance Travel modeling.

CHAPTER 2: LITERATURE REVIEW

2.1. DEFINING LONG DISTANCE TRAVEL

Long-distance travel represents a majority of our national annual miles traveled, especially those completed on interstates, on railways and through airports. This traffic continues to increase such that it is now a major determinant in prioritizing new highway infrastructure as well as existing highway rehabilitation. Unfortunately, it is challenging to collect data describing long distance travel as well as forecast this travel due to the wide range of destinations, modes, and distances it incorporates. In an effort to organize data collection and modeling, transportation planners often define long distance travel in one of three main ways: defined by trip duration (hours or days), trip distance from home, or whether a trip reaches an external destination outside the study area (Aultman-Hall, Harvey, Sullivan, & LaMondia, 2016). While tours defined by distance are most commonly used in mobility studies and tours defined by durations are most commonly used in the tourism literature, these two definitions are beginning to merge in practice and research (Christensen, 2014). The most notable source of long-distance travel data in the US is the 1995 American Travel Survey (ATS), defined long-distance travel as trips of 100 miles or more. Additionally, the 2001 National Household Travel Survey (NHTS) defined as 50 miles or more. Additionally, the American Community Survey (ACS) use a definition of "long" commute as trips over 60 min (McKenzie, 2013). Many long-distance European surveys (INVERNO, DATELINE,

MEST/TEST, and KITE) define long distance as 100 km (62.13 miles) or more. However MiD (Germany) used overnight stay and Micro Census (Switzerland) used 3 hrs or longer excursion with overnight stay (Frei, Kuhnimhof, & Axhausen, 2007). The advantage of distance thresholds is the convenience to be implemented in the spatial jurisdictions or study areas. However, these distance thresholds of 50-200 miles to define long-distance only make sense in an era before large mega-regions and increased air travel (Aultman-Hall, Harvey, Sullivan, & LaMondia, 2016). While long distance travel includes multiple modes, NHTS revealed that nine out of ten long-distance trips were taken in a personal vehicle, such as a car, pickup truck, or sports utility vehicle (Bureau of Transportation Statistics, 2017). However, more total miles were traveled with air (Reichert & Holz-Rau, 2015)

2.2. OBJECTIVES OF MODELING LONG DISTANCE TRAVEL

Long-distance and intercity travel are important travel markets that influence the planning and programming of highway infrastructure, high-speed rail development, and airport growth. Two main uses of long-distance passenger travel are (Outwater M. , et al., 2015)

- Evaluation of transportation investment in infrastructures and services to address deficiency in the national transportation system.
- Evaluation of the impact of transportation policies at the national level that have an effect in the national transportation system.

Long-distance travel models are necessary to understand and proactively address changes in state, national and global travel behavior. Doing so allows state and national transportation funds to be

appropriately used to support efficient mobility and economic growth. U.S mega-regions and global air travel are expected to grow at a rate of 4-5% per year, and long-distance becomes an important aspect of transportation planning to address the ensuing congestion (Aultman-Hall, Harvey, Sullivan, & LaMondia, 2016). Furthermore, long-distance travel by auto and air increasingly takes place under conditions of congestion and delay as the vast majority of long-distance travel is on the highway and airports that are increasingly suffering from capacity problems (Steiner & Cho, 2013). It has also been recognized that long-distance travel is a major contributor of greenhouse gas emissions (Christensen, 2016). Additionally, highway infrastructure maintenance cost, and security are considered as some of long-distance travel impacts. Therefore, states like California support initiatives aiming to reduce greenhouse emission and congestion considering long-distance travel important for policy actions and policy analysis (Davis, McBride, Janowicz, Zhu, & Goulias, 2018).

2.3. LONG DISTANCE TRAVEL IN THE MPOS AND STATE DOTS TRAVEL FORECAST

Over the past decade, daily home and work-based travel have been the focus of data collection and modeling in the United States by regional agencies including MPOs and state DOTs. Ultimately, these efforts only focus on travel within ones' region or state. With the growth of mega-regions and more national connectivity, the concept of state and regional jurisdiction boundaries is no longer useful for demarcating travel patter and volumes (Aultman-Hall, 2018). Therefore, is of great interest for MPOs and state DOTs to address travel outside their regions, usually these correspond to intercity and long-distance travel.

States like Wisconsin complete their statewide model with the objective of develop an updated policy-sensitive model of passenger and freight flows in the state (Proussaloglou, Popuri, Aunet, & Cipra, 2014). In the same study and using NHTS add-on data for Wisconsin, Proussaloglou et. al. concludes the MPOs models based on NHTS add-on will provide a level of detail on the existing origins and destinations of trips, by trip purpose, to indicate the most promising corridors for such alternative modes (Proussaloglou, Popuri, Aunet, & Cipra, 2014). On the statewide level, the same study shows the statewide travel model based on NHTS add-on data will be used extensively in testing alternative transportation initiatives; for example, estimating future heavy truck traffic on Wisconsin highways from a new major inter-modal rail facility managed by Union Pacific Railroad across the border in Illinois.

On the other hand, metropolitan models have received less attention from both practitioners and scholars (Zhang & Chen, 2009). Some reasons are hypothesized by Miller (2004): First, there were fewer intercity travel corridors of policy interest than urban regions, which diminish the intercity travel modeling market; second, intercity travel analyses often cross boundaries of the political jurisdiction of a single planning agency, and thus are performed on an ad hoc, project specific basis; third, intercity models are usually not owned by a single public agency who would otherwise spend a great effort to maintain, use and make improvement to the model; lastly, studying intercity travel model has more difficulties in study area defining, behavioral representation, data collection (Miller, 2004).

From the policy standpoint of view, long-distance travel is especially important for MPOs, as they address the planning factors of the Moving Ahead for Progress in the 21st Century (MAP-21) and Fixing America's Surface Transportation Act (FAST Act) legislation. MAP-21 requires MPOs to

"support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency" (Federal Highway Administration, 2017), and the FAST Act now tasks MPOs to with specifically "enhancing travel and tourism" and consulting with agencies and officials responsible for planning tourism activities (Federal Highway Administration, 2016). Federal Highway Administration (FHWA) recognizes that the transportation landscape will change dramatically for communities of all sizes over the next few decades, including increased population sizes, expanding megaregions, aging populations, widespread use of transformative technologies, and proliferation of automated vehicles (Federal Highway Administration , 2015). Understanding these changes is critical for MPOs to assist in allocating funds that sustainably meet the future needs of their communities.

Commonly long-distance travel models are similar in structure to the traditional 3 or 4 steps model, except that they combine trip generation and distribution into one step (Zhang & Chen, 2009). Some studies have specifically addressed long-distance travel forecast. A tour-based long-distance travel demand model for passenger trips in and between 42 European countries suggest that the perception of both travel time and cost varies with journey length in a non-linear way (Jeppe & Eriksen, 2014). While in the United States Outwater et. al., developed a tour-based micro-simulation model of annual long-distance passenger travel for all households in the U.S. This model is able to schedule travel across a full year to capture business travel (conferences, meetings and combined business/leisure) and leisure travel (visiting friends and family, personal business and shopping, relaxation, sight-seeing, outdoor recreation, and entertainment). The models are multimodal (auto, rail, bus, and air) based on national networks for each mode to provide

opportunities for evaluation of intercity transportation investments or testing national policies for economic, environmental and pricing (Outwater M. L., et al., 2014).

2.4. DATA REQUIREMENTS FOR LONG DISTANCE TRAVEL

Long distance travel model estimation requires a significant amount of data about individuals' households, travel patterns, trip characteristics, and destinations. One of the main sources for this information comes from household travel surveys, with traffic counts offering data for model validation (Hensher & Button, 2000). Household-travel survey provide household and person-level socioeconomic data (incomes, household size, number of workers, number of vehicles, etc.) as well as activity-travel data, which typically included activity type, location, start time and duration, and if travel was involved, the mode, departure time, and arrival time. However, since models depend heavily on the geographic scale to which they are applied and the policies being considered, there is still much discussion in practice and research on the best methods for collecting this data (Donnelly, Erhardt, Moeckel, & Davidson, 2010).

Traditional data sources used by transportation agencies to address travel behavior include the National Household Travel Survey (NHTS), Highway Performance Monitoring System (HPMS), American Community Survey (ACS), and Census Transportation Planning Package (CTPP) (Tawfik & Zohdy, 2017). Other sources included local or regional household travel surveys such as California (California Household Travel Survey -CHTS), Michigan, Ohio, and Oregon. A study by Donnelly and R. Moeckel (2017) show main data sources used in the statewide modeling process. The results conclude that two-thirds of states used NHTS as source of their behavioral data for

model constructions and application, while half of states included in the study use household travel surveys and other types of synthetic and transferable rates (Donnelly & Moeckel, 2017).

Additionally, there are some sources with data collected specifically for modeling long-distance and intercity travel. These include the 1995 American Travel Survey (ATS) and the 2001 National Household Travel Survey (NHTS). ATS is the only comprehensive national database on long-distance passenger travel. It was administrated by the Bureau of Transportation Statistics (BTS) and collected during one-year travel information reported quarterly from approximately 54,000 households (Horowitz, 2006). More recently, the Longitudinal Survey on Overnight Travel (LSOT) collected overnight travel for a national sample over a year timeframe (Aultman-Hall, Harvey, Sullivan, & LaMondia, 2016).

Annual long-distance data has been demonstrated to be more accurate for leisure and tourism (LaMondia, Chandra, & Hensher, 2008). Similarly, work and business trips require longer timeframes to adequately define their trips. Furthermore, a study based on LSOT data concluded the necessity to use annual timeframes to capture full variation in overnight travel patterns (Aultman-Hall, Harvey, LaMondia, & Ritter, 2015). It should be noted that collecting information over a long-time frame create concerns for respondent burden and fatigue, therefore; Aultman-Hall et. al, recommend a monthly recall period as appropriated to collect long-distance information.

Considering that annual data can be complex and usually expensive to collect, some research has investigated the feasibility of using shorter timeframes. Rather than collecting an entire years' worth data, collecting household travel during a single quarter and scaling this data up to describe the annual travel trends of the region has been shown to be representative when compare to LSOT data

(LaMondia, Fisher, Burmester, & Cordero, 2019). Additionally, a new Danish survey investigates if it is possible to collect long distance travel data with overnight stay(s) by only asking for information about the two most recent journeys instead of the traditional retrospective survey. This study show that the alternative methodology increases the number of reported journeys by 120% (Christensen, 2019).

Alternative methods to the traditional household travel surveys included the use of passively collected data. As an example, the Tennessee Department of Transportation (TDOT) used passively collected cell phone data that represent 3,335,539 observed trips, in contrast the combined amount for TDOT add-on sample to the 2008-2009 NHTS and other local travel survey from MPOs in the state contained a total of 81,065 trip made by 10,344 households in 39,782 OD pairs (Bernardin, Ferdous, Sadrsadat, Trevino, & Chen, 2016). A study conducted in 2016 used passively collected data to develop a simulation-based model for Asheville, North Carolina. Different model measurements were collected passively from different mobile sources. GPS data provide statistical characterization about the time of the day people travel to work from home summarized by spatial representation zones (Kressner, Macfarlane, Huntsinger, & Donnelly, 2016).

2.5. FACTORS INFLUENCING LONG DISTANCE TRAVEL TRIPMAKING

Several studies have been conducted to find the factors influencing long-distance travel tripmaking to help inform long distance travel demand models and data collection efforts. Travelers' gender, role in the household, and incomes were observed as important determinants of participation in medium-and long-distance commute and business travel by private car in the

United Kingdom and the Netherlands (Limtanakool, Dijst, & Schwanen, 2006). Aultman-Hall et al. also conducted a similar study using a longitudinal panel of 628 individuals surveyed monthly online for 1 year about overnight travel. The study concluded that men make more long-distance work and air trips than women (Aultman-Hall, Harvey, Sullivan, & LaMondia, 2016).

A study based on the 2012 California Household Travel Survey (CHTS) found that households who reside in areas with a higher mixed density index where found to less likely commute long-distance, whereas households with a higher car to drivers ratio were found to be more likely to commute long-distance (Mitra & Saphores, 2017). Other study conducted by LaMondia et al. analyzed 1200 self-reported questionnaires using an ordered probit model. The findings show that the type of a long-distance trip matters and is influenced by the presence of a spouse and children (LaMondia, Lissa, & Greene, 2014). Also, a better education and a higher income increase most types of long-distance travel.

A study that investigate the Michigan State's 2009 Long-Distance Travel Survey show that household size, the number of workers in the household, the number of vehicles owned by the household, and the share of higher income household are correlated with an increased in trip-making (LaMondia, Fagnant, Qu, Barrett, & Kockelman, 2015).

One of the strongest influencing factors in tripmaking is the income of the individual or the household. A study based on the Great Britain 1995-2006 National Travel Survey (NTS) data found that long-distance travel is strongly related to income (Dargay & Clark, 2012). This study also showed that women, older populations, and those that work more are less likely to take long distance trips. The Michigan DOT concluded that tripmaking was influenced by household size and

number of workers in the household, as well as higher total household incomes (McGuckin, Casas, & Wilaby, 2016). Conversely, Mallett (2001) concluded that about two-thirds of people in low-income households did not make a single long-distance trip in 1995, a proportion that rises to 4 out of 5 from some sub-groups of the low-income population such as non-Hispanic African Americans (Mallett, 2001).

In one final study on long-distance travel tripmaking, Goulias et al. found that households with higher income are more likely to take long distance trips and tours, and car ownership has a positive effect on tripmaking (Goulias, Davis, McBride, Janowicz, & Zhou, 2017). Living in a single-family home (as opposed to apartment or mobile home) also correlates with more tripmaking, indirectly supporting the ideas that more discretionary income motivates long-distance travel (Goulias, Davis, McBride, Janowicz, & Zhou, 2017).

2.6. EXISTING GUIDANCE ON LONG DISTANCE TRAVEL MODELING AND DATA COLLECTION

Minimal national guidance on long distance planning currently exists in the US, especially as it relates to MPOs of different sizes. Appropriate guidance should include data collection procedures, standardized concepts for planning area definition, intercity-travel definitions, equable procedures for model estimation and validation, and a legal framework to support each action to be considered.

The most current and detailed guidance comes from the National Cooperative Highway Research Program (NCHRP) Report 735 titled Long-Distance and Rural Travel Transferable Parameters for

Statewide Travel Forecasting Models. Introduced in 2012, it provides guidance on model parameters estimation to help MPOs and state DOTs to formulate policies and allocate funding. Additionally, this research incorporates and developed transferable parameters for long-distance and rural trip-making (Schiffer, 2012). This guidebook used travel surveys information such as the 1995 American Travel Survey (ATS) or more recent as the National Household Travel Survey (NHTS), additionally incorporate statewide models. Basically, this is a framework to identify the scenarios in which is convenient to transfer model parameters. It provided as summary of statewide statistics and benchmarks for long-distance and rural trip generations, distribution and mode choice.

The prior NCHRP Report 365 also provides guidelines for travel modeling, albeit in much less detail. In fact, this report treats long distance trips beyond a planning boundary simply as "external trips" and provides a method to estimate external travel when there is absent of available data (surveys) with many limitations (Martin & McGuckin, 1998). One approach described in this report to measure through trips use the average daily traffic (ADT) from external station located at major highways entering the study area. However, this is limited to the size of the urban area, it worked only for areas with population no greater than 50,000. The through trips estimation used a model based on the functional classification of the highway, ADT, and percentage of trucks (Martin & McGuckin, 1998).

Additionally, a number of mode-specific national guidelines are available: FHWA Traffic Analysis Framework provide a number of long-distance trip tables for auto and bus ridership using the 1995 ATS data. For air used two datasets were used: Airline Origin and Destination Survey Data (DB1B) and T-100 data, describing both air passenger trips between airports (Federal Highway

Administration, 2013). Rail trips were based on Amtrak system data for passengers' trips. All trips were estimated for a base year (2008) and projected to future (2040).

Finally, while not national guidance per se, a variety of research activities have led to national long-distance modeling initiatives. For example, Outwater et. al developed a framework to estimate long-distance passenger travel demand model at a national level based on behavior simulation of long-distance passenger movements (Outwater M. L., et al., 2014). In this effort to develop a national framework, the authors address estimation, calibration, and validation on long-distance travel data in the United States available at that time. The model was designed to account for land-use and economic models as well.

Before more guidance can be developed in the US to support this effort, an understanding of the current needs, expectations, and perspectives of MPOs and State DOTs needed. These findings can provide the foundation to which current research can be applied and future research can be tailored.

CHAPTER 3: LONG DISTANCE SURVEY OF MPOs

3.1. INTRODUCTION

In order to understand MPOs' current state of the practice relative to long-distance travel, an online survey was developed and emailed to all 405 MPOs listed with Association Metropolitan Planning Organizations (AMPO). The survey included questions organized in 3 sections: a) how the MPO characterizes itself, b) how important is long-distance travel to the MPO, and c) how does the MPO model long-distance travel.

The first section asked questions about how the MPOs best describes their planning area, the number of independent cities included in their planning area, and finally who works on their LRTP. These questions provide information to better describe the MPOs from a general perspective.

