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Is Transportation Planning Effective? A Critical Review of Long-range Regional Transportation Planning in the United States

Razieh Nadafianshahamabadi
University of New Mexico

Razieh Nadafianshahamabadi

Candidate

Civil, Construction, and Environmental Engineering Department

Department

This dissertation is approved, and it is acceptable in quality and form for publication:

Approved by the Dissertation Committee:

Dr. Gregory Rowangould, Chairperson

Dr. Yan Lu

Dr. Nicholas Ferenchak

Dr. Fernando Moreu

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Razieh Nadafianshahamabadi

B.S., Urban Planning, Yazd University, Yazd, Iran, 2011

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DEDICATION

This dissertation is dedicated to my loving husband, Mohammad, who has been a constant source of support and encouragement during the challenges of graduate school and life. This work is also dedicated to my daughter, Dena Toranj, the greatest achievement of my life, and my always encouraging parents and my husband's parents.

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ABSTRACT

The Federal-Aid Highway Act requires urban areas with a population greater than 50,000 to create Metropolitan Planning Organizations (MPOs) to ensure that funding for transportation projects and programs are based on a continuing, cooperative, and comprehensive planning process. A major responsibility of each MPO is the creation of a long-range transportation plan (LRTP) that addresses the transportation needs of a metropolitan region over the next twenty years or more. While long-range regional transportation planning goals have grown to include a wide range of concerns and technical methods for evaluating planning scenarios have advanced substantially over the past 50 years, there has been little progress in addressing transportation-related challenges such as mitigating greenhouse gas emissions, reducing travel demand and providing congestion relief. This lack of progress raises the question, is the long-range regional transportation planning process effective?

To comprehensively evaluate the question of effectiveness and understand what may cause plans created by some MPOs to be more effective than others, this dissertation evaluates three research questions:

1. What goals and performance measures are included in LRTPs and are they evaluated in the planning process?
2. Are the plans described in LRTP's likely to produce outcomes that make progress towards common planning goals?
3. What factors are associated with MPOs that create more effective plans?

This dissertation evaluates these questions by reviewing a representative sample of 182 recent LRTPs created by MPOs in the United States. Effectiveness is defined as a plan where outcomes make progress towards common planning goals such as reducing GHG emissions or traffic congestion from today for a future counterfactual baseline. Since outcomes of current plans will not be realized for many years, in my research I evaluate forecasted planning outcomes made by MPOs.

Overall, the results suggest that MPOs generally develop plans that consider a wide range of contemporary challenges but that these plans are not expected (i.e., forecasted) to make much, if any progress, towards achieving common goals. In most cases, the future transportation system is expected to be more congested and may also produce more GHG emission than today. While most plans discuss environmental justice and equity concerns, most do not define concrete goals or quantitatively evaluate these concerns. A more effective planning process is likely necessary to address current and emerging challenges.

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CHAPTER 1
INTRODUCTION

Prior to the widespread use of automobiles in the United States, no formal regional planning processes existed. Transportation planning was limited to the construction of new highways, later shifting to also include prioritizing the improvement and expansion of existing highways and roads (Weiner, 2013). In the years following World War II, a shortage of urban housing and more affordable automobiles spurred widespread suburbanization around American cities. With more automobiles on the roads and continuing suburbanization, travel patterns became more complex and traffic congestion became a major concern (Johnston, 2004; Weiner, 2013). These facts, combined with a substantial increase in the federal funds allocated to transportation and a lack of institutions that were specifically charged with addressing problems associated with regional mobility, resulted in the emergence of urban transportation planning as a specific function. The establishment of MPOs within urban areas that had a population in excess of 50,000 people was first mandated in the Federal-Aid Highway Act of 1962, and guidelines were established to ensure that funding for transportation projects and programs was based on a continuing, cooperative, and comprehensive planning process (Johnston, 2004; Sciara, 2017). The primary responsibility of an MPO is to develop a long-range transportation plan (LRTP) for a region by which it is possible to address the anticipated mobility and accessibility needs of a region over a 20 plus year time horizon. LRTPs typically include strategic goals that address regional challenges and performance measures that evaluate progress toward meeting these goals. MPOs also develop a short-term plan referred to as a transportation improvement program (TIP) that is aligned with the goals of the LRTP. The TIP lists specific transportation projects that will be implemented over a six-year period and the methods by which they will be funded.

To broadly understand the effectiveness of transportation planning efforts, one can review the performance of the transportation system from the 1960s, when the first MPOs were established (Figure 1-1). This high-level assessment suggests that little progress has been made. Although many MPOs have developed plans that say they are addressing long running transportation challenges such as congestion, automobile dependence and greenhouse gas emissions, historical data suggests little progress has been made. In fact, many of the objectives of the initial Act to address transportation challenges remain unfulfilled despite the decades of transportation planning initiatives that have aimed to address them. The gravity of the situation is exemplified in a few basic statistics: vehicle miles traveled have increased by 346% since 1960, and energy consumption from the transportation sector by 163%. Since 1980, vehicle hours of delay per capita have increased by 135%, the travel time index—the ratio of travel time in the peak period to the travel time at free-flow conditions—by 12%, and the congestion index as a measure of vehicle travel density on roadways by 44%. Moreover, GHG emissions produced by the transportation sector have increased by about 17% since 1990 (USDOT, 2015). These statistics indicate that despite the creation of MPOs and a formal, long range, planning process many indicators of transportation system sustainability remain unchanged or have become worse, which raises the question of whether or not the current planning process is effective?

The effectiveness of planning efforts can also be evaluated based on the outcomes of plans that are being formulated by MPOs today. This approach has its own inherent challenges since the effects of today's plans will not be realized until the future. Past studies related to planning effectiveness have focused on evaluating planning process inputs such as the inclusion of certain planning goals, objectives, or use of particular planning methods. There has been very little research focused on how these inputs or other factors affect planning outcomes. In fact, there has been little research evaluating outcomes at all. There is a fundamental need to address this gap in understanding since regional transportation planning forms the basis of most transportation decisions that are executed in metropolitan areas. Each LRTP identifies the major investment needs and priorities of a region over a period of at least 20 years. If MPOs fail to formulate effective plans and projects, they may waste large sums of money (roughly US$350 billion each year) while also failing to address congestion, air pollution, climate change, public health, and environmental justice concerns. As such, the present study aims to evaluate the effectiveness of the current regional transportation planning process in the U.S. be studying planning outcomes. The current study is based on a quantitative evaluation of recent long-range regional transportation plans created by a large and representative sample of Metropolitan Planning Organizations (MPOs). Outcomes are evaluated based on each MPO's expected planning outcomes which each MPO derives from forecasting models and discuss in their LRTP reports.

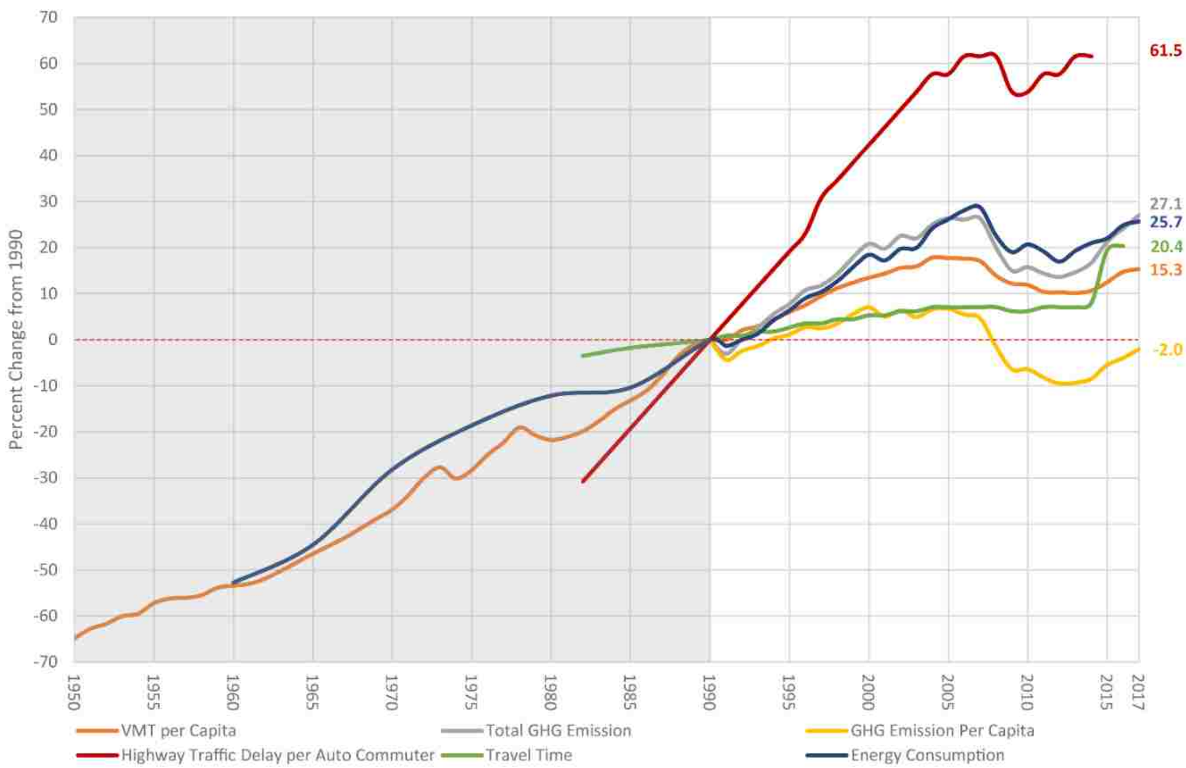


Figure 1-1 Percent Change in Transportation Performance Measures from 1990

In this dissertation, I evaluate three research questions that aim to broadly understand the effectiveness and identify factors that may be related to more effectiveness.

1.1 Do plans link goals with measurable performance outcomes?

MPOs are in the process of adopting a performance-driven, outcome-based approach to long-term and short-term transportation planning in response to legal requirements and a need for considering a wider range of goals and performance measures. To apply performance-based planning in developing a long-range plan, MPOs typically define a set of goals that describes the desired outcome, a set of objectives that supports the accomplishment of a goal, and a set of performance measures that evaluate progress toward an objective.

Prior studies have evaluated if various transportation planning goals and objectives are included in the long-range plans created by MPOs. The main purpose of these studies is to evaluate the state of practice in considering contemporary goals and identify potential barriers and challenges to including them in the planning process. These studies find the inclusion of important goals varies widely across MPOs that were evaluated by researchers. While including contemporary goals in the planning process is perhaps a necessary condition of an effective plan, prior studies have not evaluated how these considerations affect planning outcomes.

In this study, I aim to understand whether conducting performance-based planning is associated with creating more effective transportation plans. This research aims to provide insight into the following key questions: what goas are included in the LRTPs created by MPOs? What performance measures are included in the planning process? What is the relationship between the integration of goals and performance measures and creating more effective transportation plans? I define effectiveness in this dissertation as achieving progress towards goals; plans that create more progress toward goals are more effective. Plans that show little or no progress towards goals, or work against them, are considered ineffective.

1.2 Are long range transportations plans expected to be effective?

Since the establishment of MPOs, U.S. urban transportation policy evolved over the past half-century. It began with early planning efforts which were dominated by travel demand modeling to develop highway systems, followed by a continuous stream of new concerns over growth in urban travel demand and congestion and their effects on the environment, pollution, and quality of life. The planning process has also been affected by changes in federal transportation legislation, shrinking revenues, new technologies, and economic recessions. Over this time, the federal government's role in regional transportation planning has be to influence the regional planning process by tying federal transportation funding to specific planning processes and planning goals.

The federal surface transportation funding act, *Moving Ahead for Progress in the 21st Century (MAP-21),* placed a greater emphasis on performance-based planning (U.S. Department of Transportation 2012), leading MPOs to define a set of performance measures for comparing alternative plans and measuring progress toward goals. Typically, planners define the intended direction of each performance measure and a specific target for each measure to attain over 20 years or more. MPOs then use a variety of analytic tools, typically regional travel demand models, to quantitatively estimate the performance of each planning scenario (Zegras, Sussman, and Conklin 2004). Included in each LRTP is typically a base/current year scenario, an adopted or "preferred" scenario as well as a business as usual or "trend" planning scenario.

Evaluating the difference plans can make on quantitative planning performance measures (outcomes) is a way to measure planning effectiveness. Effectiveness can be defined as the difference between the future with the plan (expected outcome) and future without the plan (trend) or the difference with the plan and the baseline condition (base) in terms of various performance measures such as mobility, accessibility, justice, and environment.

In this study, I evaluate the outcomes LRTPs are predicted to achieve. While one criticism is that most "ex-post" studies evaluate planning outputs rather than actual outcomes. Waiting to observe actual outcomes would take decades. Besides the logistical difficulties in such a long-term study, the data collected would be of little practical value in the future since the planning methods and challenges would have likely changed significantly over a 20 year or longer period. Therefore, I base my study on an evaluation of expected outcomes. Each MPO uses modeling to forecast the expected performance of their plans and compare performance amount alternatives. I quantitively evaluate the difference between the current value and future predicted values of common performance measures for a large and representative sample of recent LRTPs created by MPOs, and the difference between the predicted future with and without each plan.

1.3 What factors are associated with the effectiveness of long-range transportation planning?

Few studies have examined if factors thought to influence the ability of MPOs to create more effective LRTPs actually affect outcomes. Previous studies suggest that MPO effectiveness may depend on the MPO's organizational structure, regional challenges and characteristics, and components of the regional planning process (Goode et al., 2001; Lowe & Sciara, 2017; Oswald Beiler et al., 2016; Puentes & Bailey, 2003; U.S. GAO, 2009; Goetz et al., 2002; Hatzopoulou & Miller, 2009; U.S. GAO, 2009; Vanasse Hangen Brustlin Inc, 2007).

There might be a correlation between creating more effective transportation plans and characteristics of MPOs, such as budget; number of staff and their knowledge; structure and size of MPO executive boards, and how they prioritize local and regional concerns. It is also likely that the socio-economic characteristics of the metropolitan areas such as the rate of population growth influence the level of effectiveness that MPOs achieve in their LRTPs. Significant population growth may increase the urgency to address congestion while also making the planning process more complex (Davidson et al. 2007; Goetz, Dempsey, and Larson 2002). In addition, it might be reasonable to assume that the size of the region that an MPO serves relates to its effectiveness.

Previous studies show that the type of modeling system used to predict travel demand may also be associated with effectiveness. Travel demand modeling provides much of the data used to forecast performance measures. Although travel demand modeling advanced substantially in the 1960s, it continues to provide the same basic information used to evaluate plans: traffic volumes, speed, and mode share. These outputs are used directly or as inputs to additional models and calculations that evaluate the performance of alternative planning scenarios and their effectiveness.

While there are many studies on inputs to the planning process and planning methods that may affect an LRTP's effectiveness, no study to date has quantitatively evaluated planning outcomes from a large and representative sample of MPOs. There is little existing evidence about how effective or not the planning process used since the 1960s is. Furthermore, existing studies are hampered by small sample sizes and typically focus on the largest MPOs. There is very little research on most aspects of small and medium sized MPOs. I will fill this gap by using statistical analyses to explore the relationships between planning effectiveness and MPO characteristics and geographical characteristics, that may be associated with effectiveness.

CHAPTER 2
BACKGROUND

In this section, first, the history of regional transportation planning is discussed. Then, the effectiveness of the transportation planning process is defined. Finally, the research on evaluating the performance of long-range transportation plans across the United States is reviewed.

2.1 History of Regional Transportation Planning

Early in the 20th century, before widespread ownership and use of automobiles in the United States, transportation planning was based on observation of current roadway and traffic conditions and no formal regional planning process existed, except for a few areas like New York where private regional planning organizations conducted plans (Weiner 2013). After World War II due to the wide availability of the inexpensive automobile, travel patterns became more complex and traffic congestion became a severe issue (Weiner 2013). Later in the 1940s and 1950s new planning techniques and the household travel surveys were introduced and were replaced with traffic observations to model the existing travel pattern (Holmes and Lynch 1957). Housing Act of 1954, Section 701 was a major change in regional planning policy which encouraged conducting comprehensive planning process at the regional scale which formulates, analyzes, evaluates and implements policies and strategies to address problems associated with rapid urban growth (Weiner 2013). However, the focus of traffic engineers was still mostly on the engineering and technical aspects of road construction rather than congestion relief. Factors such as growth in automobile production, growth in development in the suburbs, and a decline in transit ridership increased the demand for travel and made urban transportation planning increasingly important. The Federal-Aid Highway Act of 1962 was the first mandate that ingrained the establishment of Metropolitan Planning Organizations (MPOs) for urban areas with population greater than 50,000 to ensure that all funding for transportation projects and programs are based on a continuing, cooperative, and comprehensive ("3C") planning process (Weiner 2013).

Under this Act and its predecessors MPOs are required to develop a 20 year or more Long-Range Transportation Plan (LRTP). The plan defines long term regional visions, goals, and objectives for the transportation system, a series of planning scenarios, a set of performance measures to monitor progress toward achieving goals for each scenario and provide fiscally constrained lists of transportation projects under the adopted scenario to be funded and built over the planning horizon. Included in the LRTP is typically the base condition scenario, adopted or "adopted" scenario as well as the business as usual or "trend" planning scenario that is considered but not adopted. After the adopted scenario is selected, a financial plan is developed to indicate resources from public and private sources required for implementing the adopted plan. The financial plan then helps to create a fiscally-constrained project list for the operation, maintenance, and capital investments of the plan (Federal Highway Administration and Federal Transit Administration 2004). LRTPs are reviewed and updated every five years to ensure they meet the intended objectives.