The second section asked questions about the importance that long-distance travel represent for the MPOs. This sections initially asked if the MPOs considered long-distance travel outside their planning boundary, and if this type of travel was considered from rural and/or urban destinations. It then asked about coordination with neighboring planning areas and types of modes included in the Long-Range Transportation Plan (LRTP). Finally, MPOs were asked about the expected changes in volumes for both rural and urban destinations in two scenarios: next 5-10 years, and next 15-20 years.

The third section of the survey asked questions about MPOs modeling, including the type of model used to forecast, the number of external zones included in the travel demand model and how are those zones are defined. Following those questions, MPOs were asked about the methods used to calculate traffic volumes and the respective proportion of volumes considered in their travel demand models for both Internal-External / External-Internal trips and External-External trips. Lastly, MPOs were provided with a question about preferred tools to implement in the long-distance travel demand modeling.

Two rounds of beta testing were completed to ensure the questions in the survey used familiar language and were easy for anyone (including those who were unfamiliar with the specific field of long-distance travel forecasting) to understand and answer.

After 24 days and one reminder email, 96 MPOs responded to the survey, or a 23.7% response rate. These responses represent the distribution of MPOs across the United States well. Figure 3-1 demonstrates the distribution of MPO respondents across the country, with the actual percentages of MPOs in each region noted in parentheses at the base of each bar. The south is overrepresented, and the northeast is underrepresented in the study.
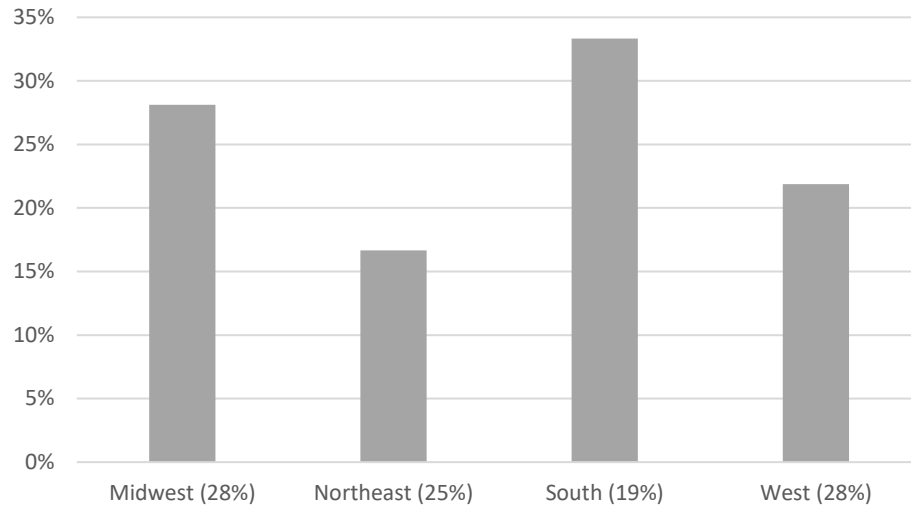
Figure 3-1: MPO Responses by Census Region (with % of all MPOs within that region).

Two of the main lenses through which the long-distance travel needs are interpreted in this study are MPOs' size and connectivity. For this reason, MPOs were identified as small (50,000 to 200,000 residents), medium (200,001 to 500,000 residents) or large (500,000 or more residents), as noted by the Bureau of Census and designated by the Secretary of the U.S Department of Transportation (DOT) which designated a MPO to all urbanized area (UZAs) greater than 50,000 inhabitants (small MPOs), and defined a more complex urban areas of 200,000 or more inhabitants (medium MPOs) as Transportation Management Area (TMA) (U.S Department of Transportation, 2019). The responses were distributed with 50% small, 24% medium, and 26% large MPOs.

Additionally, MPOs characterized themselves in terms of their connectivity. Specifically, they could self-identify as: a) well connected to many neighboring urban areas, b) well connected to some neighboring urban areas, c) not well connected to some or many neighboring urban areas, or d) isolated from any neighboring urban area. Figure 3-2 shows the distribution of the responses, in relation to the MPO size. Interestingly, small MPOs presented the most variability in responses,

showing that these communities experience the widest range of connectivity of the three types. Medium-sized communities predominantly felt they were either well-connected to many or some neighboring urban areas (78%). Eighty-percent of large MPOs felt well connected to many or some neighboring urban areas, while a relatively large 16% felt isolated (and may limit their planning and modeling parameters). These results highlight the growing megaregions across the country, and the need to consider cross-boundary regional planning and models across small, medium, and large MPOs.

Finally, MPOs were asked how many independent cities were included in their planning area, as seen in Figure 3-3. While it was anticipated that all the large MPOs have 4 or more cities in their planning, it is interesting to see that 43% of small and 57% of medium sized MPOs also consider 4 or more cities in their planning. This too emphasizes the need for intercity and long-distance travel as inherent to their long-range transportation plans.

Figures 3-4 and 3-5 show how MPOs conduct their long-range transportation plan, regardless of whether long distance or intercity travel is considered as part of the plan. The majority of large MPOs complete the plan in-house, while 32% of medium-sized MPOs and 24% of small-sized MPOs do it in house. Instead, much larger proportions of the small and medium sized MPOs partner with a consultant to share the workload.

Figure 3-5 highlights that the majority of MPOs, independent of size, still utilize a 3 or 4 Step Travel Demand Model in support of their long-range plan. Activity-based models are most common in small MPOs, perhaps due to the smaller geography, reduced data collection effort needed to implement such a model, and higher likelihood of involving a consultant. These combined results

demonstrate that if long distance travel forecasting is incorporated into the LTRP, a) modeling methods need to be flexible enough to integrate with 3 or 4 step travel demand models as well as activity-based models and b) data needs must be reasonable and accessible to support the in-house data collection being done by all MPOs.
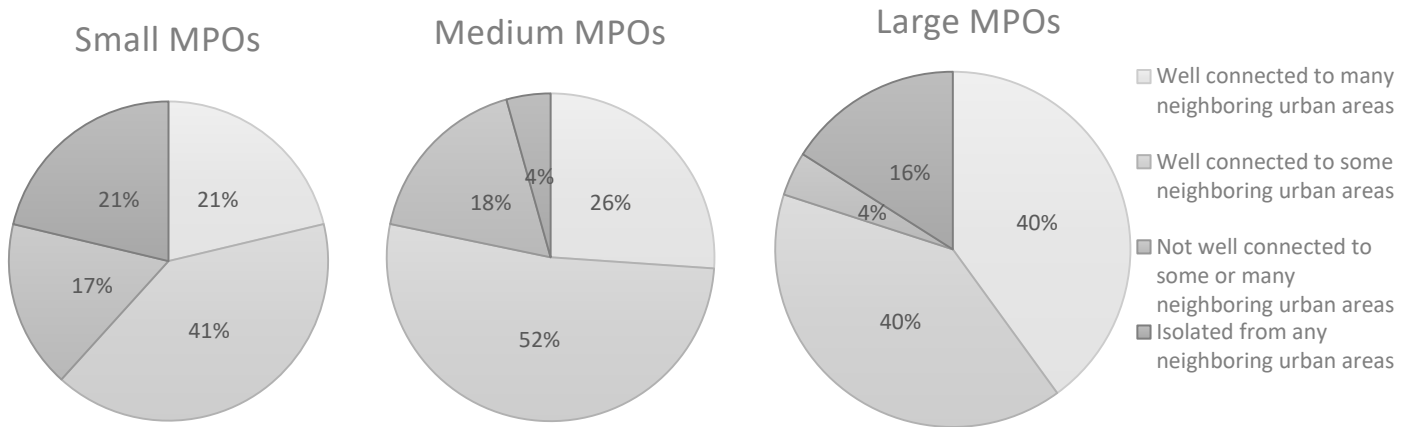
Figure 3-2: Planning Area by MPOs Type
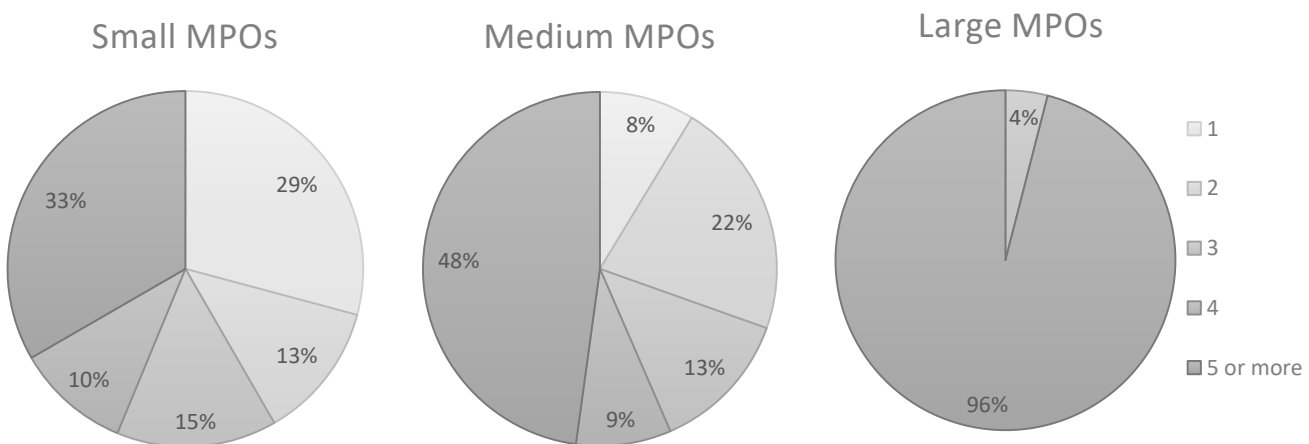
Figure 3-3: Independent Cities by MPOs Type

Small MPOs

24%
39%
37%

Medium MPOs

32%
27%
41%

Large MPOs

20%
12%
68%

☐ We do it in-house.

☐ We hire a consultant.

☐ Part of the work is done in-house, part by a consultant.
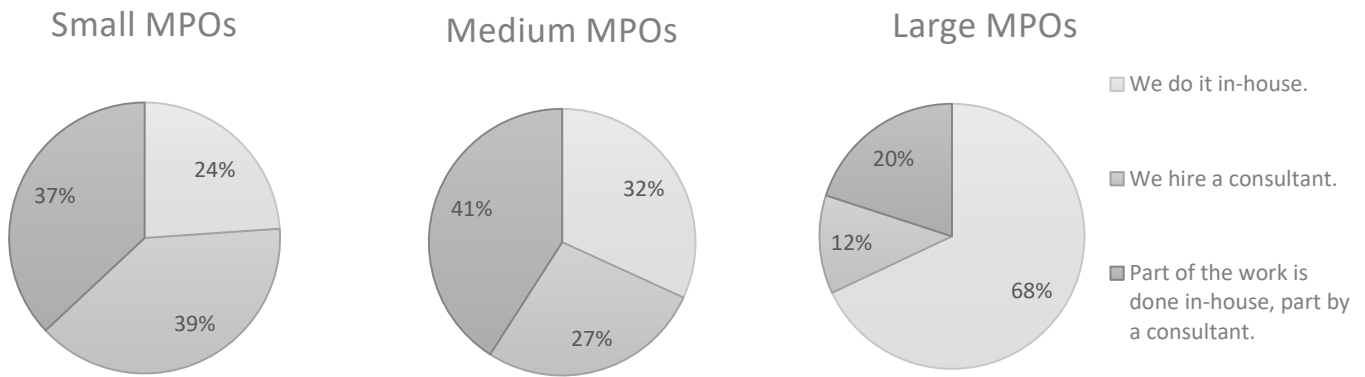
Figure 3-4: Long-Range Transportation Plan Estimation

Small MPOs

39%
61%

Medium MPOs

12%
6%
82%

Large MPOs

29%
9%
62%

☐ 3 or 4 Step Travel Demand Model

☐ Tour-based Travel Demand Model

☐ Activity-based Model
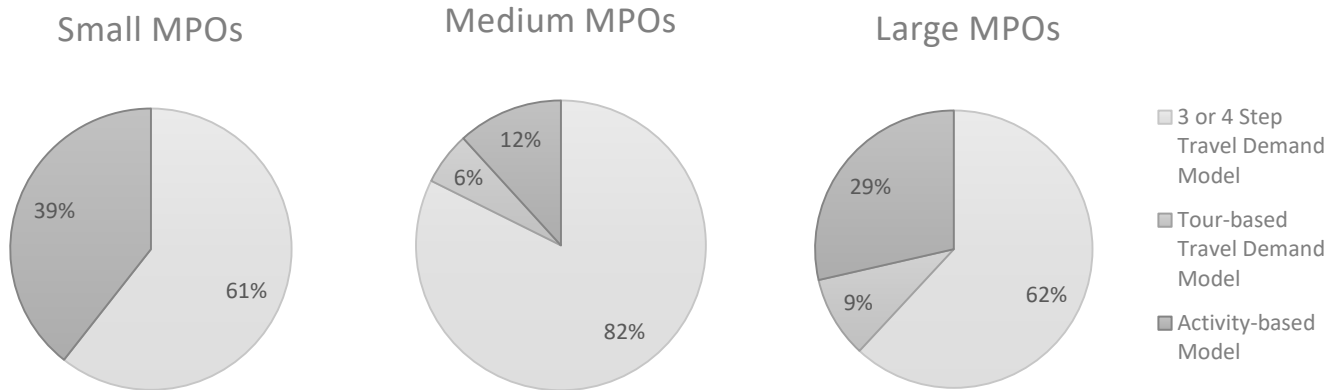
Figure 3-5: Type of Travel Demand Model Used by MPOs

3.2.CURRENT LONG DISTANCE AND/OR INTERCITY TRAVEL VOLUMES

In order to gauge the current role of long distance or intercity travel within MPO planning areas, respondents were asked two questions about travel related to origins or destinations outside the planning area. The first question asked, "What percentage of total traffic volumes in your Travel Demand Forecast involves either an origin or destination outside your planning boundary (urban or rural)? These are often referred to as Internal-External or External-Internal trips." The results, divided by MPO size and connectivity, can be seen in Figure 3-6.

In small MPOs, the less connected the community is, the less volume will cross the planning boundary, indicating that residents are not as willing to drive to destinations the further away they are. In medium MPOs, the opposite is true; if the community is not well connected or isolated, the majority of traffic begins or ends outside of the community. This emphasizes the critical role medium-sized communities play in connecting rural communities and urban centers. In large MPOs, the vast majority of traffic stays within the zone if it is connected to some urban areas, not well connected or isolated. However, if the community is well connected to *many* urban areas, long-distance travel across the planning boundaries begins to comprise a larger percentage of travel. These trends show that MPO size and connectivity play a meaningful role in long-distance travel and how it should be addressed. Large MPOs (except for those that are well connected to many urban areas) have the most contained daily travel and forecasting should emphasize intrazonal trips. Medium-sized MPOs most need to consider larger geographies in their planning processes in order to support the largest percentages of long-distance trips with origins or destinations outside the planning boundary.

The second question asked, "What percentage of total traffic volumes in your Travel Demand Forecast are "pass-through", with both origin and destination outside your planning boundary (urban or rural)? These are often referred to as External-External trips." These results, again divided by MPO size and connectivity, can be seen in Figure 3-7 and provide significantly different results.