In addition to taking general planning process steps, LRTPs should meet other federal requirements, as well. MPOs must involve local stakeholders and community members within the MPO region in the planning process. Furthermore, federal legislation (the Clean Air Act Section 176(c) and U.S. Environmental Protection Agency transportation conformity regulations) requires that LRTPs be restricted to those new facilities which impact upon air quality are addressed under “conformity” process for the non-attainment areas. A non-attainment area is an area where air quality does not meet the National Ambient Air Quality Standards. In addition, based on Title VI of the 1964 Civil Rights Act, MPOs are responsible for considering their plans’ impacts on the community of concerns including low-income people and people of color (Karner and Niemeier 2013).

Since the establishment of MPOs, U.S. urban transportation policy evolved over the past half-century, started with early planning efforts which were dominated by travel demand modeling to develop highway systems, followed by a continuous stream of new concerns over growth in urban travel demand and congestion and their effects on environment, pollution, and quality of life, which is also affected by external forces like new transportation legislation, shrinking revenues, new technologies, and economic recessions. The federal government attempts to address issues of concern through funding to reinforce actions such as air quality conformity, public involvement, performance-based planning, and environmental justice which MPOs should incorporate in to receive federal funds.

2.2 Effective Transportation Planning: Definition

Effectiveness means "producing a decided, decisive, or desired effect" (Merriam-Webster, n.d.); however, there is no consistent definition of the meaning of effectiveness within the context of evaluating transportation plans in the existing literature.

For instance, Goetz et al. (2002) defined the effectiveness of MPOs' planning efforts as being determined by the extent to which the MPOs meet regional transportation needs, and argued that this can be measured by criteria such as effective leadership, staff competence, quality of public involvement, collaboration among stakeholders, transportation capacity, safety, non-motorized and transit transportation, long-term regional needs, and fairness. Goode et al. (2001) defined a set of criteria that can be employed to measure the effectiveness of an MPOs' planning process: The competence and knowledge of staff, coordination with land use planning, coordination with other stakeholders, and public involvement. Miller (2011) argued that effective transportation planning, as a collaborative effort, should exhibit the following characteristics: Collaboration between different jurisdictions, sponsorship from authorities that have sufficient power and funding, transparency of decision-making processes, experienced staff, and staff credibility. Wolf and Farquhar (2005) evaluated the extent to which MPOs were effective in incorporating multimodal transportation in planning, integrating related policy programs and planning requirements, and the quality of coordination with other governmental and nongovernmental organizations. Deyle & Wiedenman (2014) put forward criteria that could determine the effectiveness of LRTP. This consisted of the achievement of planning objectives, determination of planning concerns, equity of planning outcomes, consideration of participants' goals and concerns, and the planning of implementation support by participant organizations.

Given the inconsistency in the methods that are employed to determine the performance of LRTP, we recommend that effectiveness is measured by comparing planning outcomes with the desired results. The greater the progress toward the goals outlined in the original plan that are observed, the more the plan can be considered to be successful. Similarly, the less the progress, the less effective the program has been.

2.3 Literature Review

The research on evaluating the performance of long-range transportation plans can be classified into three groups.

I first review the studies that evaluate whether planning issues and challenges are incorporated into the planning process. I selected these studies because as Baer (1997) discussed, "the adequacy of scope" is a criterion to evaluate a plan which investigates how the plan can be related to a larger environment and how all possible issues and concerns are considered. In this perspective, including wider areas of public policy in the form of planning goals might be translated into policies and methods, which they are applied to address specific concerns and eventually generate expected outcomes (Laurian et al. 2010).

Second, are the studies that identify the affected factors on planning effectiveness. The literature indicates that there might be too many layers of planning which are key inhibitors to more effective LRTPs. For plans to be more effective and yield expected outcomes, we should identify any potential barrier and find ways to overcome it. Therefore, it is important to know the barriers currently limiting the effectiveness of the LRTPs made by MPOs.

Third, are the studies that evaluate the outcomes of the planning process. This type of plan evaluation is science-driven and highly technical which relies on the quantitative methods and focuses on measuring effectiveness (Guyadeen and Seasons 2018). As Baer (1997) discussed, evaluating plan outcomes aims to measure the plan's effectiveness in terms of differences between the plan and reality and between the plan outcomes and the expected outcomes if there had been no plan. However, since the scope of an LRTPs is at least 20 years, evaluators assume that the planning predictions will be the actual outcomes which can be compared with the base condition or with the results if there had been no plan.

2.3.1 Studies on Incorporating Transportation Challenges into The Planning Process

Although regional transportation planning is primarily seen as a way to address the particular issues facing a metropolitan area, including transportation concerns common to all regions in LRTPs have drastically redefined the planning evaluation framework. Some research has been conducted on how MPOs are incorporating health, equity and justice, environmental impacts, affordability, land use planning, and livability planning into the transportation planning process.

While including public health in the MPOs activities is not mandated, evaluating public health effects is stated indirectly in the federal law, through safety, accessibility, air quality, and active transportation (Poorfakhraei, Tayarani, and Rowangould 2017). Lyons et al. (2012) evaluated the current state of practice of MPOs in considering aspects of health during the transportation planning process. By scanning the MPOs considering health, four MPOs are selected and their documents are read and reviewed, and their planners are interviewed to understand how health concerns are reflected in the regional visions and goals, development of transportation plans, development of TIP, and monitoring system performance. The results show that although each MPO has a unique approach to incorporating health into the planning efforts, the process, strategies, and challenges are very similar. Singleton and Clifton (2017) also analyzed the content of current plans from 25 most populous MPOs to understand how policy statements including visions, goals, objectives, and their supporting performance measures reflect health concerns. The results show that safety and accessibility are mostly considered as the planning goals while air quality concerns are considered by fewer MPOs. Planning goals are mostly aligned with the MAP-21 national goals and performance measures are generally related to the goals. They also found that MPOs' modeling capabilities to predict physical activities may not lead planners to consider physical activity as a goal or performance measure.

Quality of life is an essential indicator of the health assessment which might be considered in the transportation planning process. Lee and Sener (2016) defined the quality of life in transportation as well-being in four different aspects of human life: physical, mental, social, and economic. Lee and Sener (2016) evaluated LRTPs developed by 148 MPOs with a population greater than 250,000 across the country to understand how MPOs are addressing quality of life in the planning process. A keyword in content analysis of planning documents including “accessibility”, “air quality”, “economic”, “health”, “mental”, “mobility”, “physical activity”, “quality of life”, “safety”, and “security” is conducted for frequency analysis. Thirteen plans which are diverse in geography, population, and level of commitment to quality of life are selected and their documents are reviewed in a more in-depth way. The frequency analysis shows that safety is the most frequent factor used in the planning documents. Accessibility and mobility are also prevalent. However, terms like physical activity, social, and mental are less frequent. The in-depth analysis shows that while physical activities are addressed by some LRTPs, mental and social well-being are ignored in the planning process.

One mission of MPOs is to fulfill the coordination of transportation planning and environment, the federal requirement of the MAP-21 which states the need to “protect and enhance the environment, promote energy conservation”. Amekudzi et al. (2012) conducted a survey of the 45 largest MPOs to understand the current state of practice in linking environmental factors and transportation planning. The survey includes questions about the importance of environmental factors, methods of considering environmental impacts, the existence of data for considering environmental factors, obstacles to incorporating environmental factors into the transportation planning, and reasons for considering environmental factors earlier in project development. Most respondents believe that only part of the data needed for integrating the environment into the planning process is available. Less than half of MPOs use performance measures that include environmental factors for transportation planning. Most MPOs believe that competing priorities that distract from environmental issues and a lack of appropriate tools are the main obstacles to considering environmental factors. Most MPOs have taken at least one action to incorporate environmental factors in planning and they believe that incorporating these factors earlier in planning generally leads to better decisions (Amekudzi et al. 2012).

While US DOT encourages considering GHG emission in transportation planning, it does not require consideration of GHG emissions in the metropolitan planning process. Based on the California Senate Bill (SB) 375, California is the only state that requires MPOs to develop a sustainable community strategy (SCS) as a key element of LRTPs to reduce GHG emissions (Tayarani et al. 2018). However, evaluating MPOs regarding incorporation of climate change considerations is receiving some attention. Schmidt and Meyer (2009) reviewed the planning documents of 60 largest MPOs to investigate their efforts to incorporate GHG emission considerations, adaption and mitigation strategies, into the planning process. The presence of climate change considerations in different parts of the planning process is evaluated including vision, goals, objectives, performance measures, analysis, identifications of strategies, and evaluations. The results show that climate change is considered in a few plans, mostly in the planning goals and objectives, with more focus on mitigation strategies than the adaptation strategies. Gulf Coast study (Savonis, Burkett, and Potter 2008) also investigates the impacts of climate change on the transportation system. Seventy largest MPOs are targeted, and their planning documents are reviewed. To understand the extent to which these agencies are including climate change, the statements in the text which explicitly include “climate change” and “adaption” are identified. The study finds that the MPOs are not including climate change as an issue or potential problem in their planning process (Lindquist 2007). For further investigation, 10 MPOs in the US central Gulf Coast are identified, their current long-range transportation plans are reviewed and their representative MPO officials responsible for planning are reviewed. Results reveal that none of the plans directly addresses or acknowledges climate change. In addition, none of the planners mentioned that they used climate change data in the transportation planning process, however, they think climate change is a matter of some concern (Leonard et al. 2008). Oswald Beiler et al. (2016) evaluated the level of progress of MPOs in the Mid-Atlantic region to incorporate climate change concerns in their policies before and after Hurricane Sandy. Two sets of surveys are conducted. 18 and 12 MPOs which vary in population and size completed the survey before and after the hurricane. The survey asks about the barriers that prevent the agency from incorporating climate change issues in the planning process and the practices that agencies are doing to include climate change concerns. The results show that limited budget and resources and lack of policies and standards affected the agencies’ ability to consider GHG adaption measures. The results of the post-hurricane survey show that the fewer agencies mentioned to three barriers than the pre-hurricane survey, including lack understanding of risks, the uncertainty of climate change issue, and the viewpoint that climate change is not a significant issue.