Pass-through travel patterns are significantly different than to/from travel patterns, again based on geography. Small and medium-sized MPOs report very little pass-through traffic, unless the location is isolated. This highlights that this traffic is traveling extra-long distances between urban areas. Large MPOs, across all connectively levels, report notably more pass through trips, which can add to congestion on major highways in the planning area. While the low percentages of external-internal trips did not motivate the inclusion of long-distance travel in the LRTP, these results do. Large MPOs need to understand the origins, destinations, and choices of these pass-through travelers in order to sustainably plan for the future.
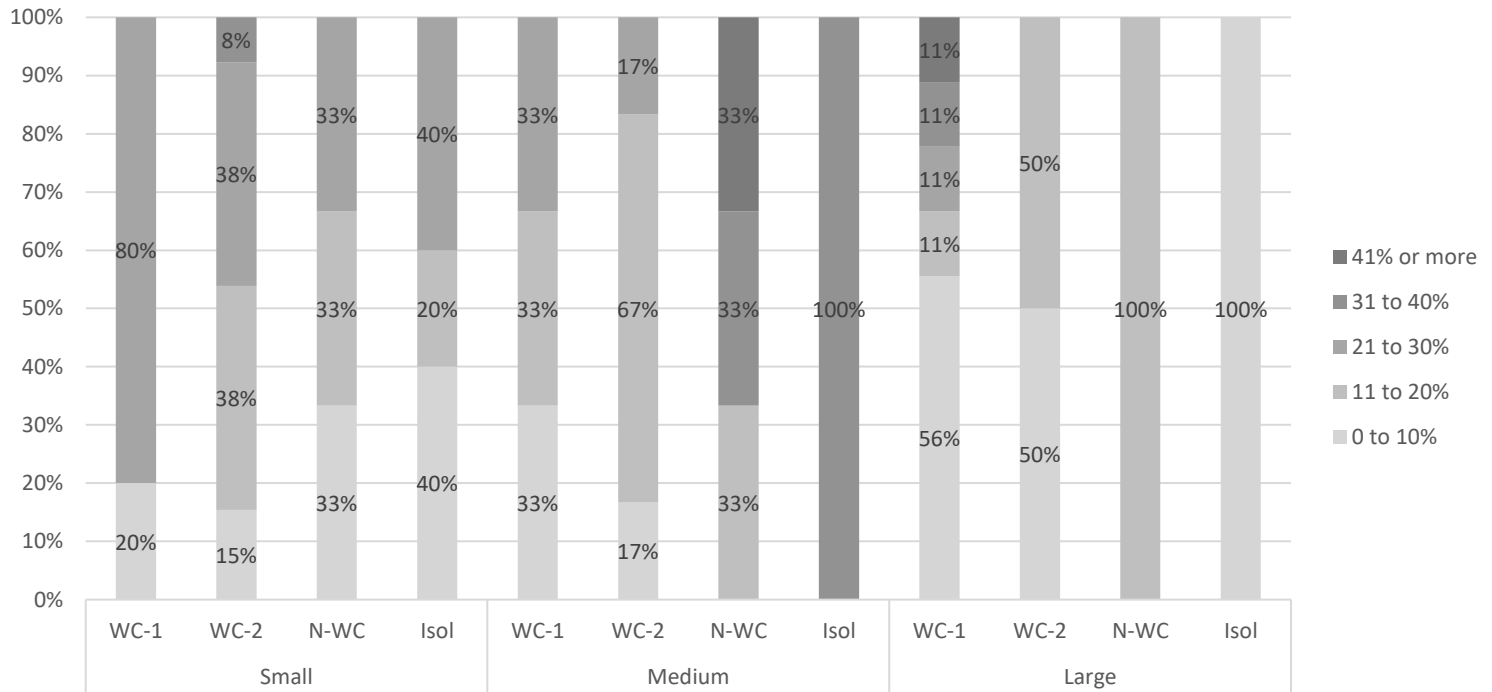
Figure 3-6: Internal-External or External-Internal Trips
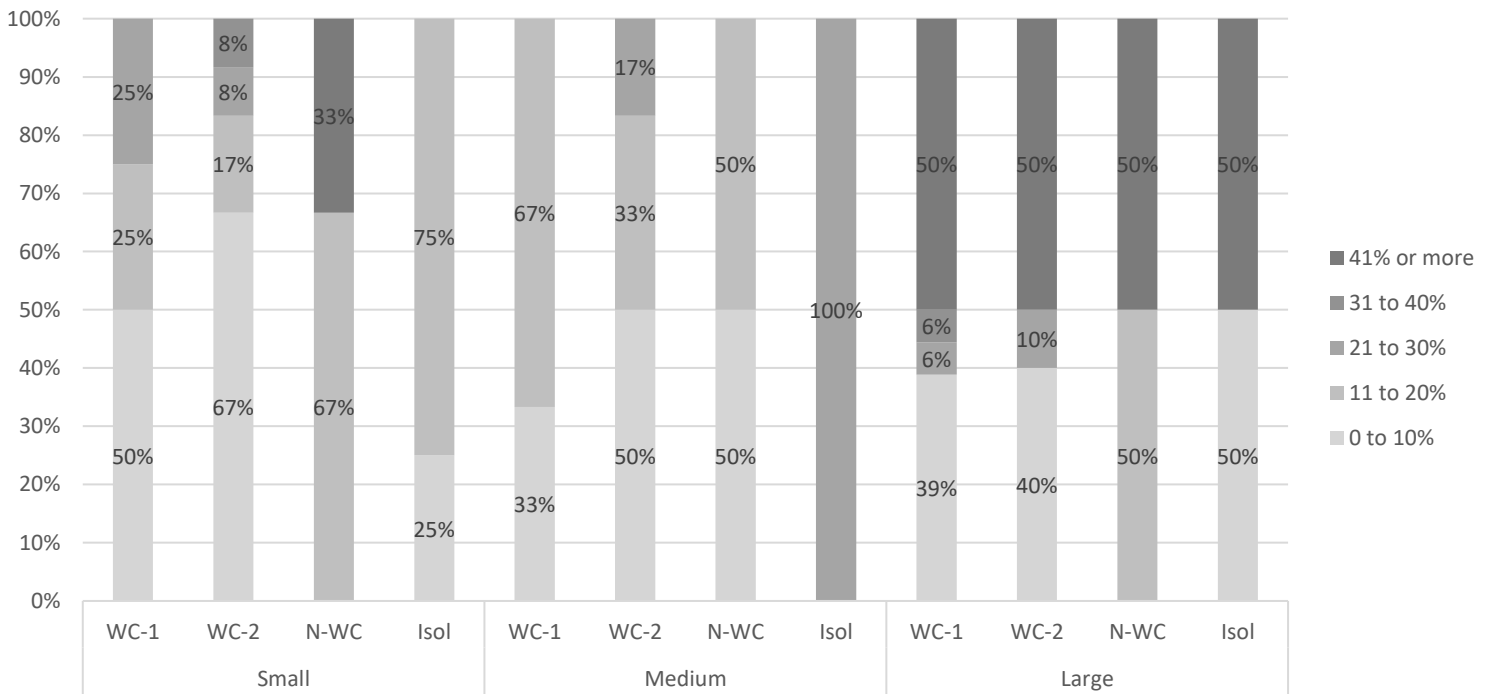
Figure 3-7: External-External Trips

3.3. ANTICIPATED CHANGES IN LONG DISTANCE AND/OR INTERCITY TRAVEL

Next, the survey asked MPOs about how they anticipate traffic volumes to urban and rural destinations outside the planning region will change within a shorter (5 to 10-year) and a longer (15 to 20-year) timeframe. Specifically, MPOs were asked how they "anticipated travel between their planning area to and from urban or rural destination types to change" over these two timeframes. Figures 3-8 and 3-9 highlight the results of these two questions, respectively. Each figure differentiates MPOs by size (small, medium or large) as well as by external origin/destination type (i.e. urban or rural). MPOs could choose from the five answers seen in the figures below.

Figure 3-8 shows that the majority of all MPOs (66.8%, on average) anticipate that traffic traveling between their community and both urban and rural destinations will greatly or somewhat increase within the next 5 to 10 years. Both small and large MPOs think more growth will happen in traffic to urban destinations than rural destinations, while medium MPOs project a more even growth between destination types. Across all three types, medium-sized MPOs had the highest percentages of "no change" responses, for both urban and rural areas. These projections show that communities of all sizes are anticipating a need for more access to their surrounding urban and rural areas. Many travel demand models focus on intra-regional daily travel, but these results highlight that models need to expand the urban and rural external trip forecasting abilities in order to sustainably plan for this increased intercity long-distance travel.

Figure 3-9 describes anticipated long-distance travel demand for a 15 to 20 year forecast. Medium-size MPOs report a jump in long-distance traffic volume growth to urban areas in this longer timeframe (compared to the shorter forecast timeframe), whereas small and large

communities anticipate growth will continue to increase at a similar rate. Traffic volume growth rates to rural areas are anticipated to remain constant, although large MPOs report less ability to predict these volumes this far ahead. These results also emphasize that the demand for long-distance travel will not diminish over a longer timeframe and that more highway improvements will need to be made to support this travel. Travel to and from long distance origin and destinations will become a larger proportion of our travel, and, as a result, the LRTP needs to specifically consider the role of long-distance travel.

Finally, MPOs were asked, "What indicators make your select your answer"? In their write-in answers, respondents noted their projections were based on (in order of frequency as a response): sociodemographic projections, model trends, traffic surveys, already planning infrastructure projects, and proximity to already growing regions. These quantitative methods and data sources underline the confidence that planners have in these projections. While planners may not have specifically thought about long distance travel demand, there is evidence that long distance and intercity traffic volumes are a concern for many MPOs, regardless of size.
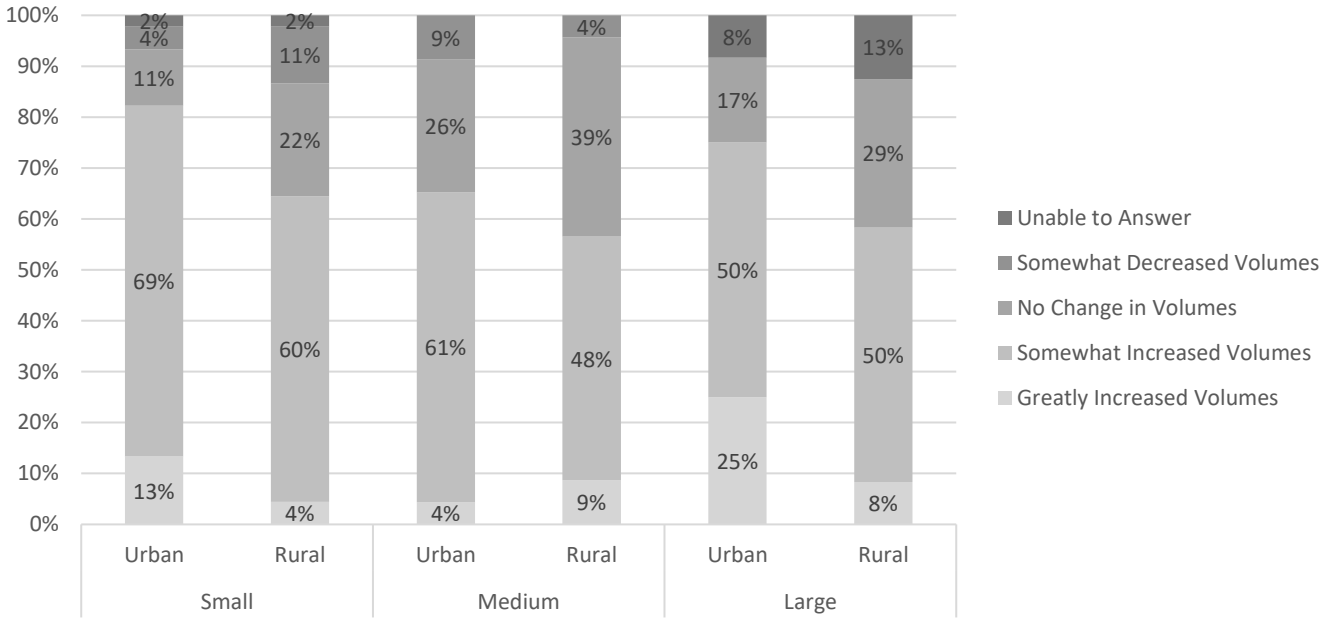
Figure 3-8: Expected Changes Within the Next 5-10 years
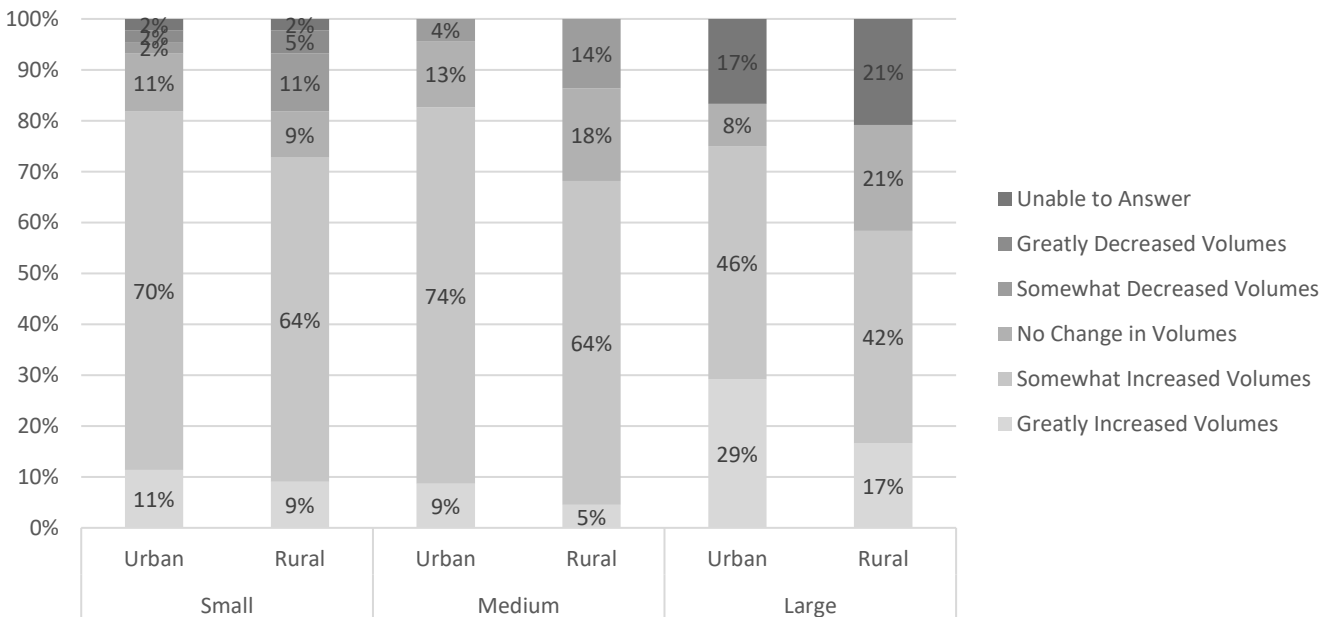
Figure 3-9: Expected Changes Within the Next 15-20 years

3.4. CURRENT LONG DISTANCE AND/OR INTERCITY TRAVEL PLANNING

Once the current scale of intercity and long-distance travel was established, MPOs were asked about how they currently address this type of travel in their planning process. Five questions explored this topic: 1) whether they consider long-distance travel in the planning process, 2) how they defined external zones for planning, 3) the importance of urban and rural external destinations in the planning process, 4) how their planning process coordinates with agencies representing these external zones, and 5) how the travel demand model reflects these needs.

First, MPOs were asked if they consider long-distance travel outside the planning boundary, and, if so, how this travel is defined in their planning process. Overall, 63% of small MPOs, 83% of medium MPOs and 72% of MPOs consider long-distance travel in their planning process, in some capacity. How they define this travel is seen in Figure 3-10, again organized by MPO size. Very few MPOs consider long-distance travel by the national data collection method, defined as a one-way trip of 50-miles or more from the home location. Instead, the majority (between 73% and 83% of MPOs by size) plan for travel with an origin/destination outside the planning area. Intercity and other definition (e.g. most commonly noted as regional connectivity between economic centers and through traffic) were also present, most commonly in medium-sized MPOs. These results provide critical insight into how researchers and planners should be defining travel when developing planning tools and models. Unfortunately, distance-based trip definitions are less relevant for developing actionable planning tools at MPOs. Instead, long distance trips should consider origins and destinations outside the planning area, independent of distance.