Based on Title VI of the 1964 Civil Rights Act, MPOs are responsible for considering their plans’ impacts on the community of concerns including low-income people and people of color. Some studies evaluate how environmental justice is incorporated into the transportation planning process. Sanchez and Wolf (2007) examined the incorporation of social equity into the MPOs' planning process. The evaluation includes a content analysis of planning documents to determine the presence of words like civil rights and environmental justice in the planning documents of 50 largest MPOs. The results show that in most cases, environmental justice is considered as part of planning goals, public participation, and socio-economic trends. The common analyses of environmental justice include defining the protected population and their proportion of total population, mapping the location of proposed projects along with the location of targeted groups, and evaluating whether proposed projects are biased toward these groups. Few MPO examined the secondary impacts such as unemployment, wages, or regional accessibility. Manaugh et al. (2015) examined 18 LRTPs of large urban areas in Canada and the US to evaluates how social equity is defined and prioritized relative to other planning objectives. A "keyword in content" analysis of planning documents is conducted in the mission statements, goals and objectives, and performance measures. The results show that social equity is considered in many of the reviewed plans, however, only a few plans analyzed the impacts of transportation investments on different justice groups. Similar results are taken by Cambridge Systematics Inc (2002) which reviewed the methods being utilized in undertaking analyses of environmental justice by 21 MPOs known to be active in addressing environmental justice issues and their staff persons are interviewed. Interviewees are asked about the activities to address environmental justice, the definition of environmental justice population, public involvement and outreach activities, performance measures to identify the distribution of impacts of the projects, and data and tools to analyze the environmental justice. The results show that there is some progress in integrating environmental justice. The most common activities are identifying low-income and environmental justice groups and involving people in the transportation planning process. Only a few MPOs quantify the impacts of the proposed projects on the different population groups. A small number of MPOs define indicators to measure the negative impacts of transportation policies on the different population groups. In addition, most MPOs lack the analysis of the secondary and cumulative impacts of transportation system investments.

MPOs should consider planning for accessibility to be compliant with MAP-21. A study by Boisjoly and El-Geneidy (2017) evaluates what and how accessibility is included in the metropolitan planning process. Long range transportation plans created by 32 MPOs around the world are selected and 18 of them are large MPOs in the US. A structuring content analysis is conducted to identify the visions, goals, and objectives of the plans and extracting the performance measures related to the accessibility. A keyword in context analysis is also conducted to see how accessibility is used in the planning process. Finally, an in-depth review is done on a subset of plans to evaluate accessibility analysis and indicators. The results show that accessibility is included in most plans' visions, goals, and objectives. However, despite the presence of accessibility in goals, accessibility is defined as the access to mobility rather than the ease of getting different destinations. In addition, accessibility is not clearly translated into planning performance measures. Proffitt et al. (2017) evaluate the incorporation of accessibility into the planning process of LRTPs adopted by 42 MPOs which vary in size and geography. The study evaluates to what extent MPOs focus on mobility versus accessibility and what are the characteristics of the MPOs with focus on mobility versus MPOs with a focus on the accessibility. A content analysis of LRTPs is conducted to answer 14 yes-or-no questions about the definition of accessibility, incorporating accessibility in the planning goals and project selection process, and using accessibility-related performance measures. A regression tree analysis is also conducted to understand the association between the accessibility index and MPOs characteristics such as population, density, income, fuel price, highway lane mile, VMT, transit route miles, and transit revenue miles. The results show that only a few MPOs explicitly define accessibility concept. Half of LRTPs include accessibility in goals or project selection process. However, in the plans with the accessorily-related goals, there is not a strong link between accessibility goals and accessibility performance measures. The scoring approach shows that less than half of plans are accessibility-oriented, while above 80% of LRTPs aim to relieve congestion as the main purpose.

Wolf and Fenwick (2003) evaluate the extent to which MPOs consider land use factors in the planning process. A telephone survey of MPOs with a population over 500,000 is conducted to understand how MPOs coordinate transportation and land use planning and 44 MPO staff who are responsible for transportation planning are responded. The results suggest that large MPOs coordinate transportation and land use planning. 30 percent of MPOs undertake the activities to coordinate land use and transportation planning. These activities, however, are limited to examining the impacts of land use plans and projects on the transportation policies or they are heavily driven by local policy boards. 39 percent of MPOs have limited activities related to coordination of land use and transportation planning. Another study by the US General Accounting Office (GAO) (2001) determined the extent to which MPOs consider the impacts of alternative land uses on their activities to protect air quality. 295 MPOs responded to the survey about the evaluation of land use scenarios in the transportation planning process and the efforts to protect air quality. The results show that 75% of MPOs do not consider the impacts of different land use scenarios on air quality. 25% of MPOs which estimate the emissions generated by different land use strategies are located in non-attainment and maintenance areas. In addition, MPOs in attainment areas are not likely to evaluate the emissions of different land use policies because they are not required to estimate the impacts of land use policies, they have limited power to influence land use policies and strategies, and while the transportation planners must work with land use decision makers when deciding on the projects to include in transportation plans, they are not obligated to share the results of any emissions evaluation with the local officials to help them choose better land use policies.

The main purpose of these prior studies has been to evaluate the state of practice in considering various goals and identify the barriers and challenges of considering them in the planning process. These studies suggest that plans with strong attention to broader goals and policies bring better results which comply with policy goals. Berke and Godschalk (2009) introduced "internal plan quality" as a way to evaluate the planning effectiveness which emphasizes on evaluating the content of the planning goals, visions, and policy frameworks. Dalton & Burby (1994) note that considering broader goals which are mandated by states could improve plan quality and its commitment to addressing more concerns. Goetz et al. (2002) argue that examining the effectiveness of an MPO's planning activities should be based on the specific transportation goals that are reflected in the planning products such as safety, land use, and non-motorized transportation. While prior research finds gaps in the adequacy and completeness of mandated planning tasks, we still do not know how these gaps affect planning outcomes.

However, solely including the key issues related to planning quality does not necessarily guarantee more effectiveness in addressing problems (Jun 2017). For example, Conroy & Berke (2000; 2004) argue that with respect to wider planning goals like sustainability, the integration of sustainability in the planning process does not make a difference in the plan effectiveness. While many plans include goals like safety, mobility, and accessibility (Singleton and Clifton 2017; Lee and Sener 2016; Boisjoly and El-Geneidy 2017), goals are not clearly translated into the planning performance measures (Boisjoly and El-Geneidy 2017; Handy 2008; Proffitt et al. 2017; Seggerman and Kramer 2013; Washington et al. 2006; Wolf and Farquhar 2005). The literature shows that the lack of appropriate planning analysis tools, lack of data, and lack of regulations are among the most cited obstacles to follow through with goals in other stages of the planning (Amekudzi and Meyer 2006; Handy 2008; Washington et al. 2006). For example, despite the presence of accessibility as a goal in many plans, it is defined as the access to mobility rather than the ease of getting different destinations (Boisjoly and El-Geneidy 2017; Proffitt et al. 2017). As another example, while there is some progress in integrating environmental justice, most MPOs lack the analysis of the secondary and cumulative impacts of transportation system investments on different justice groups (Manaugh, Badami, and El-Geneidy 2015; Sanchez and Wolf 2007).

2.3.2 Barriers to Effective Planning

There are some studies that focused on the identification of barriers that can directly impact the factors that are incorporated into the long-term plans developed by MPOs and, therefore, the extent to which they can effectively address regional needs and goals. Common barriers include the amount of funding that is available, whether planners have access to advanced modeling tools and relevant travel data, how the MPO boards are formed and operated, the existence of bureaucracy in the process, and the degree of coordination and collaboration between federal, state, and local stakeholders. Each of these elements is examined in more depth below.