Second, MPOs were asked how many external zones, "defined as origins and destinations outside the planning boundary" in the travel demand model. Figure 3-11 shows that the complexity of defining external zones increases with MPO size, perhaps related to the total traffic volumes being considered. A large proportion (30%) of small MPOs simply count all travel outside the planning area as a single zone, while medium-sized MPOs have more variety in how they characterize external areas (from 2 to 21 or more zones). This is consistent with the results found in the importance of external-internal trips in medium-sized MPOs. The majority (81%) of large MPOs include 21 or more external zones in their travel demand model. MPOs were also asked how they defined these zones (e.g. sizes, distances, accessibility), especially when they had to model so many. There was little to no consistency in responses, even between MPO sizes, except to say that DOTs provided some guidance in selecting zones. This is an area requiring further research and standardization.
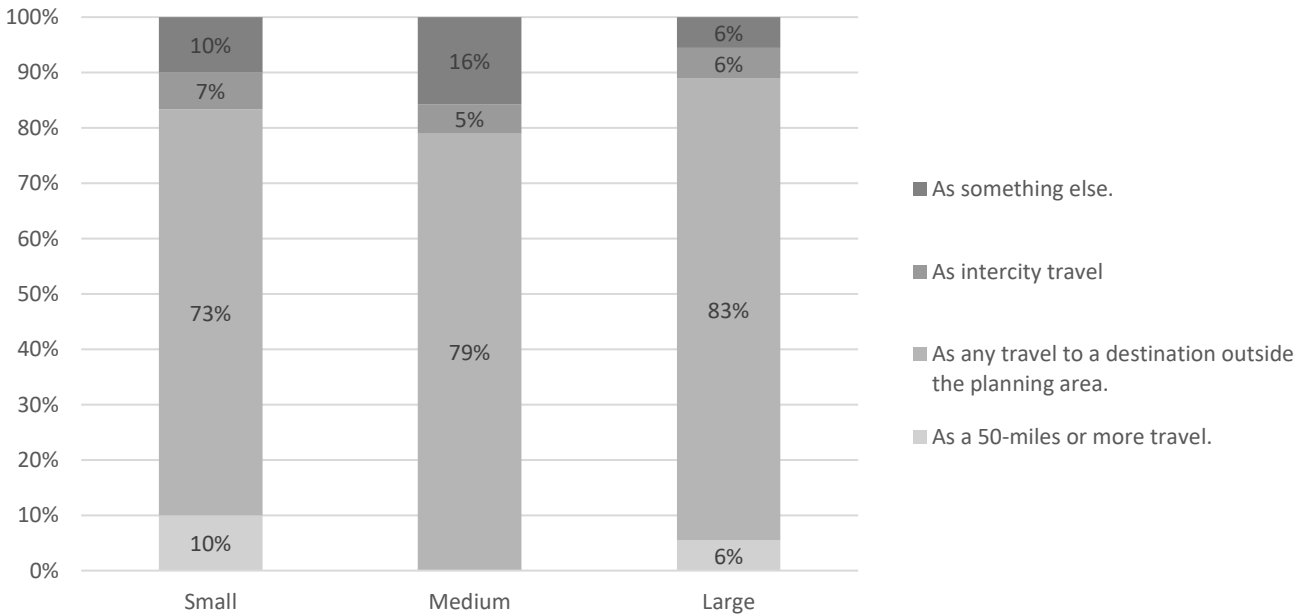
Figure 3-10: Long-distance / Intercity Travel Definition by MPOs
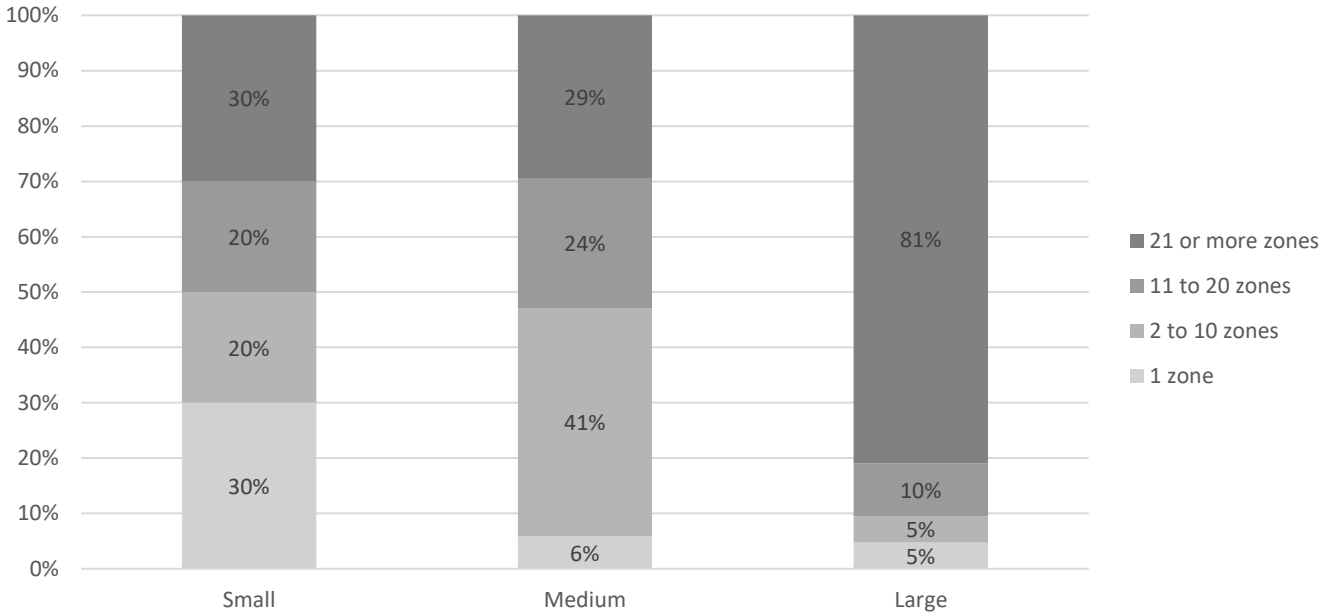
Figure 3-11: Number of External Zones Considered by MPOs

Third, MPOs were asked if "their LRTP specifically addresses travel to/from urban or intercity destinations outside the planning boundary" as well as for rural destination, and, if so, "how important is this to the LRTP". The discussion of results so far emphasizes the importance of long-distance travel on MPO traffic volumes and planning, but the results (seen in Table 3-1) describe two important and surprising patterns. First, despite the importance of this travel, not many MPOs consider this travel in an important capacity for the LRTP. For example, over 41% of medium-sized MPOs do not specifically consider long-distance travel to external urban or rural destinations in their LRTP. The two largest responses for large MPOs are split between not considering either (28%) or treating both as important considerations to the LRTP (24%). Small MPOs predominantly considered both but did not describe them as important (31%). Second, long distance urban destinations are considered more than rural destinations in LRTPs.

Fourth, MPOs were asked about their coordination with other planning areas. Responses, organized by size and connectivity, are presented in Figure 3-12. Most MPOs coordinate with other areas, as expected, but it is interesting that small MPOs and isolated large MPOs included a notable number of negative responses. This coordination can be leveraged to share data and long-distance travel projections, as well as potentially linking travel demand forecast models.

Fifth, the specific methods MPOs use to model long-distance travel were analyzed. Previous findings show that many MPOs use either the 4 Step Method or Activity-based models, but independent, simpler methods are often used to forecast these external trips. Small MPOs extrapolate traffic counts (59%), rely on provided DOT statewide model data (23%), combine counts and statewide model results (14%), and estimate models themselves based on travel surveys (5%). Medium-sized MPOs rely on DOT statewide model results (43%), model volumes from permanent traffic stations or Bluetooth data providers (36%), estimate models themselves (14%), and extrapolate traffic counts (5%). Large MPOs most often include these trips as part of their own estimated models (33%) or apply DOT statewide model results (albeit with more input that the small and medium MPOs, 33%), model volumes from permanent traffic stations (29%) and extrapolate traffic counts (5%).

Finally, MPOs indicated a critical need for tools for improving long-distance travel forecasting. Figure 3-13 shows their responses to three types of potential tools that improve ability to: a) predict long distance or intercity traffic volumes, b) evaluate policy impacts on long-distance travel, and c) evaluate equity issues related to long-distance travel. While the results were relatively consistent (and in favor of all three tools) across all MPO types, medium-sized MPOs

31

again demonstrated the most variability, with slightly more interest in predictive tools and significantly less interest in equity measures.

Comprehensively, these findings show a notable range in small, medium, and large MPOs' ability to adequately forecast and plan for long distance and intercity travel. These MPOs previously highlighted the significant role that this travel plays in their communities, and structured methods for addressing this future demand, tailored for each MPO size, are needed.

Small | Medium | Large MPO		RURAL destinations outside the planning boundary			Total
		Important Consideration	**Considered, but Not Important**	**Not Considered**	
URBAN or INTERCITY destinations outside the planning boundary	**Important Consideration**	18% | 18% | **24%**	9% | 5% | **12%**	0% | 5% | **4%**	27% | 27% | **40%**
	Considered, but Not Important	4% | **5%** | 0%	**31%** | 14% | 12%	**9%** | 5% | 16%	**44%** | 23% | 28%
	Not Considered	**4%** | 0% | 0%	7% | **9%** | 4%	18% | **41%** | 28%	29% | **50%** | 32%
	Total	**26%** | 23% | 24%	**47%** | 27% | 28%	27% | **50%** | 48%	100%

Table 3-1: Consideration of Urban or Intercity and Rural destination outside the planning boundary

33

Small MPOs

	WC-1	WC-2	N-WC	Isol
No	50%	33%		44%
			88%	
Yes	50%	67%	13%	56%

Medium MPOs

	WC-1	WC-2	N-WC	Isol
No	17%	25%		
Yes	83%	75%	100%	100%

Large MPOs

	WC-1	WC-2	N-WC	Isol
No		50%		100%
Yes	100%	50%	100%	
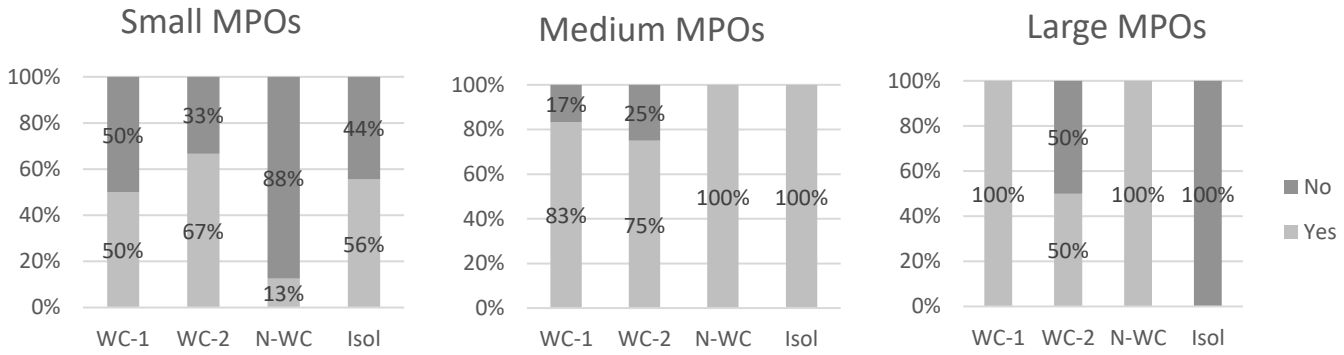
Figure 3-12: MPOs Coordination with Other Planning Areas

Small MPOs: Improve Ability to Predict Long-Distance or Intercity Traffic Volumes 35%, Improve Ability to Evaluate Policy Impacts on Long-Distance Travel 33%, Improve Ability to Evaluate Equity Issues Related to Long-Distance Travel 32%

Medium MPOs: 44%, 36%, 20%

Large MPOs: 38%, 31%, 31%

Legend:
- Improve Ability to Predict Long-Distance or Intercity Traffic Volumes
- Improve Ability to Evaluate Policy Impacts on Long-Distance Travel
- Improve Ability to Evaluate Equity Issues Related to Long-Distance Travel

Figure 3-13: MPOs Tools

This chapter presented the results from a national survey of MPOs that collected information about the current state of the practice related to long-distance or intercity travel planning. The main motivation of this work is based on the lack of guidelines to provide MPOs with a framework to address this type of travel planning. A population range was used to categorized MPOs in three groups: small, medium, and large. The second item

considered to classify MPOs was based on their connectivity. All fourth census regions have a percentage of their MPOs population represented in this project, between 19%-28% of their respective population.

The main finding of this chapter supports the necessity of implementing cross-boundary planning. These efforts inevitably need to coordinate with neighboring planning areas due to the strong connectivity and reasonable number of independent cities within these areas. Therefore, intercity and long-distance travel planning becomes a fundamental factor to include. Since a large proportion of MPOs complete their LRTP with their own staff or partially hired external firms, there is the need to provide methods to facilitate data collection. Additionally, efforts to improve the 3 or 4 steps models are required, since is the most notable used model. These should include all possible modifications and considerations necessary to address intercity travel such as data implementation and forecasting.

Cross-boundary travel needs to be addressed in different ways based on the MPOs size and connectivity profile, however all levels should require the same objective of providing accurate and meaningful information to implement in the LRTP. Traffic to/from destinations outside the planning are and pass-through traffic have different levels of influence depending of the MPOs connectivity. Because of this variability, efforts to understand intercity travel patterns and choices are required to generate a more reliable plan in the future. This will be fundamental for large MPOs especially due to the large volumes of traffic generated from long distance travels.

MPOs acknowledge the impact that future changes will have in intercity traffic volumes. These results highlight the need to include rural and urban external trips in the travel demand model, especially because of the greatly perception of experiencing future changes in travel between MPOs communities. Therefore, planning for long distance travel should remain as major factor to address in the LRTP.

Although large segments of MPOs do consider long-distance travel outside their planning boundary, the way MPOs need to work with it shows that distance-based definitions are not appropriate, whereas an origin-destination trip approach should become the standardized method to account such trips. MPOs need to also measure external zones, which become more complex as MPOs size increases. Additionally, lack of consideration of intercity travel to/from urban or intercity and rural destinations in the LRTP provide more evidence about the necessity to not only addressing this trip, but also creating the mechanisms of provide MPOs with guidelines that set a standardized framework to account long distance travel.

CHAPTER 4: HOW LONG DISTANCE TRAVEL IS INCORPORATED INTO STATEWIDE MODELS

4.1. INTRODUCTION

Statewide travel demand models are inherently focused on forecasting long distance and intercity trips, with a main objective of anticipating future traffic congestion and interstate demand. Much work has been done over the past decade to improve statewide models so they are responsive to state and national economic, demographic, societal, and policy changes. Additionally, the models equations have been restructured to better represent travelers' decision-making processes and behaviors. These improvements should provide more accurate data to inform roadway improvements and rehabilitation project decisions. However, much of this work mirrors the modeling techniques used in metropolitan planning areas, which include notably different behaviors and travel choices.

Simultaneously, more work has been done recently exploring the unique nature of long-distance mode choices, destination choices, and tripmaking frequency. However, it is unclear if this new knowledge has yet been implemented into statewide models. Therefore, a survey of states with statewide travel demand models was conducted to evaluate the current state of the practice of, and opportunities for, introducing such long-distance travel

behavior into these processes. By incorporating these unique travel choices into statewide models, we can further improve our ability to accurately anticipate congestion and understand how policies influence our traffic patterns.

NCHRP Synthesis 514 (2017) lists that 30 states currently utilize a statewide travel demand forecasting model, as seen in Figure 4-1, and all 30 were contacted to complete either an email or a computer-aided telephone interviews (CATI) about the details of their models. This work builds specifically off the NCHRP Synthesis 514, which was more focused on broad questions about planning horizons, data sources, and other traditional model technical details not specifically related to long distance travel.
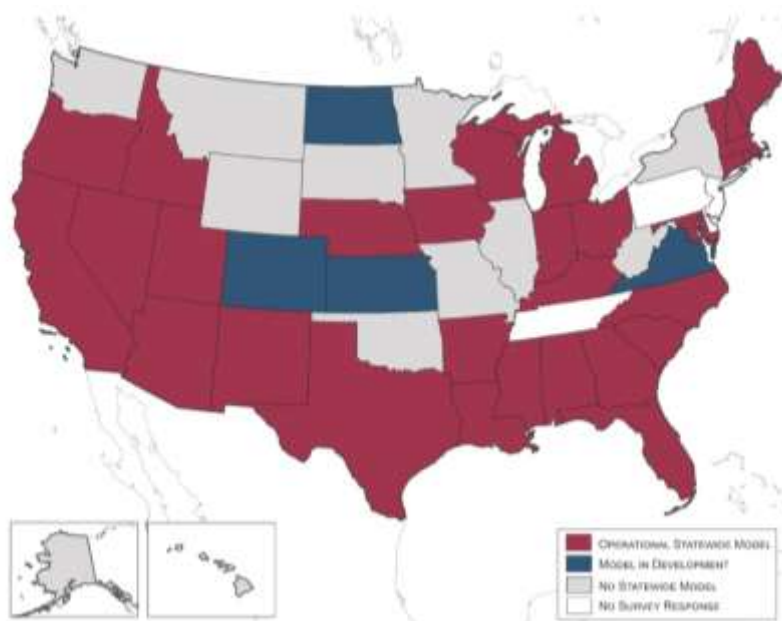
Figure 4-1: States with Operational, In Development, and with no Statewide Models (Donnelly & Moeckel, 2017)

This survey focused on four main areas that could potentially be improved by considering long distance travel models and behavior: how states identified long distance destinations

and zones in their model, how the statewide models dealt with internal and external long distance travel models, how long distance models and purposes were introduced, and the long distance data used to support these models. These questions provide a snapshot on the methods and data currently implemented to address trips going through the planning area or trips with at least an origin or destination outside the planning area. Also, the zonal study section helps understand the degree of analysis of the different models. To answer the survey, either the State DOT or the consulting firm that developed the model were contacted through e-mail and/or phone calls. Eighteen states were considered in this study, or a 52.9 % response rate. Table 4.1 show the States that responded, and the method used to survey them.