Funding can impact the effectiveness of planning in various ways. It is important that planners have access to the finance required to fund the capital projects outlined in the plan. Access to this finance can be directly influenced by the flexibility of federal funds and the extent to which state and local agencies have the ability to match federal funds (Goode et al., 2001; Lowe & Sciara, 2017; Oswald Beiler et al., 2016; Puentes & Bailey, 2003; U.S. GAO, 2009). Where funds of this nature are lacking, planners will not have access to the capital required to achieve the goals of the plan (U.S. GAO, 2009). The level of funding that is available for MPO operations can also impact whether an MPO can recruit and retain the resources required to deliver plans, the level of data they have access to, and their ability to source, use, and create advanced modeling tools, all of which will affect its ability to generate well-informed planning strategies (Goetz et al., 2002; Hatzopoulou & Miller, 2009; U.S. GAO, 2009; Vanasse Hangen Brustlin Inc, 2007). According to Deyle and Wiedenman (2014), the more funding an MPO has access to, the higher the quality of the plan it develops as measured by the achievement of the goals outlined in the 2005 SAFETEA Act; for example, safe and efficient movement of people and goods, eradication of the issues that undermine the effectiveness of the regional transportation system, and the equity of outcomes with regards to project funds. Deyle and Wiedenman's research involved a survey of the planners involved in developing LRTPs, through which the appropriate professionals were asked to outline the methods by which they ensured their operations were aligned with the requirements of the SAFETEA Act. They subsequently developed a regression model by which he outlined the correlation between the quality of a plan and the funds that were available. They concluded that there is a significant link between funding and the achievement of quality parameters, in particular, those associated with the goals of the SAFETEA Act.

To create effective plans, MPOs need access to reliable data and advanced modeling tools by which they can project future travel demand, identify mode choices, and determine traffic patterns. However, the modeling processes by which data is compiled and analyzed can be complex and costly; as such, they frequently represent barriers that impede the achievements of plan objectives (Hatzopoulou & Miller, 2009). Furthermore, the time needed to generate, and model scenarios can directly impact how many planning scenarios and ideas are comprehensively evaluated.

Transportation modeling has been applied since the 1940s and 1950s when data from the initial household travel surveys were used to forecast future travel behavior

(Holmes and Lynch 1957). The Federal-Highway Act engrained the use of four-step travel demand model in transportation planning (Bartholomew 2006). The four-step or trip-based travel demand model has been used since the 1960s. It takes the single trips of individuals as a basic unit of modeling travel and then estimates the total number of trips generated, their geographic distribution, the travel modes used, and the corresponding networks taken (Ortuar and Willumsen 2011). Tour-based and activity-based travel demand models have been introduced to address shortcomings identified in the trip-based models (Castiglione et al. 2014). Tour-based travel demand model considers all trips of the same tour as the basic unit of modeling. In other words, a tour is defined as a closed chain of trips starting and ending at the same location (Davidson et al. 2007). The activity-based model creates travel demand from activities in time and space in contrast of four-step model that aggregates all daily trips on peak hour and lacks the spatial and temporal resolution (Algers, Eliasson, and Mattsson 2005).

Several shortcomings have been identified in trip-based models. Trip-based models are unable to predict the linkage between travel behaviors of members of the same family, which results in partially ignoring the effects of high occupancy lanes policy, as an example. These models also cannot estimate consistent choices for a single individual and if he/she makes multipurpose and multi-stop trips. Trip-based models do not consider the time of travel, yet the time of travel is critical in designing congestion relief policies (Davidson et al. 2007). In addition, trip-based models cannot take into account the dynamic interaction between land use structure and the transportation system. Furthermore, the effects of certain policies, such as biking, walking, and road diet, cannot be estimated (Algers, Eliasson, and Mattsson 2005). When travel demand modeling is insensitive to the policies that support more effective plans, it seems likely that the outcome will deviate from effectiveness.

In the current planning process, travel demand modeling provides important information for evaluating planning scenarios. Much of the regional transportation planning research has focused on improving the technical ability of regional travel demand models to provide more detailed information or improve sensitivity to new planning strategies under the assumption that better modeling may result in selecting better scenarios (Iacono, Levinson, and El-Geneidy 2008). There have been very few studies, however, investigating the role of modeling in creating more effective transportation plans. Based on these studies, modeling may be a significant barrier for at least three reasons.

The credibility of Transportation Models

First, it is not clear how much value transportation modeling provides and whether modeling improves the accuracy of choosing the most effective transportation plan from a finite set of scenarios. Certain modeling outputs may improve decision making but the others may not. Brömmelstroet and Bertolini (2011) believe that these computer-based planning tools generate "valuable knowledge [that] is not useful" (Brömmelstroet and Bertolini 2011). One reason might be that the modeling outcomes are fairly obvious. Two studies suggest that planning experts think that modeling is unable to provide new knowledge more than what they already know (Hatzopoulou and Miller 2009). For example, a plan with more highway capacity investment will result in more vehicle use and therefore more greenhouse gas emissions as compared to a plan with less highway capacity investment. In addition, the value of modeling output for improving the accuracy of decision making depends on one's experience with different transportation modes, land-use forms, and policies as well as one's technical knowledge (Hatzopoulou and Miller 2009). Lack of transparency in travel demand outcomes is also mentioned as another reason for low implementation rate problem (Brömmelstroet and Bertolini 2011).

Models' Dependency on Planning Policy

Second, travel demand models only evaluate the planning scenarios supplied to them. Therefore, the ability of a travel demand model to aid in identifying more effective transportation plans requires that planners develop more effective transportation planning scenarios. However, planning agencies typically create two or three scenarios to be modeled (Bartholomew 2006). A more accurate or precise model will not make an ineffective transportation plan any better. In addition, these few scenarios tend to offer only marginal improvements over "trend" or "business as usual" scenarios in key effectiveness measures over the planning horizon.

Costs and Complexity of Models

Third, the cost and complexity of the modeling process present a barrier to considering a large number of scenarios or alternative strategies (Plumeau and Lawe 2009). Brustlin (2007) surveyed a large sample of MPOs investigating the current practice of travel demand modeling (Vanasse Hangen Brustlin 2007). MPOs are concern that they don't have "enough staff members to carry out advances in modeling techniques and budgets not large enough to try advanced model development" (Vanasse Hangen Brustlin 2007). Davidson et al. (2007) point out that developing and updating travel demand models for smaller MPOs is a more difficult job due to the low budget that they have (Davidson et al. 2007). If data is highly technical and a “black box” whose benefits for supporting decision making is not clear, it is plausible to be rejected (Transportation Research Board 2011).

A study by Deyle and Wiedenman (2014) hypothesized that the availability of resources like access to credible information might affect the quality of LRTPs output. Their regression analysis shows that there is a positive relationship between more available resources and considering mobility efficiency and safety in the planning process.

An additional factor that can have a bearing on the effectiveness of long-term planning is the composition of the MPO governing boards. The majority of MPOs operate such that each member of the governing board has one vote each and no more than one member from each jurisdiction within their planning area sits on the board (Bond & Kramer, 2010). Very few MPOs take into consideration the extent to which the member reflects the population in each given jurisdiction by appropriately weighting voting and membership. Existing research has found that the one-vote-one-jurisdiction approach may lead to situations in which the populations involved in each area of the plan are not adequately represented and, as such, the resulting plan does not take into consideration the funding priorities of each population or jurisdiction type (Lewis, 1998; Luna, 2015; Sanchez, 2006). For example, Nelson at al. (2004) concluded that there is a positive association between the ratio of urban-to-suburban votes on MPO boards and the way in which funds are allocated between transit and highway initiatives. The board composition can also affect the outcomes of long-term plans. For example, Gerber &

Gibson (2009) concluded that elected officials have more of a local focus, while non-elected public managers adopt a more regional focus.

The outcomes of planning efforts may also vary according to the level of collaboration and coordination between federal, state, and local stakeholders (Deyle & Wiedenman, 2014; Goetz et al., 2002; Sciara, 2017; Sciara & Handy, 2017, FHWA, 2012). Furthermore, the existence of bureaucracy in and between these stakeholder organizations can also directly undermine achievements. While MPOs are responsible for developing and prioritizing transportation projects at the regional level, the implementation of these plans is the responsibility of local transportation agencies, and local governments are in control of expenditure and funding.

Furthermore, there is a significant amount of evidence to suggest that the planning process as a whole is directly influenced by politics and biases that undermine the diversity of the plans that MPOs put forward (Wachs 1989, 1990, 1982). For example, Wachs (1989; 1990) described how modeling professionals frequently informed him of situations in which they were retrospectively tasked with developing travel demand models that supported the decisions that had already been made. Even in situations in which the political interference is not as direct, planning agency staff are not typically encouraged or incentivized to develop model planning scenarios that defy the prevailing view of the decision makers they report to. A survey of 124 Dutch planning professionals revealed that many of the respondents believed that modeling tasks were performed to justify prominent actors' existing positions as opposed to generate meaningful insights (Brömmelstroet and Bertolini 2010). In addition, there is evidence to suggest that the outputs of transportation planners are directly influenced by optimism biases (D. Lee 1973; TRB 2007; Wachs 1989). Plans and models are based on a variety of assumptions, and planning and modeling professionals can unwittingly introduce biased parameter inputs or planning strategies into the process when seeking to move it along.