State	Survey Method	State	Survey Method
Arkansas	Phone Call Interview	Massachusetts	E-mail
Arizona	Phone Call Interview	Maryland	Phone Call Interview
California	Phone Call Interview	Michigan	E-mail
Colorado	Phone Call Interview	North Carolina	E-mail
Connecticut	E-mail	Nebraska	E-mail
Delaware	E-mail	New Mexico	E-mail
Florida	Phone Call Interview	Nevada	E-mail
Kansas	E-mail	Rhode Island	Phone Call Interview
South Carolina	Phone Call Interview	Vermont	E-mail

**Table 4-1: States Participants and Survey Method**

The responses were aggregated by census region to show representation at the national level (Figure 4-2). The distribution is based on the number of states in each region that reported to have operative models in the NCHRP-Synthesis 514. South and Midwest region have similar representation with 45% and 50%, respectively. While West and Northeast region have greater representation with 71% and 83%, respectively. Generally, the survey captures a broad number of states that properly represent the different census regions of the country.
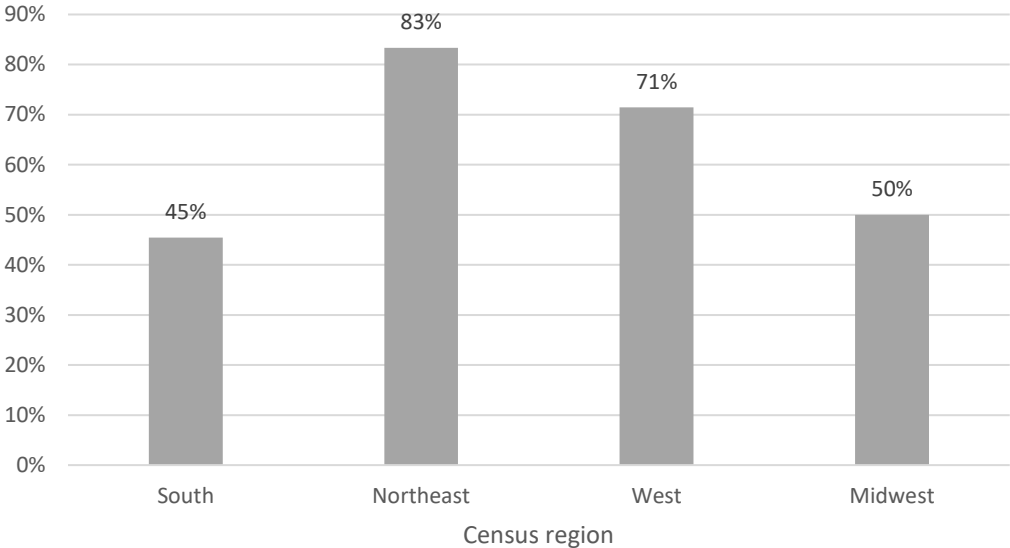
Figure 4-2: Region Distribution of Survey Respondents

For this chapter, responses were characterized by state population density. Density greatly influences statewide and metropolitan planning methods because residents have varying degrees of mobility and travel opportunities locally, regionally, and statewide. All US states were clustered into one of three density scales with equal numbers of states in each: low (less than 65 residents per square mile), medium (between 65 and 280 residents per square

mile), and high (280 residents or more per square mile). Interestingly, the survey responses mimic much of the actual distribution of low/medium/ and high distributions in the US, with the northeast being underrepresented in the "low density" category and overrepresented in the "medium density" category (Figure 4-3).
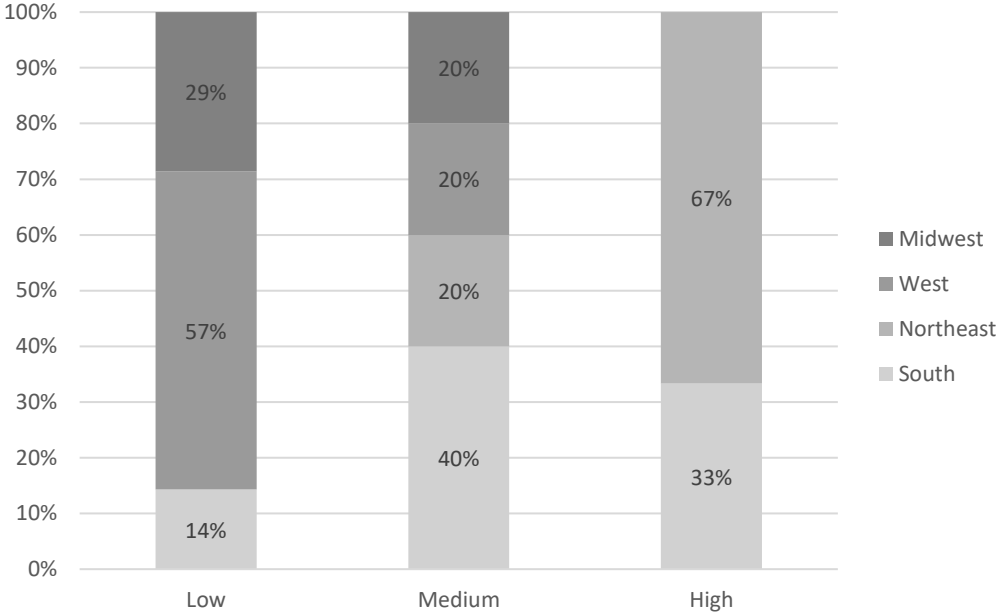
Figure 4-3: Population Density Size

In general, our survey supported the results from NCHRP 514 in finding that the majority of states are currently using 3 or 4-step trip-based forecasting models, rather than the more advanced activity-based models. While trip-based models are more traditional and simpler to implement, activity-based models often are more precise and more sensitive to changes (though more complex to implement). Both models are described and discuss in detail on previous sections. As observed in Figure 4-4, nearly 90% of respondents utilized a trip-based model and only 10% of them use an activity-based one. Small and Medium density states are the main users of activity-based models.

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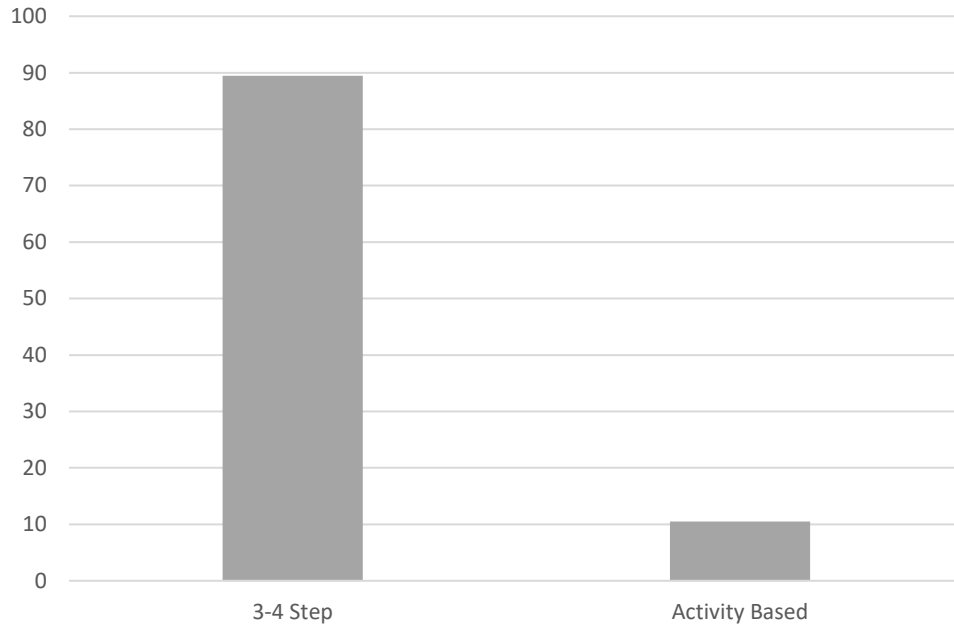
Figure 4-4: Type of Model Implemented for Statewide Travel Forecasting

State agencies were also asked how the statewide model relates to their internal MPOs models. There were given the follow options as shown in Figure 4-5: relates to the Traffic Analysis Zones (TAZ), relates to the projections of socioeconomic, demographic, land use, and traffic characteristics, relates to the Model (Model) development, or design, or relates to Other (Other) variables or methods.

It was observed that statewide models rely heavily on two main aspects from the MPOs models: geography and projections. TAZ and projections are commonly implemented based on MPOs models at similar proportions for low and medium states. However, it was noted that high-density states implement more model specific characteristic from MPOs beyond just TAZ and other projections. These include trip productions and attractions, mode choice, and trip distribution methods.

In some of the surveys conducted via phone call, the respondents directed the research team to specific MPOs models for further information about the statewide modeling process. This trend has also been observed in previous research (e.g. the Wisconsin Department of Transportation (WisDOT), when developing a new statewide multimodal transportation demand model utilized elements of the MPOs models as inputs of the passenger forecasting process (Cipra, et al., 2006)). This is a notable advance in the coordination between State agencies and MPOs towards regional modeling, especially as a means of providing benefits for the long-range transportation planning process.
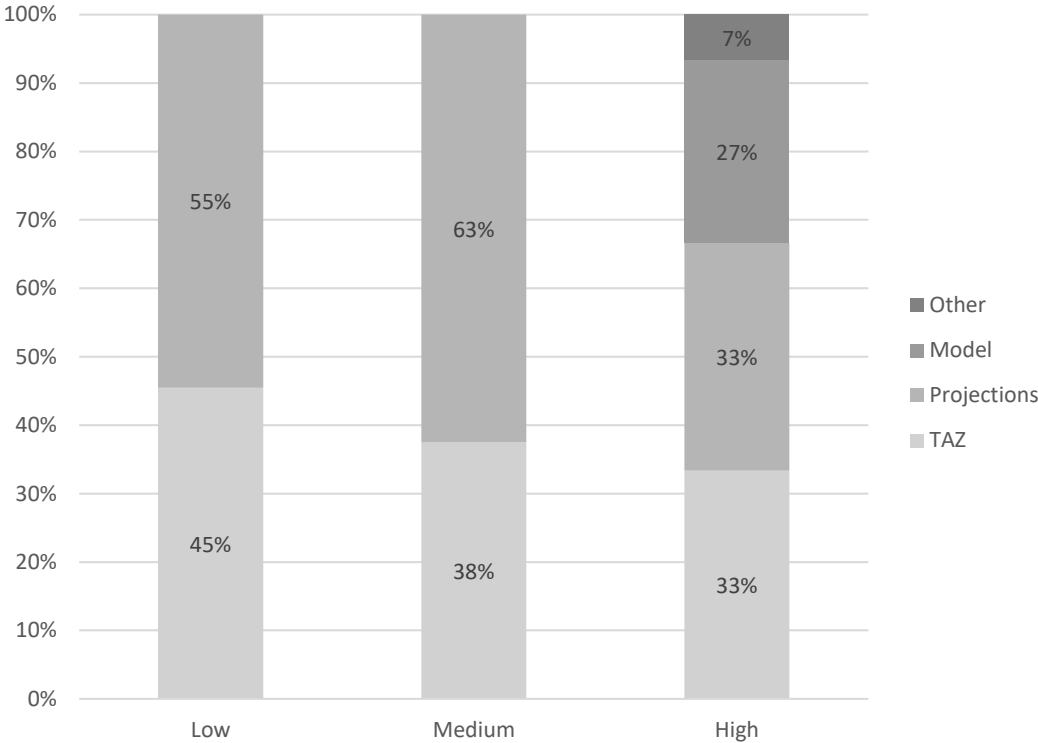

Figure 4-5: Relation Between Statewide Model to MPOs Models

4.2.IDENTIFYING LONG DISTANCE DESTINATIONS AND ZONES

Second, the survey collected information about how states are defining long distance destinations in their statewide models. This section is intended to help understand statewide models' spatial coverage to model travel inside and outside their borders. In general, there were three main learnings from the survey that influenced the responses listed below. First, states are very inconsistent in the scope and scale of internal and external zones because there is little documentation to provide guidance for states on the proper scales, especially related to external zones, to consider in this process. Second, even though they are inconsistent in how it is implemented, many states utilize a buffer zone defined by external stations or state border crossings when defining travel outside the state. Third, most states recognized that their zone system was not defined by modeling/behavioral need but by data availability. All three offer opportunities for improvement by incorporating long distance travel patterns and choices.

The first question asked states how they defined their internal zone geography, seen in Figure 4-6. Four main geographies were used across states: census block and/or census tracks (CB), used same MPOs geography (MPOs), used Traffic Analysis Zones (TAZ), and other state-specific geography (Other). Across all three density groups, states predominantly rely on census blocks, followed by TAZs. In fact, as evidenced by the sums adding to over 100%, many states used a combination of these two to match to the variety of data sources. MPO-defined zones are more important for less dense states, where more population is focused around these urban hubs.
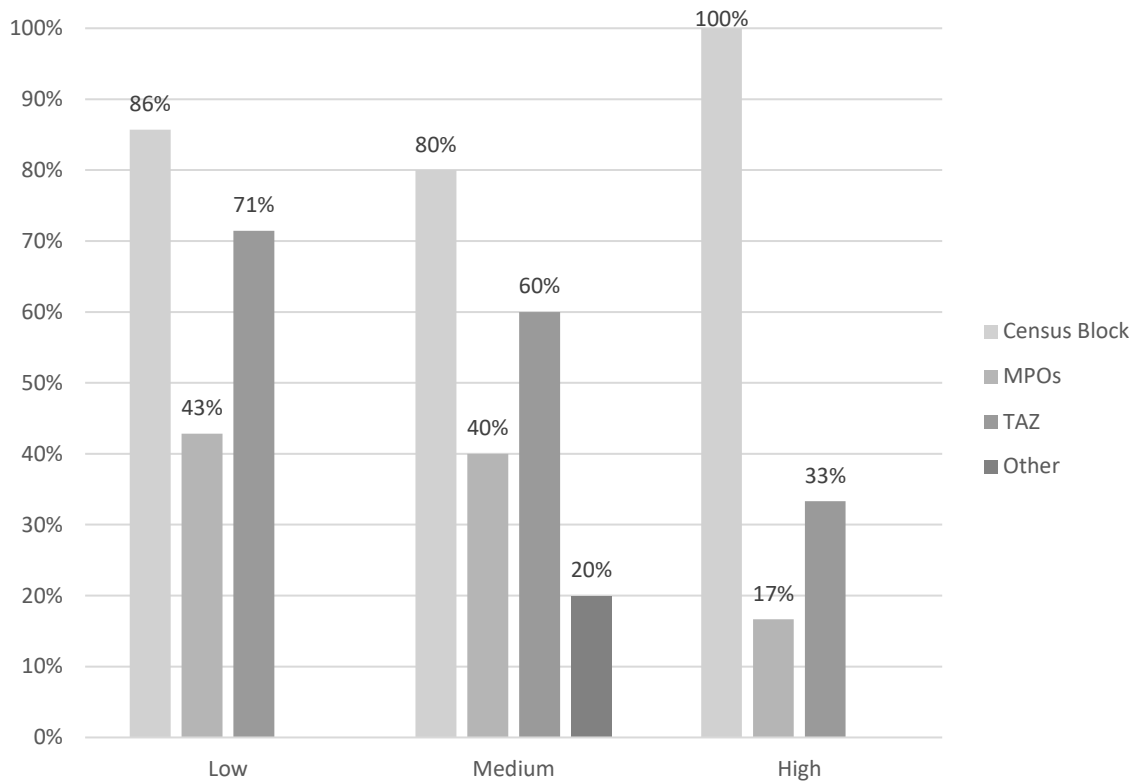
Figure 4-6: Internal Zone Geography

More important to long distance travel are external zones. When asking the same question for the external zones, the responses included were (Figure 4-7): boundary crossing, neighboring areas, including counties and / or TAZ, neighboring states, states beyond neighboring areas, and other state-specific geography (Other). Again, states could choose as many zones as they considered externally, letting values sum to over one hundred percent.

Figure 4-7 highlights the lack of accuracy and modeling detail associated with travel across state boundaries. Surprisingly, most states only focus on travel across a specific boundary, especially in the states with the highest densities. Long distance travelers often travel far beyond these state boundaries and these choices should reflect the changes in potential

destinations. External stations are used to represent origins and destinations of trips that leave or enter the study area. Many states find too complex to simulate external travel; therefore, some would rather simulate those external trips from points locations rather than zones. The use of boundary crossing is implemented by at least 40% of low and medium-density states. Whereas, 100% of high-density states implemented. States often use boundary crossing points on major roadways access/egress at the state boundaries. In some cases, these boundary crossing are located inside the states, yet they were used to simulate external trips. Boundary crossing are also often tied to basic traffic count stations.
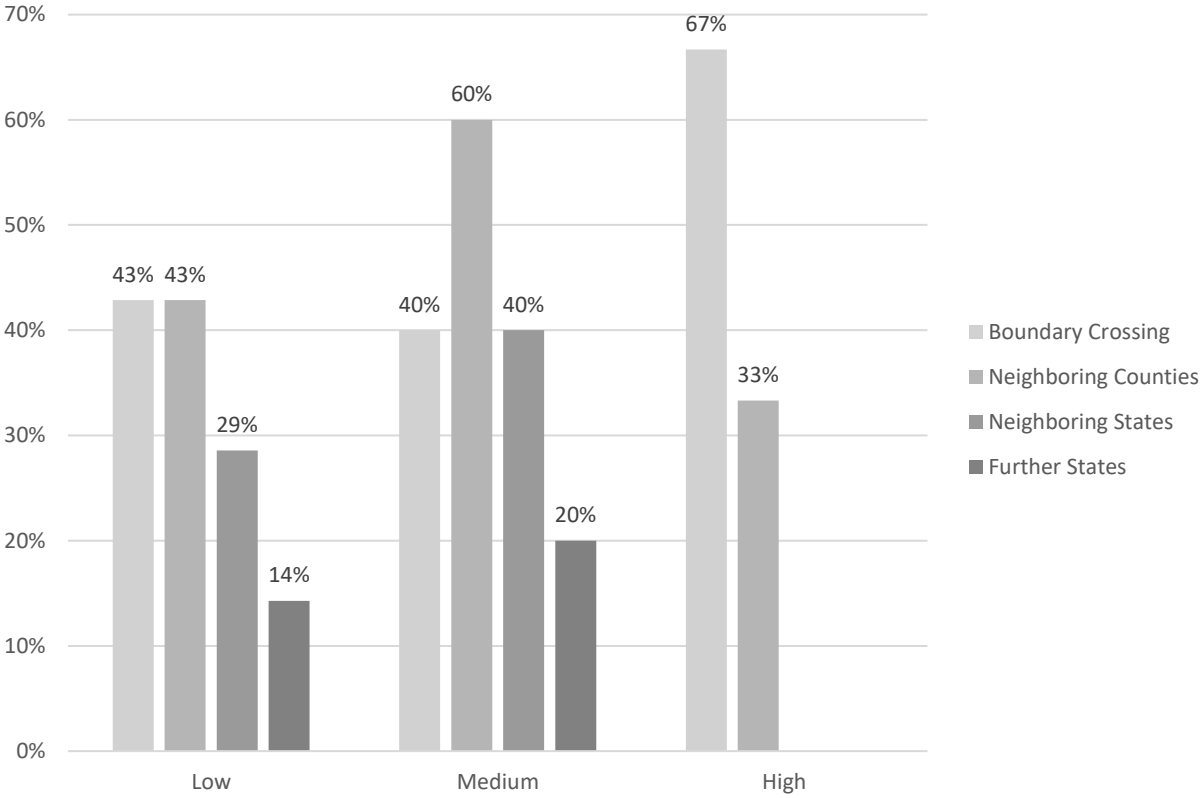
**Figure 4-7: External Zones Geography**

Table 4.2 shows the approximate range on internal/external zones use by type of density. Internal zones are observed to increase as the density becomes larger. External zones on the other hand, are relatively equal.