Although the second group of studies; i.e., those that seek to identify the factors that impact planning effectiveness, highlight the barriers that can undermine the creation and delivery of effective transportation plans, previous studies have typically focused on practicing planners' *perceived* barriers. As such, there is a lack of evidence pertaining to how *hypothesized* barriers influence planning effectiveness. Furthermore, there is a lack of clarity surrounding the relationship between these barriers. For example, we lack insights into how the planning outcomes would vary if the barriers related to elements such as lack of budget, data, or weak inter-agency relationships were removed.

2.3.3 Studies on the Planning Outcomes

The existing literature presents a limited evaluation of the outcomes of LRTPs. One study that does address this need is that of Bartholomew and Ewing (2008), whose work is built upon in the current study. The purpose of the current study was to understand if plans created through land use and transportation scenario planning results in plans with greater density – an indicator of smart growth. Eighty planning scenarios spanning 50 MPOs were selected for the purpose of this study. Each scenario was evaluated against the vehicle miles traveled (VMT), emission of oxides of nitrogen (NOx), and population density performance measures and their change between now and future. However, it is important to note that the current study was limited to an evaluation of a small number of performance measures. They only choose to evaluate plans that had used scenario planning, rather than a sample of plans from all MPOs, and they only considered plans that provided the performance measures related to smart growth. I am using the same general approach but am asking more broadly is long-range planning (not just scenario planning) effective.

2.3.4 Limitation of Existing Research

Although previous studies have generated meaningful insights that have informed the work of planners, there is a lack of evidence evaluating how effective LRTPs are or if some are more effective than others. The aim of this study is to quantitatively evaluate long range transportation planning effectiveness by studying planning outcomes. While one prominent criticism is that the majority of "ex-post" studies focus on planning outputs as opposed to outcomes, in this case, it was not possible to wait until the plans had been implemented. As such, the study is performed on the assumption that actual outcomes will mirror predicted outcomes. We quantitatively evaluate the difference between current and future performance measures that are predicted by MPOs. A plan that achieves greater predicted progress towards goals is considered more effective than a plan that shows little or no progress towards the achievement of goals. If a plan is not predicted to make progress on performance measures, it is considered to be ineffective. A systematic evaluation of plans created by many MPOs can provide information on effectiveness of the LRTP process overall and factors that may explain differing levels of effectiveness among MPOs.

CHAPTER 3
CASE STUDIES

This dissertation is based on an evaluation of data collected from the LRTPs and supporting publicly available documentation created by MPOs in the United States. Data is extracted from a representative sample of 182 MPOs out of the total population of 408 MPOs (National Highway System 2016). This is one of the largest systematic reviews of MPO long-range plans that the author is aware of. In this chapter, I discuss how I select the study areas and how they are reviewed to provide data for my study.

3.1 Selecting MPOs for Review

A stratified random sampling method was used to select the MPOs for this study. I first selected the 50 most populous MPOs. Large MPOs often have the most data available and also face some of the greatest transportation planning challenges. I then divide the remaining MPOs into 50 groups or strata, one for each state. I draw random samples from each stratum, then pool them to get the overall sample population. This process selects MPOs from all states to capture the diversity of current practice and include a sufficiently large sample to support my analysis. Equation 1 shows the method used to determine the sample size for this study.

$$n = \frac{z_{\alpha/2}^2 S^2}{(r\bar{y}_U)^2 + \frac{z_{\alpha/2}^2 S^2}{N}}. \qquad \text{Equation 1}$$

N= Population size (408)
$\alpha = 0.05$
$z_{\alpha/2}$ = Critical value (1.96)

S= Sample proportion (50%)
$r\bar{y}_n$= Margin of error (5%)

In addition to a wide geographical coverage, I aimed to include various small and mid-size metropolitan areas. LRTPs and their supporting documents are about 70,000 pages of text, for 182 MPOs combined. Figure 3-1 shows the location and population of each selected MPO.

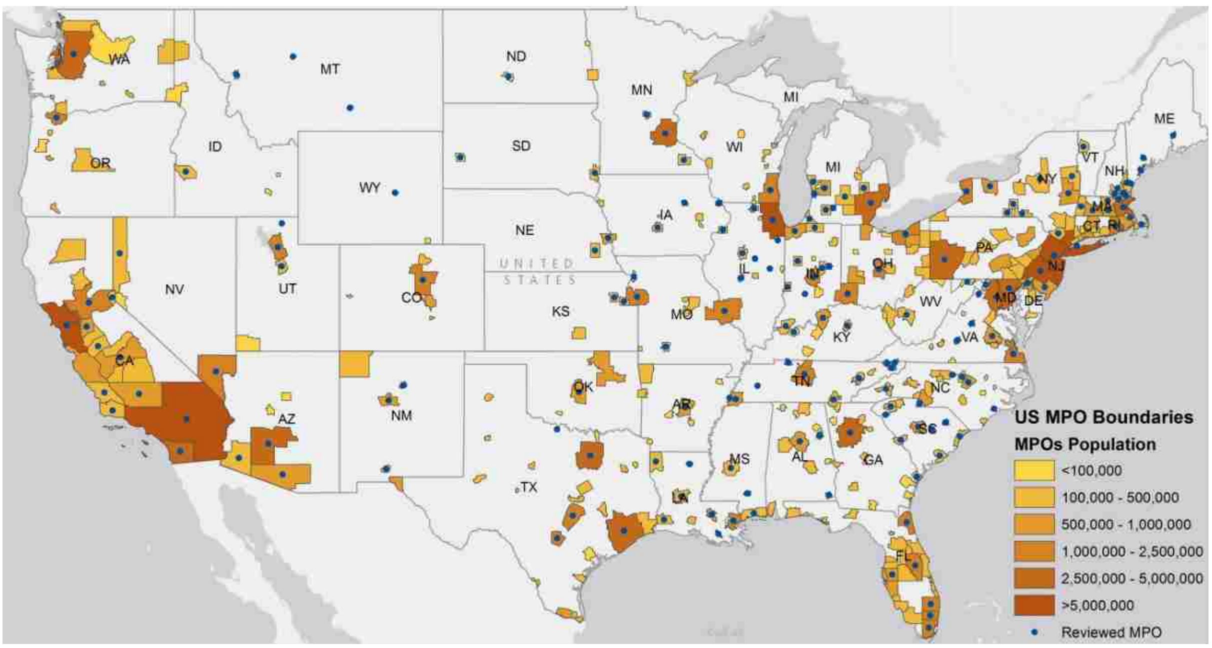


Figure 3-1 Selected MPOs for Review

CHAPTER 4
GOALS AND PERFORMANCE MEASURES

4.1 Introduction

The *Safe Accountable Flexible Transportation Efficiency Act,* a Legacy for Users (SAFETEA-LU) of 2005, included eight goals that MPOs must consider in their planning process. The *Fixing America's Surface Transportation Act* (FAST Act) of 2015 continued this requirement. These planning goals include supporting economic vitality, increasing the safety of the transportation system, increasing the security of the transportation system, increasing accessibility and mobility, protecting and enhancing the environment, enhancing the connectivity of the transportation system, promoting efficient system management, and preserving the existing transportation system. The FAST Act also requires MPOs to develop a performance-driven, outcome-based approach to support these national goals. The Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) have released a set of rulemakings for the implementation of the performance-based planning and programing (PBPP) process. Based on the rulemakings, a performance-based transportation plan should include collecting baseline information, setting goals and objectives, identifying performance measures, identifying adopted trends and targets, forecasting future conditions, system performance report, identifying strategies to support the target, and developing a financial plan.

While the increased emphasis on goals and performance measures might help MPOs monitor their progress toward desired goals, the achievement of these goals is not certain. Prior studies have not evaluated if performance-based planning and programing helps achieve better planning outcomes.

In this chapter, I aim to provide insight into the following key questions: what goals are included in the long-range transportation plans (LRTPs) conducted by MPOs? What performance measures are included in the planning process? What is the relationship between goals and performance measures? Then, I go one step further than prior studies and determine which goals and objectives are aligned with performance measures that are evaluated quantitatively within the plan.

4.2 Background

4.2.1 Effective Performance-Based Planning and Programming: The Definition

Effective performance-based planning depends on a clear linkage between goals and performance measures which ultimately turns the planning activities toward desired outcomes. The U.S. Government Performance and Results Act of 1993 suggests the basic principles that should be considered in a performance-based planning application:

- "A comprehensive mission statement for the agency;
- General goals and objectives, including outcome-related goals and objectives;
- More specific performance objectives expressed in an objective, quantifiable, and measurable form;
- Identification of performance measures or indicators to be used in measuring or assessing the relevant outputs, service levels, and outcomes of each program activity;
- A description of how performance measures relate to the goals and objectives;
- A reporting method for comparing actual program results with the established goals;

- Identification of those factors beyond the agency's control that could affect the agency's performance;
- A description of the resources required to achieve the performance goals" (Office of Management and Budget 1993).

US Department of Transportation evaluates the effectiveness of the PBPP based on the level of steps that MPOs adopt toward performance-based planning. In this regard, the activities of MPOs are divided into three groups including initial PBPP steps, intermediate PBPP steps, and mature PBPP process. Initial PBPP steps include developing a limited number of performance measures based on available data which represents the lowest level of effectiveness while the mature PBPP process is a fully integrated process through an MPO's planning process and products represent the highest level of effectiveness (Figure 4-1).