Density	Number of Internal Zones	Number of External Zones
Low	890-6440	35-615
Medium	866-6400	48-317
High	1151-8519	15-437

Table 4-2: Number of Zones by Density size

Additionally, as part of the survey state agencies were asked if the internal zone geography match the state boundary. This question is especially important to understand the effect of cross-state megaregions on statewide models and long-distance / intercity travel forecasts. Some agencies acknowledge the connectivity with neighboring areas and account for this effect on the statewide modeling process. As observed in Figure 4-8, 71% of low-density states use the state boundary to delimitate the internal zone. Similarly, 80% of medium-density states agencies respond to use same state a different boundary to delimitate the internal zones. The rate decreases to 67% of high-density states. This is probably due to well-connected urban-area within the state that mandate the use of different boundaries for internal and external zones. This use of different boundary than the state itself show these states are concern about the effect of megaregions and/or connectivity to neighboring areas.
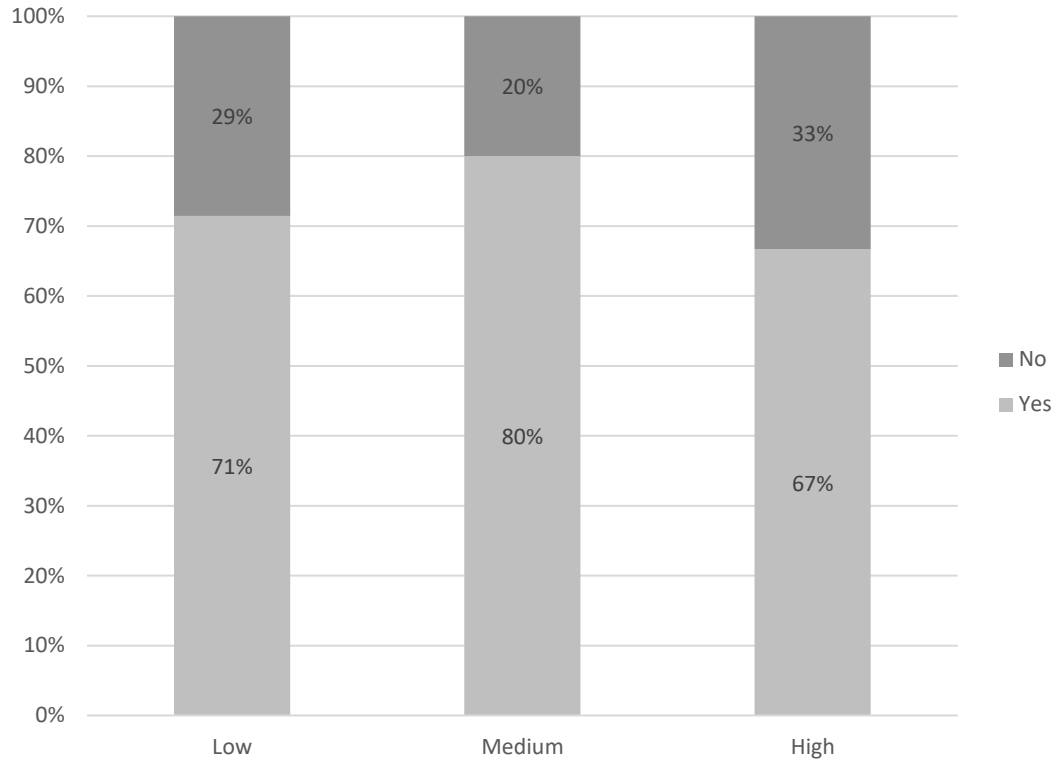
Figure 4-8: Relation Between Internal Zone Boundary and State Boundary

Agencies were also asked about the distance (miles) from the state boundary to the furthest external zone. To understand the relation between the distance from the border line of the state to the location of the furthest external stations, each distance is plot with their respective density as observe in Figure 4-9. Consistent with the table above, where the lack of high-density statewide models considering destinations beyond "border crossings" was found, these states are not looking far beyond their boundaries. Medium and low-density states are more likely to consider a wide range of destinations beyond the state boundaries. This lack of detailed origin and destination geographies is a prime opportunity for incorporating long distance models, especially as individuals choose between destinations both near and far for leisure travel as well as those accessible by air and car. Our statewide

models need to be sensitive to changes in economics and accessibility, which can change

individuals' choice of destinations and modes; simply focusing on modeling the number of

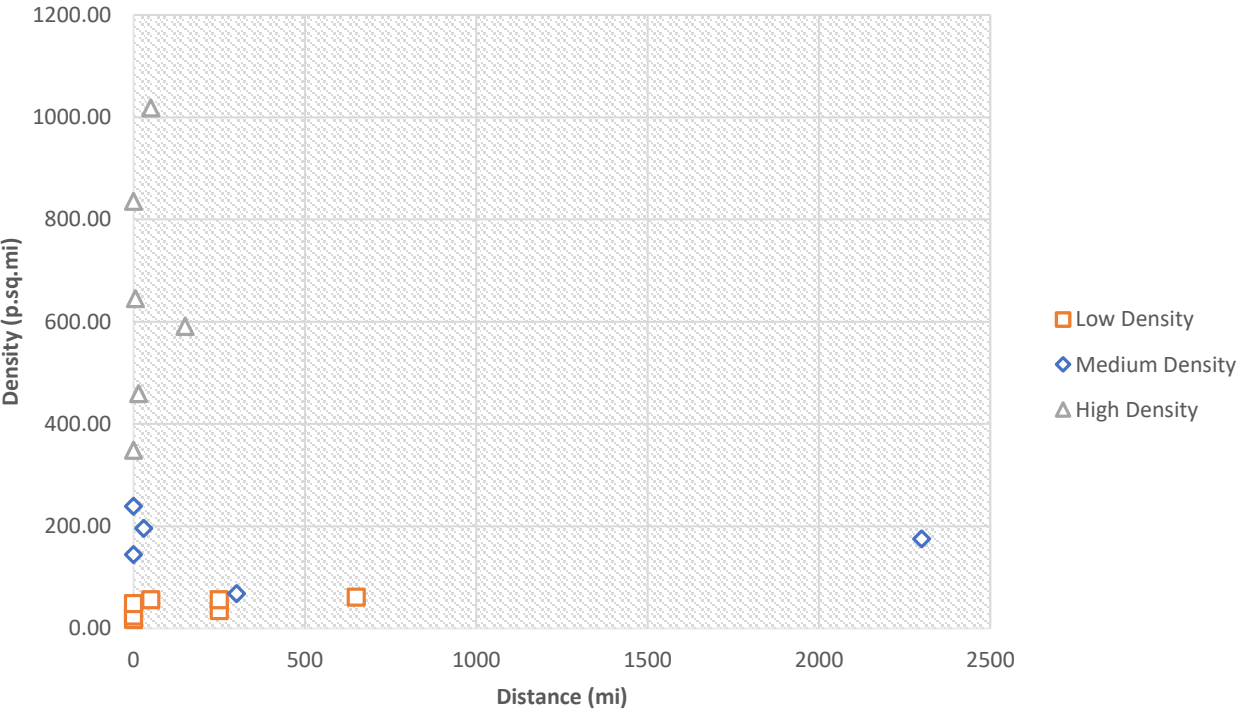vehicles that pass a specific border location is neither accurate nor sensitive to change.

Figure 4-9: Distance from Furthest External Zone to State Boundary

4.3. INTERNAL AND EXTERNAL LONG DISTANCE TRAVEL MODELS

This section of the survey reflects details about the internal and external modeling process. The purpose of this section is to reveal what are the common practices for trip generation and trip distribution, and whether long distance travel behavior is appropriately incorporated into these models.

Figure 4-10 shows the proportion of agencies that implement separate methods for internal and external trip generation. Long distance trip rates in internal areas may access both internal and external zones, whereas external zones are specifically generating trips that end within the state or pass through the state. Because of this, it is more realistic to have separate models for trip generation. However, this requires different sets of data for estimation. Appropriately, the denser the state, the more likely they are to implement separate trip generation models for internal / external zones. 43% of low-density states use a single methodology for both scenarios.
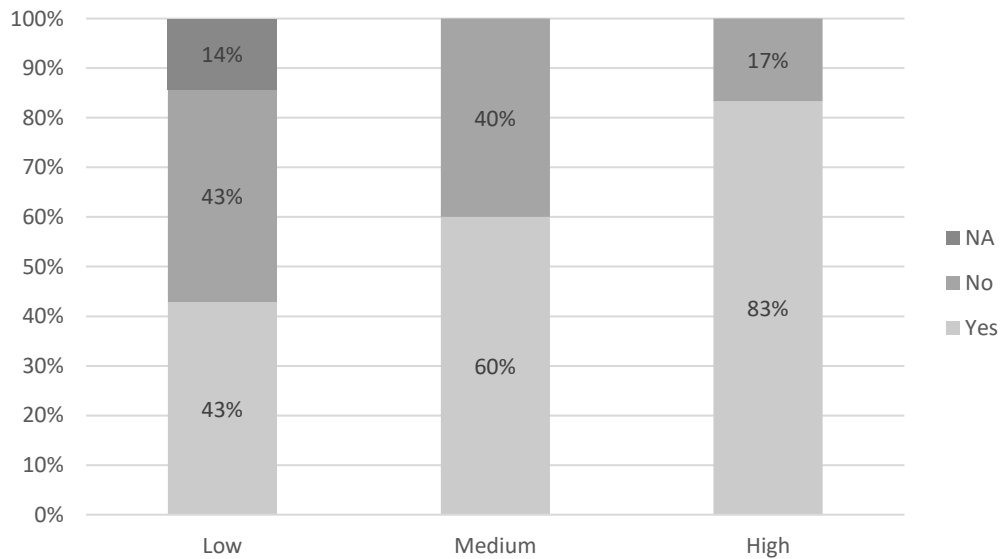
Figure 4-10: Use of Separate Methodology for Internal and External Zones

When states use different models for internal and external trip generation, they do so with notably different techniques, as seen in Figure 4-11. Cross classification tables are common across low, medium and high-density states for forecasting internal zone trip rates. Regression and scaling factors are also surprisingly common for internal zones forecasting. For external zones traffic, counts are largely commonly used for low and medium-density states at rates of 50% and 67%, respectively. This method consists in converting traffic counts in vehicles classification, then based on external stations survey they are converted to person trips. Trip rates data is implemented by 60% agencies high-density states. Medium density states demonstrate the only microsimulation trip generation models for both internal and external trip making.
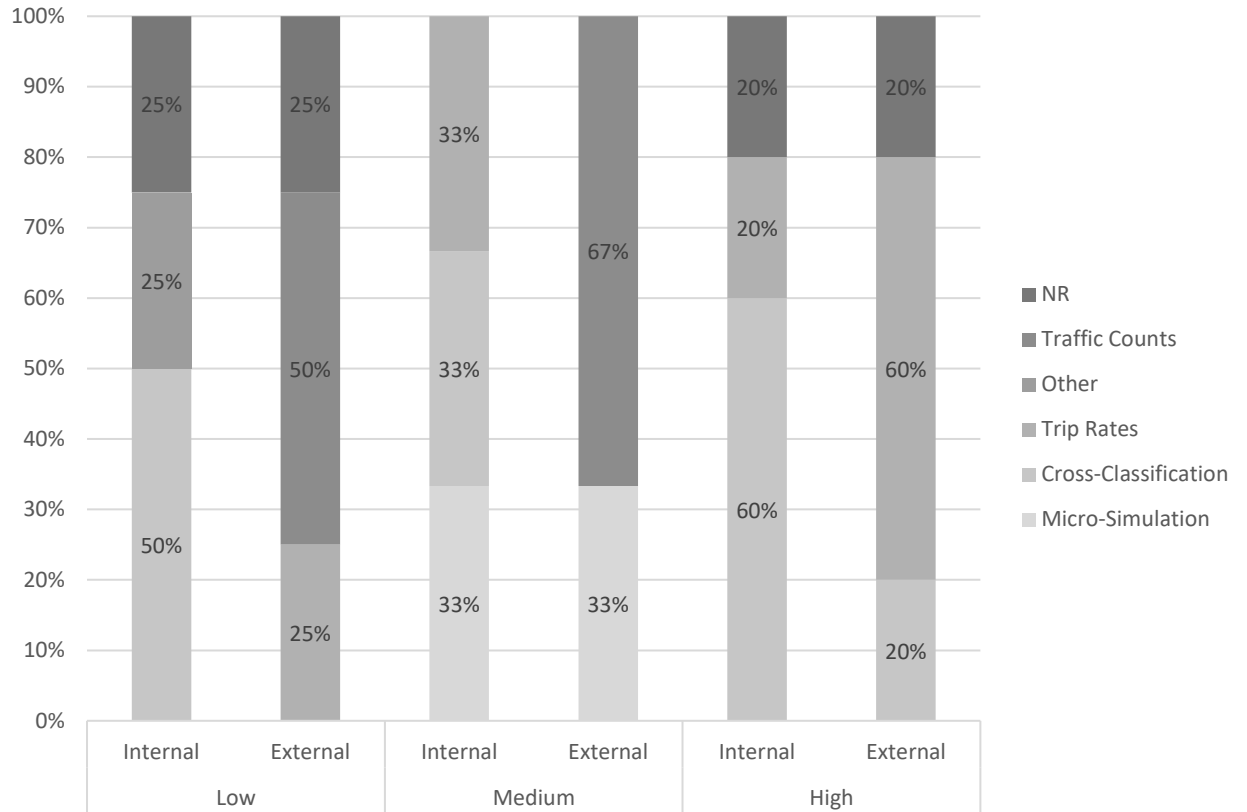
Figure 4-11: Method to Calculate Trip Generation from Internal/External Zones

When agencies implement the same trip generation methods for both internal and external zones, cross-classification is observed to be widely implemented across all density levels as show in Figure 4-12. Although, is more notably implemented by high-density states. 50% of medium-density states use trip rates from different studies. Colorado, which is classify as a low-density state is the only to implement multinomial logit and nested logit models (TransCAD) from disaggregate data about people and households.
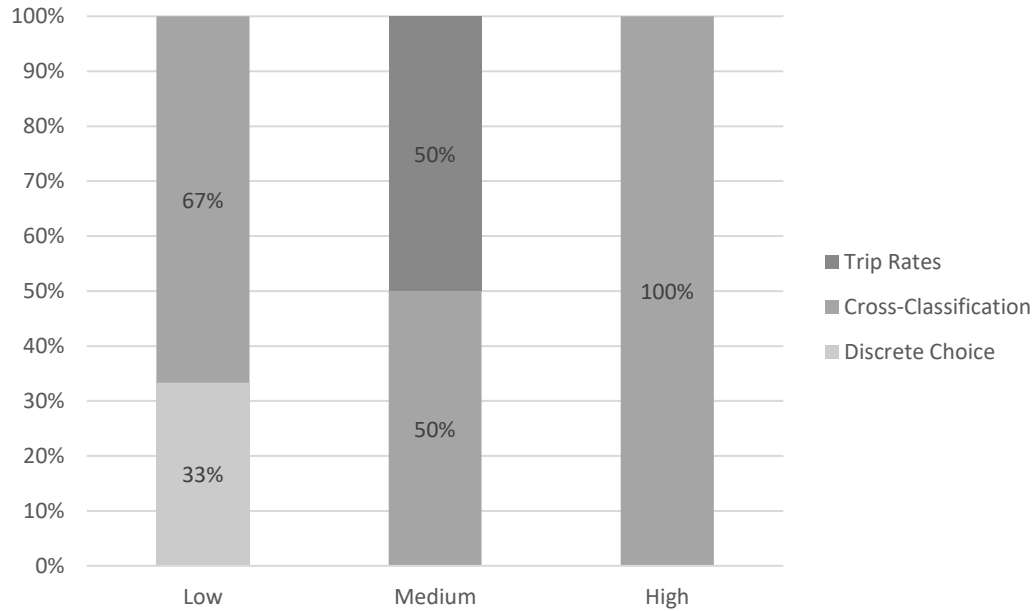
Figure 4-12: Method to Calculate Trip Generation for both Internal and External Zones

Alternatively, if statewide models are reflecting true long-distance travel behavior, they should ideally consider trip distribution simultaneously. Individuals often do not differentiate destinations that are instate versus those that are out of state, so they should be able to choose from among the options equally. Figure 4-13 summarized agencies responses about the method for trip distribution implemented for internal-internal and internal-external trips. Internal-internal trips occur within the modeling area. In statewide models these trips are identified as long-distance or intercity trips occurring between urban areas inside the state. Internal-external trip are those with one end inside the modeling area and the other outside. These trips are practically not address in urban models, and they are a source of major traffic particularly in states with especial generators such as major airports, national parks, and other tourist attractions.

Agencies surveyed responds that gravity models are the most common method for trip distribution of internal-internal trips at all density levels. The greater percentage of gravity model implementation occurs at high-density states (67%). A minor percentage of medium and high-density states implement destination choice based on utility and discrete choice modeling such as multinomial logit models. Notable models implementing such a methodology include Arizona, California, and Connecticut. Similar results were observed for internal-external trips. For all density levels the percentage of states implementing this methodology exceed 60%. Similarly, discrete choice model is observed to be constant in the number of agencies that implemented compared to internal-internal trips analysis.
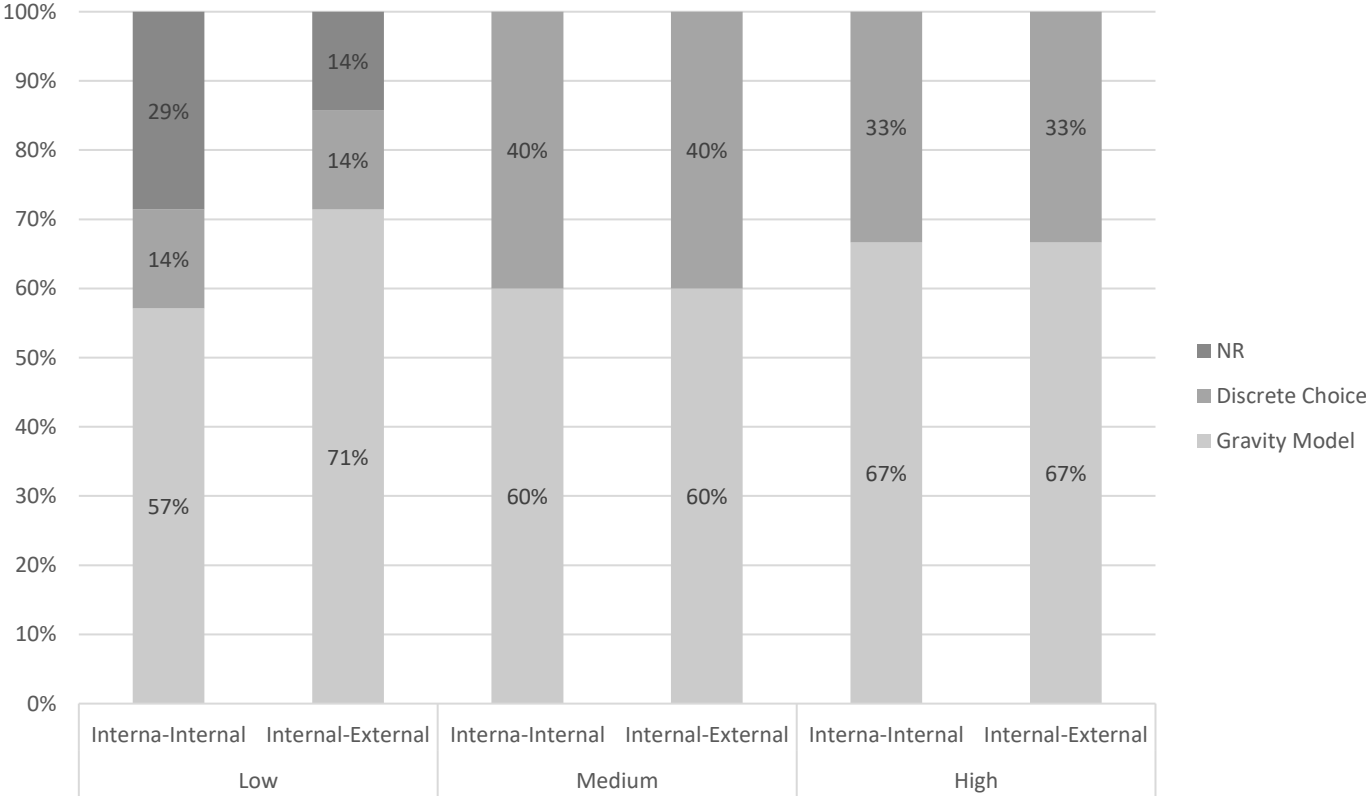

Figure 4-13: Trip Distribution Methods for Internal-Internal and Internal-External Trips

Generally, it was observed the majority use gravity models for both internal-internal and internal-external trips. This trend is not surprise since the model is easy to implement and calibrate. However, if the model should more accurately include long-distance and intercity trips scheme, gravity models show drawbacks and make it challenging to simulate. This is mainly because the tail of longer trip lengths cannot be fine-tuned adequately with only one impedance parameter (Donnelly & Moeckel, 2017). To address this issue is recommended to develop a separate long-distance model, however this information is not considered in the current survey.

4.4. INCORPORATING LONG DISTANCE TRAVEL MODES AND PURPOSES

Next, the survey asked about which modes and purposes are considered in the model. Statewide models that accurately address long distance travel needs incorporate many modes and purposes beyond simply work/leisure and automobiles, respectively. Surprisingly, air and rail were not considered by all states. In fact, air was only considered by medium-density states, and then only by 20%. Transit was considered in many states, across the three categories, but still at lower levels as well. This is a significant opportunity for improvement for these models to accommodate measures of change and long-distance choice behaviors. Mode choices should include air, rail, bus, carpool and driving alone (Figure 4-14).
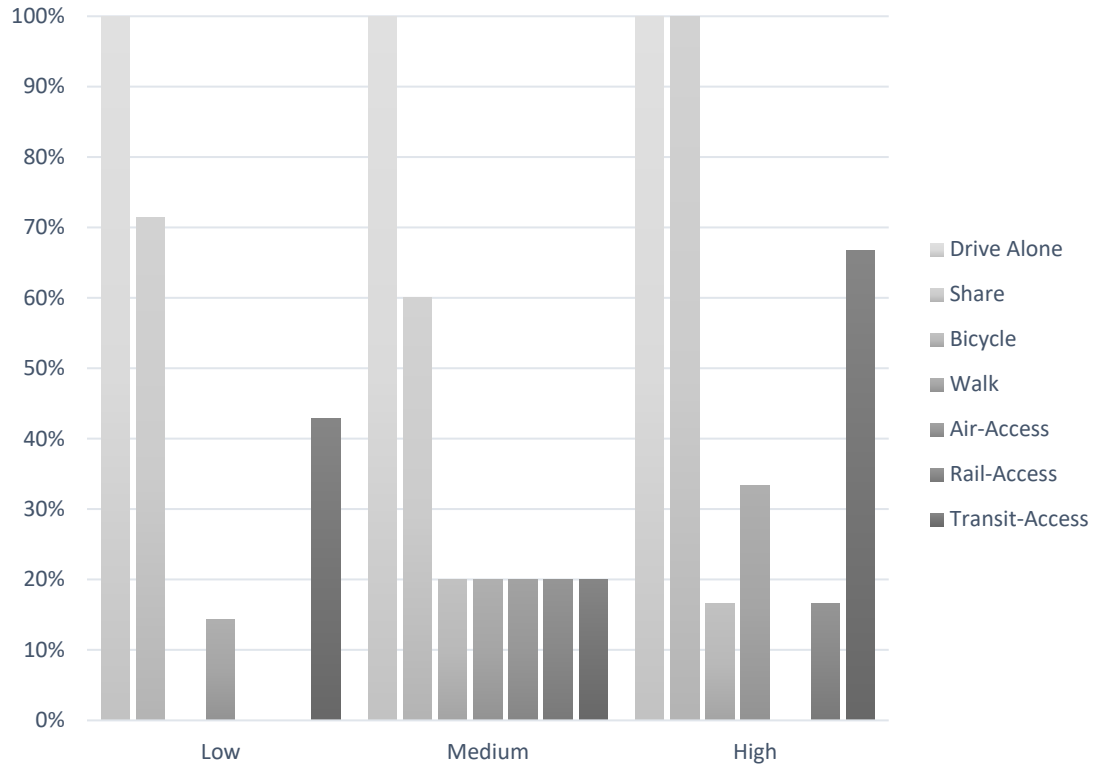
Figure 4-14: Mode Implementation by Density

Trip purposes by density size is observed in Figure 4-15. Trip purposes included in the survey are: Home-Based Work (HBW), Home-Based Other (HBO), Non-Home Based (NHB), Home-Based School/University/College (HBS), External-Internal (E-I), External-External (E-E), Home-Based Business (HBB), Home-Based Recreation/Leisure/Pleasure (HBR), Home-Based Shop (HBSH). For long-distance modeling, the purpose of activities undertaken on the trip is a significant estimator for travel behavior (Outwater M. , et al., 2015). Therefore, trip purpose is important when trying to understand the source of long-distance or intercity travel.
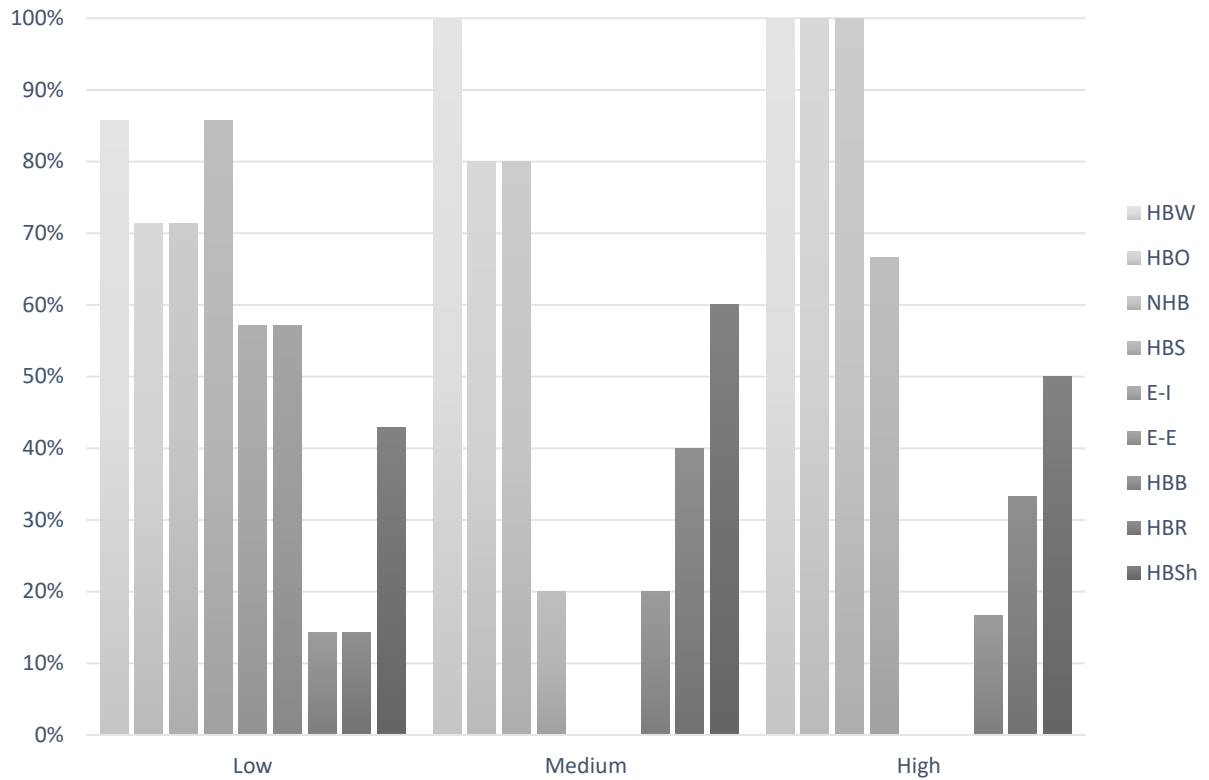
Figure 4-15: Trip Purposes by Region

Although there is not a source that define strictly which purposes have more weight in the total number of long-distance and intercity travel, previous research such as (Outwater M. , et al., 2015) indicate that personal business, visit friends and relative, leisure and vacations, commute, and employer's business were on the greatest sources of long-distance. Also, is of great concert to study the impact of E-E and E-I trips since they are a large source of long-distance and intercity trip as well. When considering the previous references, it was observed that only low-density states incorporate the following trip purposes: E-I, E-E, HBB, HBR, and HBSH, in their statewide modeling process. This guarantees a source of data for long-distance and intercity modeling as well. HBW is implemented by 100% of the medium and high-density states. While HBO and NHB is implemented by 80% to 100% of medium to

high-density states. BHSh and HBR are more commonly implemented in medium to high-density agencies.

4.5. LONG DISTANCE DATA

Finally, this section discusses the data sources that are used by State agencies in the statewide modeling process. These models, by their nature, account for a wider and more diverse travel market, so the data collection needs are often more complex than those for metropolitan planning models. Overall, the interviewed state agencies highlighted that they account for statewide travel using five main sources: Traffic Counts, State or other household travel survey, National Household Travel Survey NHTS, American Community Survey, ACS or Census Transportation Planning Package, CTPP, and Trip tables and/ or trip rates from different reports such as ITE, and NCHRP.

Figure 4-16 shows the data used by agencies that develop or calibrate different trip generation models for internal and external state travel. Interestingly, across all states, a personalized statewide household travel survey is used to estimate internal travel demand models (with some additionally adapted the NHTS or CTPP data for this purpose). However, while traffic counts are predominantly used for modeling external, cross-state boundary trips in medium and high-density states, low density states do not have a common data source. It is encouraging that a notable percentage of medium and high-density states are also incorporating state household travel survey data into their long-distance external models. These corresponds to California, Massachusetts, and Michigan. The traffic count

data includes many sources, but mainly refers to state AADT collected from external stations. However, in some states it was reported to use AirSage data. Also, it should be noted that in some models more than one data source is implemented.
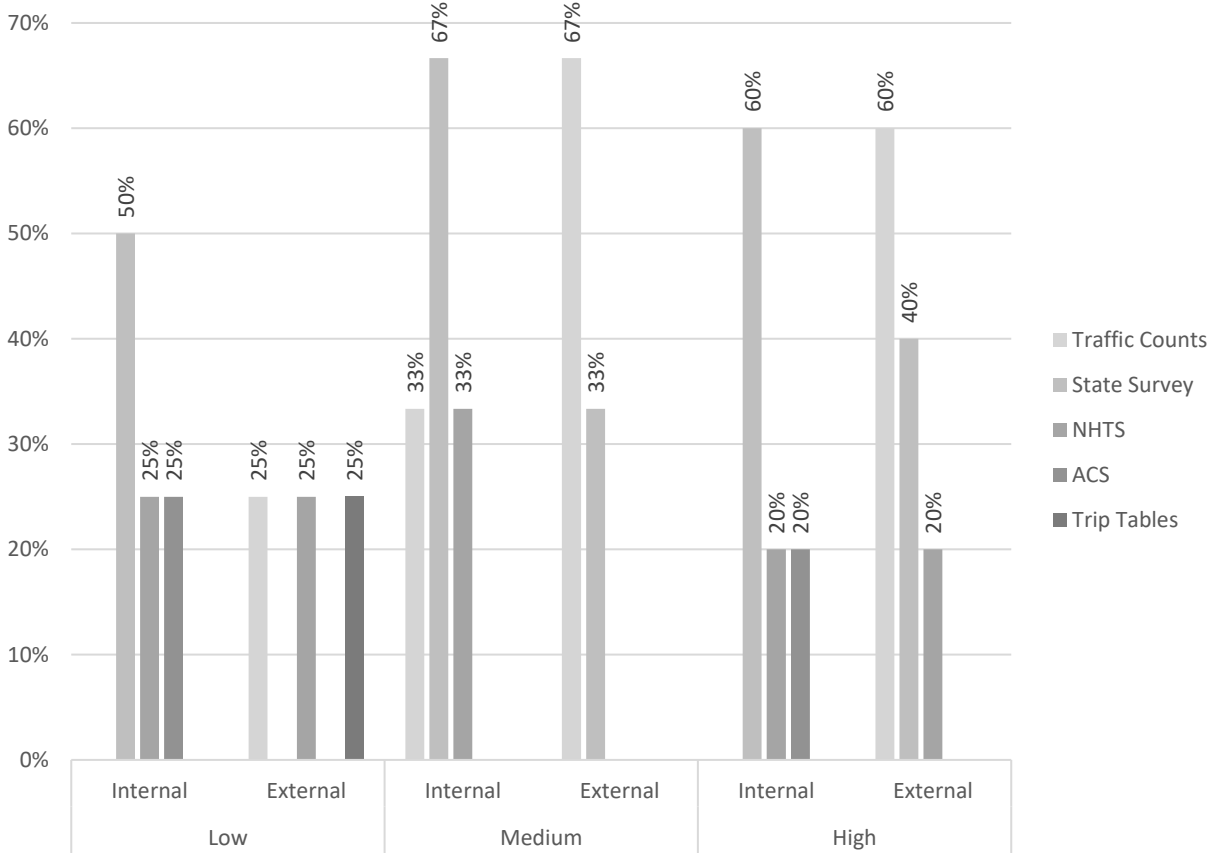
Figure 4-16: Data sources for trip generation in Internal/External zones