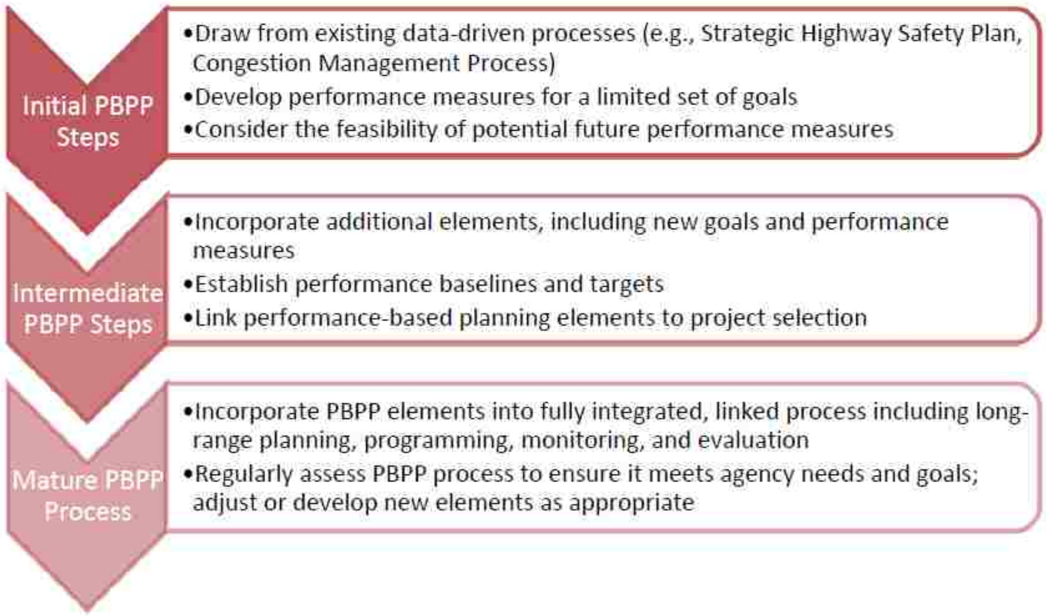


Figure 4-1 Different Levels of Effectiveness of PBPP Efforts (Evaluation Framework Suggested by USDOT (FHWA 2017))

In this study, I evaluate how completely goals and performance measures are incorporated in to LRTPs. I define three levels of completeness. In level one, I evaluate if any goals and performance measures are included in the LRTPs. In the second level, I evaluate if the goals are included in the LRTPs and if their related performance measures are included. In the third level, I evaluate besides including goals and performance measures as they are stated as the policy guidance if the numeric values of performance measures for base condition and future scenario are estimated (Figure 4-2).

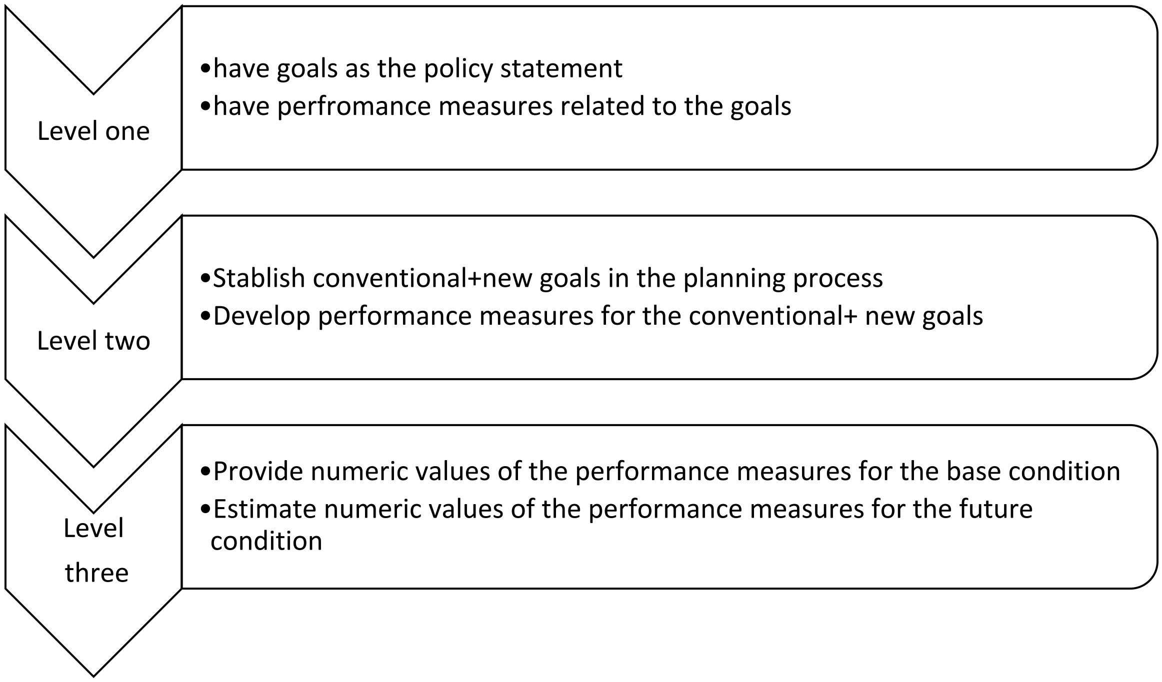


Figure 4-2 Evaluation Framework of The Completeness of the Inclusion of Goals and Performance Measures

4.2.2 Effective Performance-Based Planning and Programming: Literature Review

Previous studies have evaluated the extent to which various transportation planning goals and objectives have been incorporated into the long-term plans developed by MPOs. For example, some studies have examined the quality of plans based on whether they included sustainability principles (Berke & Conroy, 2000; Jun & Conroy, 2013). Boisjoly & El-Geneidy (2017) and Proffitt et al. (2017) evaluated whether accessibility goals were incorporated into the planning processes of LRTPs, while Wolf and Fenwick (2003) and US General Accounting Office (2001) evaluated the extent to which MPOs consider land use factors in their planning approaches. Other researchers have considered the role public health plays in the planning process (Lee & Sener, 2016; Lyons, Peckett, Morse, Khurana, & Nash, 2012; Singleton & Clifton, 2017; Washington et al., 2006) and/or the incorporation of climate change concerns (Leonard et al., 2008; Lindquist, 2007; Oswald Beiler, Marroquin, & McNeil, 2016; Savonis, Burkett, & Potter, 2008; Schmidt & Meyer, 2009). In addition, a few studies have examined the context of environmental justice in the context of the metropolitan planning process (Cambridge Systematics Inc, 2002; Manaugh, Badami, & El-Geneidy, 2015; Sanchez & Wolf, 2007).

Prior research shows that the observation of long-range transportation plans shows that all goals didn't get equal weight in the planning process. A study by Handy (2008) reviewed four large MPOs and found that while these plans reflect wider concerns other than congestion relief, congestion reduction represents the most significant concern in the planning process. A review of 40 MPOs shows that safety is mentioned as a goal in all LRTPs, and goals related to congestion reduction, fright movement, economic vitality, and environmental sustainability are included in 88% of LRTPs while reduced traffic delay is included in only 30% of LRTPs (FHWA 2017). Another study also shows that safety is considered in all reviewed plans, however, physical activity and public health are only considered by about the half of the plans and air quality is considered by about the 75% of MPOs (Singleton and Clifton 2017).

Prior research also shows that some MPOs didn't provide any performance measure in the planning process. A survey of 104 MPOs shows that about 25% of MPOs did not use any performance measure at all in either their long range or short-term transportation plans (Transportation for America 2017). However, a survey of 241 MPOs across the country shows that about 94% of MPOs are transitioning to performance-based planning and only 10% of MPOs have not established any performance measure at the time of the survey (Kramer, Carroll, and Karimi 2017). Handy (2008) believes that "goals without performance measures get the least weight in the planning process".

Prior studies also show that all performance measures didn't get equal weight in the planning process and MPOs only focused on the limited number of performance measures. The most common reported performance measures in the LRTPs are safety and congestion (Kramer, Carroll, and Karimi 2017; Manaugh, Badami, and El-Geneidy 2015; Singleton and Clifton 2017). For example, a survey of 40 MPOs shows the following performance measures and their percentages that are included in the planning documents: safety 63%, congestion reduction 63%, reliability 55%, freight 55%, environment protection 50%, infrastructure condition 48%, and reduced delay 10% (FHWA 2017). Another survey of 104 MPOs shows that MPOs are most focused on the performance measures related to safety, transportation system performance, economic growth, access to jobs, and freight movement, respectively (Transportation for America 2017).