Figure 4-17 shows the data sources when the states estimate trip generation to internal and external zones simultaneously. Interestingly, traffic counts become less important and, instead, these state DOTs scale *up* their survey application data to include more internal and external zones.
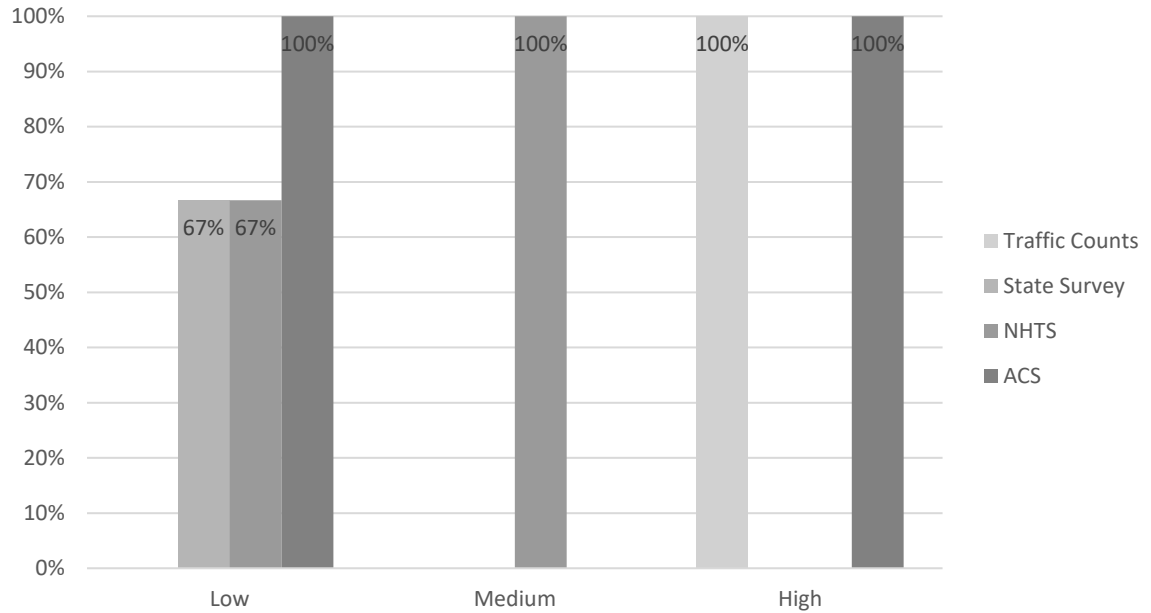
Figure 4-17: Data sources for trip generation in both internal and external zones

Data sources for trip distribution in statewide models is summarized in Figure 4-18. The data sources consider are: Traffic counts, State or other household travel survey, National Household Travel Survey NHTS, American Community Survey, ACS or Census Transportation Planning Package, CTPP, Passive data such as GPS, Streetlight, Bluetooth, and Trip tables and/ or trip rates from different reports such as ITE, and NCHRP.

The results show that between of 57% and 60% of low and medium-density states utilize NHTS data for their trip distribution analysis, respectively. Only 33% of high-density states use NHTS. State surveys are used by a large portion of states at the medium and high-density levels, with 60% and 67%, respectively. Traffic counts made are more common at high-density levels with 50% of states using it.
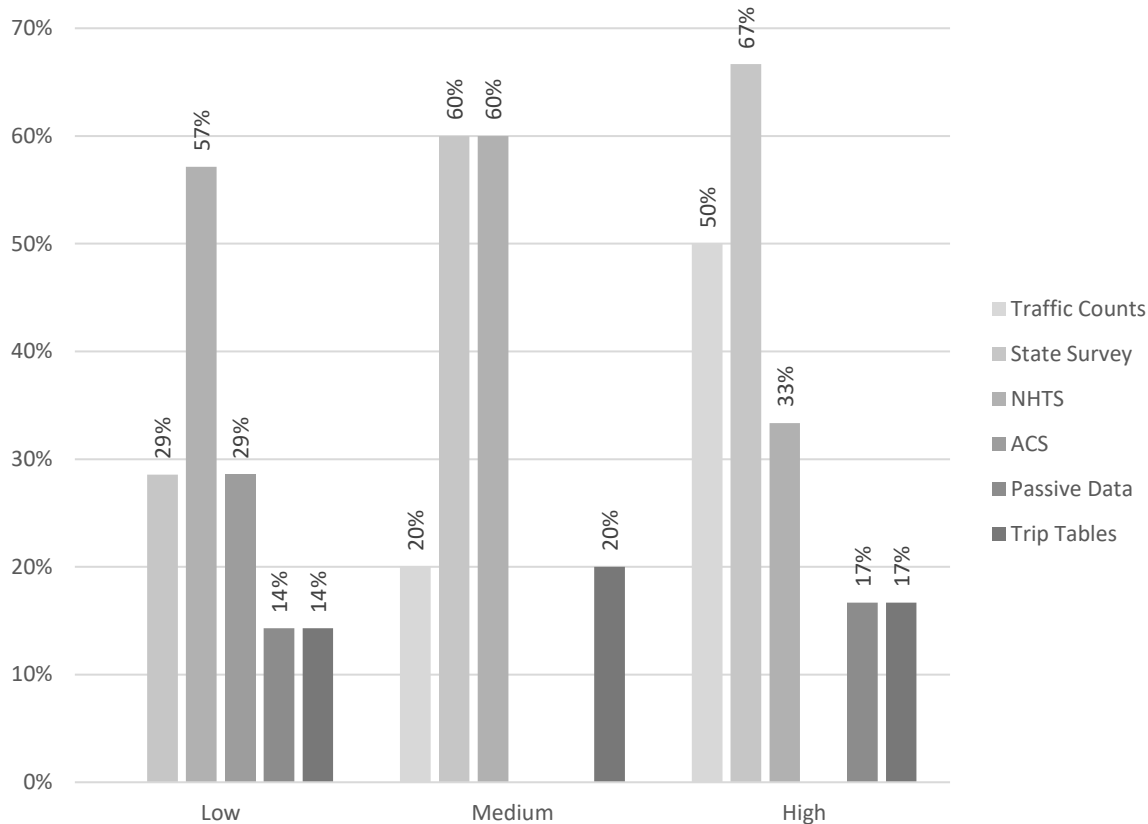
Figure 4-18: Data used for trip distribution

ACS and /or CTPP data is used by only 29% of low-density states. On the other hand, trip

table and/or trip rates from sources such as FHWA reports are used 20% or less at all density

levels. The survey results show some cases in which passive data is being implemented. This

data source is only observed at low and high-density levels with 14% and 17% of states

implementing this data, respectively. Examples of users of this data included Florida and

Kansas.

Even though there is no a clear pattern in data implementation, it can be easily noted that

NHTS and other specific household travel surveys are a major source of travel behavior data.

This reveal how important household travel survey sources are for statewide models and

especially long-distance travel forecasting. However, it should be noted that statewide household travel surveys are better in revealing rural travel patterns that are usually not identified in urban survey. Additionally, small sample size for long-distance add-ons to the NHTS represent a limitation for some states and required them to borrow data from neighboring states. The drawback of this is notably the elevated cost of implementing statewide survey.

CHAPTER 5: CONCLUSIONS

This thesis presents findings from two national state-of-the practice surveys on long-distance and intercity travel modeling at the metropolitan and statewide levels that intend to provide a baseline for future guidance on long-distance and intercity travel modeling. The results are presented based on population size and connectivity for the MPOs study and population density for the study on statewide models.

MPO connectivity plays an important role in the modeling process, especially when we considered the progress of mega-regions throughout the country. In this context, the results from MPOs connectivity to other planning areas and MPOs number of independent cities within the planning area support the need for cross-boundary regional models and emphasizes the need for intercity and long-distance travel as inherent components of MPOs long-range transportation plans. The necessity of access to neighboring urban and rural areas is an increasing concern among MPOs. However, observed issues defining external zones can impact the need for expanding rural and urban external trip forecasting. Therefore, coordination with neighboring urban areas should be enhance through implementation of statewide task forces on long-distance travel. If MPOs' regional travel demand models can be updated to effectively include long distance travel, the biggest

improvement would be in the definition of external zones, providing both destinations and origins for internal-external and external-internal travel. The results of the study also show that a new definition for long-distance travel should be implemented among researchers and planners since the results of this study show the common definition given by MPOs is of any travel to a destination outside their planning area, instead of a distance or time-based definition.

Statewide models offer further opportunities for long distance travel behavior improvements.   Specifically, statewide models can incorporate long distance travel characteristics in the process in main ways

First, statewide models should not think of the state boundaries as the limit of the planning region, instead considering more zones beyond the borders of the state to better characterize the travel to and from these regions (and adapt to economic, social and accessibility changes in these regions). This further supports the idea that long distance travelers do not identify destinations as in-state or out-of-state or by distance. Second, statewide models need to incorporate air, rail and transit as mode choices within the modeling process. As access, costs, and growth continue to evolve, statewide travelers will be choosing between these modes and models need to be responsive to these variables. Third, statewide models need to incorporate more factors in the models that influence long distance travel, including accessibility, costs, economics, regional growth characteristics, connectivity, social networks, employment opportunities and specificity. Fourth, statewide models need to develop specific models that consider external travel into the state, beyond the basic scaling of traffic counts at border crossings. Fifth, if statewide models truly seek

to be responsive to planning scenarios, they would benefit from moving beyond the traditional three or four step models to develop more behavioral models of long distance travel, recognizing that work and leisure trips are done differently, choices are made across the year, and there are limits to trip distances, travel times, and annual time budgets from which choices are made.

These improvements are feasible and realistic as we move to collect large scale passive big data in tandem with household travel surveys. Specifically, data collection is becoming more expensive, so modelers can look to integrate large OD traffic counts with the behavioral models developed with smaller surveys of new travel behaviors.

Finally, there are a number of opportunities for future work in updating metropolitan and statewide travel demand models to accurately capture the evolving field of long distance travel:

- What are the appropriate number of zones and geographies necessary to support each model?
- What is the relationship between destination and mode decisions, ad how should the models reflect this?
- Which regional factors are more influential in destination choices?
- How are destination choice sets determined for individuals with different travel purposes?
- How are external-internal and external-external trips modeled differently than internal-external trips?

- How can passive data be used to supplement household travel survey data?

- How can MPO models be best coordinated with statewide models?

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APPENDIX: QUESTIONARIES

1. **MPOS Survey Questionarie.**

    Section 1: About Your MPO

This section asks 4 contextual questions about your MPO to help compare aggregated

results.

Q1 Which MPO do you represent?

▼ AK - Anchorage Metropolitan Area Transportation)

Q2 How many independent cities are included your planning area?

○ 1 (1)

○ 2 (2)

○ 3 (3)

○ 4 (4)

○ 5 or more (5)

Q3 How would you best describe your planning area?

○ Well connected to many neighboring urban areas (1)

○ Well connected to some neighboring urban areas (2)

○ Not well connected to some or many neighboring urban areas (3)

○ Isolated from any neighboring urban areas (4)

Q4 Who estimates the Travel Demand Forecast for your Long Range Transportation

Plan (LRTP)?

○ We do it in-house. (1)

○ We hire a consultant. (2)

○ Part of the work is done in-house, part by a consultant. (3)

Section 2: How Important is Long-Distance Travel to your MPO?

This section asks 7 questions about how long-distance travel is addressed in your Long

Range Transportation Plan (LRTP).

Q5 Does your LRTP consider long-distance travel outside your planning boundary?

○ Yes, we define long-distance travel as 50-miles or more (1)

○ Yes, we define long-distance travel as any travel to a destination outside the planning area (2)

○ Yes, we define long-distance travel as intercity travel (3)

○ Yes, we define long-distance travel as overnight travel (4)

○ Yes, we define long-distance travel as something else: (5)

_____

○ No, we do not consider long-distance travel (6)

Q6 Does your LRTP specifically address travel to/from URBAN or INTERCITY destinations outside your planning boundary?

○ Yes, and this is an important consideration in our long range planning (1)

○ Yes, but it is NOT an important consideration in our long range planning (2)

○ No, this is not considered in our long range planning (3)

Q7 Does your LRTP specifically address travel to/from RURAL destinations outside your planning boundary?

○ Yes, and this is an important consideration in our long range planning (1)

○ Yes, but it is NOT an important consideration in our long range planning (2)

○ No, this is not considered in our long range planning (3)

Q8 Does your LRTP coordinate with other neighboring cities or rural areas?

○ Yes, Please note how: (1)

_____

○ No (2)

Q9 Which modes are considered in your LRTP? (choose all that apply)

☐ Personal Vehicles (1)

☐ Commuter Rail (2)

☐ High Speed Rail (3)

☐ Bus (4)

☐ Air (5)

Q10 Within the **NEXT 5 to 10 YEARS**, do you anticipate travel between your planning area to and from these destination types to change?

	Anticipated Change						Indicators
	Greatly Increased Volumes (1)	Somewhat Increased Volumes (2)	No Change in Volumes (3)	Somewhat Decreased Volumes (4)	Greatly Decreased Volumes (5)	Unable to Answer (6)	What indicators make you select this answer? (1)
URBAN or INTERCITY destinations outside your planning boundary (1)	○	○	○	○	○	○	
RURAL destinations outside your planning boundary (2)	○	○	○	○	○	○	

Q11 Within the **NEXT 15 to 20 YEARS**, do you anticipate travel between your planning area to and from these destination types

to change?

	Anticipated Change						Indicators
	Greatly Increased Volumes (1)	Somewhat Increased Volumes (2)	No Change in Volumes (3)	Somewhat Decreased Volumes (4)	Greatly Decreased Volumes (5)	Unable to Answer (6)	What indicators make you select this answer? (1)
URBAN or INTERCITY destinations outside your planning boundary (1)	○	○	○	○	○	○	
RURAL destinations outside your planning boundary (2)	○	○	○	○	○	○	

Section 3: How Do You Model Long-Distance Travel?

This section asks 7 questions about long-distance travel is addressed in your travel

demand model.

Q13 What type of model is used for the Long Range Plan Travel Demand Forecast?

○ 3 or 4 Step Travel Demand Model (1)

○ Tour-based Travel Demand Model (2)

○ Activity-based Model (3)

Q14 External Zones are used to define origins and destinations outside the planning

boundary. How many External Zones are included in your Travel Demand Model?

○ 1 zone (no specific destinations are considered) (1)

○ 2 to 10 zones (2)

○ 11 to 20 zones (3)

○ 21 or more zones (4)

Q15 How are these External Zones organized/defined?

_____

_____

_____

Q16 What method is used to calculate traffic volumes to or from these External Zones (including pass-through trips)?

Q17 What percentage of total traffic volumes in your Travel Demand Forecast involves either an origin or destination outside your planning boundary (urban or rural)? These are often referred to as Internal-External or External-Internal trips.

○ 0 to 10% (1)

○ 11 to 20% (2)

○ 21 to 30% (3)

○ 31 to 40% (4)

○ 41% or more (5)

Q18 What percentage of total traffic volumes in your Travel Demand Forecast are "pass-through", with both origin and destination outside your planning boundary (urban or rural)? These are often referred to as External-External trips.

○ 0 to 10% (1)

○ 11 to 20% (2)

○ 21 to 30% (3)

○ 31 to 40% (4)

○ 41% or more (5)

Q19 Which of the following improved tools would you be interested in? (choose all that apply)

☐ Improve Ability to Predict Long-Distance or Intercity Traffic Volumes (1)

☐ Improve Ability to Evaluate Policy Impacts on Long-Distance Travel (2)

☐ Improve Ability to Evaluate Equity Issues Related to Long-Distance Travel (3)

2. State DOTs Survey

Does the state have a statewide model?
IF YES, Answer the follow
1- What modes do you consider in the model?
2- How many **internal state zones** do you calculate trip generation from in the model?
3- Do these internal zones correspond to any specific geography?
4- How **many external zones** do you calculate trip generation from in the model?
5- Do these external zones correspond to any specific geography?
6- Is the boundary around your internal zones the same as the state boundary?
7- What is the distance from the state boundary to furthest external zone?
8- What trip purposes do you consider in the model?
9- When you calculate trip generation from your zones, do you have a separate methodology for internal and external zones?
10- IF YES: What specific model/method do you use to calculate trip generation from **internal zones?**
10- IF YES: What specific data was used to estimate these trip generation models?
10- IF YES: What specific model/method do you use to calculate trip generation from **external zones?**
10 - IF YES: What specific data was used to estimate these trip generation models?
10- IF NO: What specific model/method do you use to calculate trip generation?
10- IF NO: What specific data was used to estimate these trip generation models?
11- What specific model/method is used to calculate internal-internal trip distribution?
12- What specific model/method is used to calculate internal-external trip distribution?
13- What specific data was used to estimate these models?
14- How specifically does the state model relate to the MPO models?
15- Do you specifically consider megaregions in and/or out of your state?