Performance measures related to new goals such as climate change, health, equity, and quality of life are considered by only a portion of MPOs. For example, a survey of 241 MPOs shows that performance measures related to air quality, environmental sustainability, the economy, equity, and multimodal transportation are included in less than the 60 LRTPs (about 25%) (Kramer, Carroll, and Karimi 2017). Next example is a survey of 45 largest MPOs that shows that less than half of MPOs use performance measures related to environmental factors in transportation (Amekudzi et al. 2012). Lee and Sener (2016) defined the quality of life in transportation as well-being in four different aspects of human life: physical, mental, social, and economic. Lee and Sener (2016) evaluated LRTPs developed by 148 MPOs with a population greater than 250,000 across the country to understand how MPOs are addressing quality of life in the planning process. The frequency analysis shows that safety is the most frequent factor used in the planning documents. Accessibility and mobility are also prevalent. However, terms like physical activity, social, and mental are less frequent.

While performance measures are supposed to be used to monitor progress toward adopted goals, however, research shows that the relationship between goals and performance measures are not clear in the planning process adopted by some MPOs. Handy (2008) believes that if measures do not match the goals, they could guide planners in a direction away from those goals and if there are no measures for a set of goals, the role of those goals on decision making and project selection might be very insignificant. A study shows that three of four reviewed LRTPs do not match performance measures to goals (Handy 2008).

By reviewing the LRTP documents, prior studies found that while most MPOs have developed some level of the performance-based planning process, only a portion of MPOs have linked performance measures to project selection or investment decisions. A study shows that only 58% of MPOs linked their defined performance measures to project selection or investment decision (FHWA 2017). The effects of the performance-based planning in the investment decision-making can be reflected in the Transportation Improvement Program (TIP) which shows a list of projects that are selected by the planning process in the LRTPs. A review of TIPs adopted by 40 MPOs shows that while about 68% of TIPs linked to the planning goals, only 23% of TIPs are linked to performance measures defined in the planning process (FHWA 2017). Reviewing 241 MPOs shows that the use of performance measures in the TIPs is as follows: safety-related performance measures are used in 37 TIPs, congestion-related performance measures are used in 29 TIPs, air quality and accessibility related performance measures are used in 26 TIPs, and performance related to asset condition, freight, and livability are included in 20 TIPs or less (Kramer, Carroll, and Karimi 2017).

The main purpose of these studies is to evaluate the state of practice associated with certain goals and identify the barriers and challenges that impede the achievement of such goals as an outcome of the planning process. The majority of studies that have been performed in this domain have focused on either concern over plan adequacy and completeness with respect to a mandated planning task or have been limited to consideration of one or two components of the planning process; for example, planning goals and performance measures. Either way, previous researchers have negated to adequately examine how incorporating consideration of wider planning policies into the overall strategic plan can result in the development of more effective plans, and how the expected outcomes are closely aligned with the concerns or goals. Some scholars have suggested that plans that focus on more holistic goals and policies generate superior outcomes that are more likely to comply with policy goals. Berke and Godschalk (2009) introduced "internal plan quality" as a means of evaluating planning effectiveness. His proposed approach emphasized the need to evaluate the content of the planning goals, visions, and policy frameworks. Dalton & Burby (1994) noted that taking into consideration the broader goals mandated by states could improve the quality of a plan while also ensuring that it addressed wider concerns. Goetz et al. (2000) argued that the effectiveness of a given MPO's planning activities could be determined by evaluating the extent to which the specific transportation goals, such as safety, land use, and non-motorized transportation, are reflected in planning products.

There is some evidence that performance-based planning is heavily influenced by data availability. MPOs expressed their concern regarding the availability and cost of data and their technical capacity to adopt the performance-based planning approach (FHWA 2017). A review of four LRTPs suggests that travel demand models have an influential role in selecting and applying performance measures in the planning process. Goals and their performance measures that are taken from travel demand models got more attention than those goals whose performances are not definable or measurable by travel demand models (Handy 2008). Jeon et al. (2013) mentioned that only a few MPOs have applied planning tools to capture transportation system metrics in the regional planning process and many planners do not know how to define performance measures (Jeon, Amekudzi, and Guensler 2013). MPOs face more problems in defining performance measures for goals that are intangible or hard to define like public health (Singleton and Clifton 2017), quality of life (Lee and Sener 2016), equity (Manaugh, Badami, and El-Geneidy 2015; Karner and Niemeier 2013; Hartell 2017), and climate change (Batac, Guido Schattanek, and Michael D. Meyer 2012). A study by Boisjoly and El-Geneidy (2017) found that despite the presence of some goals in the planning process, the planner did not how to define the performance measures to measure those goals. For example, while the accessibility is included as a goal in the planning documents, accessibility is defined as the access to mobility rather than the ease of getting different destinations (Boisjoly and El-Geneidy 2017; Proffitt et al. 2017).

Although the above-mentioned studies have considered the extent to which planning concerns and goals are incorporated into the planning process, the question of how planners can determine whether the inclusion of various planning goals enhances the overall effectiveness of the planning process (e.g., in terms of outcomes) remains unanswered. While it is feasible that incorporating consideration of more issues into the planning process can potentially improve planning outcomes, the existing research does not present solid evidence to prove this correlation. Previous studies have typically assessed the quality of a given plan by performing content analysis through which they have investigated keyword frequency within all or part of a planning document using an unrepresentative sample as a means of determining the extent to which certain criteria are present in LRTPs.

4.3 Methodology

MPOs typically identify planning goals or desired outcomes for the transportation system in the early chapters of an LRTP. I searched each LRTP for a chapter that is labeled one of these words or their combinations: “goal”, “vision”, “objective”, “recommendation”, “guiding principle/policy”, “purpose”, and “strategy”. Statement of goals is then extracted and entered into a database. In the absence of an explicit chapter of goals, I visually scanned the whole documents to ensure all goals are found. I searched the database to find the most universal goals that are used in the LRTPs and count the frequency of each goal.

I followed a similar procedure to find out the statement of performance measures that each LRTP has. They are typically specified immediately after goals and objectives in the same chapter or in the following chapter. Otherwise, I searched the content of each LRTP for the terms such as “performance measure”, “factor”, “criteria”, “indicator”, and “targets”. However, all plans are fully scanned to avoid missing any data. Performance measures are entered into the database to see what indicators are stated as the planning performance measures and I counted the frequency of each performance measures.

Typically, the extensive list of performance measures in the planning statements is not fully utilized to quantify the effects of planning scenarios and all mentioned performance measures are not tracked so that affect final decisions. Some MPOs produce quantitative information for only a subset of performance measures. In some cases, MPOs measure the performance of an indicator only for the base condition while the performance of the system over the long-range plan is not forecasted. For each performance measure, I also search if they are quantified for the base and future conditions.

MPOs use a wide variety of ways to establish and define their goals. The area of interest here is to assess whether MPOs have goals related to mobility, accessibility, safety, environment protection, and environmental justice. Answering this question is almost straightforward since goal statements are typically explicit and include these terms or equivalent or similar words. For example, I searched for these words: “mobility” or “movement” and “physical trip” (Susan Handy 2002); “accessibility” or “non-physical trips”, “connect”, “opportunity” (Singleton and Clifton 2017); “safety” or “decrease accident/ crash/ collision/ fatalities/ injured"; "environment" or "sustainability", "ecosystem", "decrease pollution", "climate change"; "environmental justice" or "equity", and "communities of concern", etc. The results of this section provide evidence on the type of goals employed in each LRTP.

4.4 Results

Table 4-1 shows the number and percent of goals that are considered in the LRTPs. The results are summarized based on MPOs population. MPOs with the population less than 200,000 population are considered as small, MPOs with the population between 200,000 to 500,000 population are considered as the medium, and MPOs with a population greater than 500,000 are considered as large.

155 MPO plans (86%) called out mobility in policy guidance. The plans of 150 MPOs included goals to increase accessibility. About 75% of LRTPs have a direct goal of safety. Equity, efficient system management, and climate change mitigation are the less frequent goals which are included by less than 40% of MPOs.

Table 4-1 The Number and Percent of Goals That Are Considered in LRTPs Based on Their Size

Planning Goal	Small MPO	Medium MPO	Large MPO	Total
Increase Mobility	43 (74.14%)	41 (87.23%)	71 (92.11%)	155 (85.16%)
Increase Accessibility	42 (72.41%)	38 (80.85%)	70 (92.00%)	150 (82.42%)
Increase Safety	39 (67.42%)	34 (72.34%)	62 (81.58%)	135 (74.18%)
Support the Economic Vitality	38 (65.52%)	32 (68.09%)	56 (73.68%)	126 (69.23%)
Enhance Environmental	31 (53.45%)	32 (68.09%)	61 (80.26%)	124 (68.13%)
Preservation of Existing System	27 (46.55%)	22 (46.81%)	42 (55.26%)	91 (50.00%)
Increase Security	24 (41.38%)	19 (40.43%)	29 (38.16%)	72 (39.56%)
Environmental Equity	15 (25.86%)	13 (27.66%)	39 (51.32%)	67 (36.81%)
Efficient System Management	16 (27.59%)	9 (19.15%)	23 (30.26%)	48 (26.37%)
Climate Change Mitigation	8 (13.79%)	11 (23.40%)	26 (34.21%)	45 (24.73%)

As Figure 4-3 shows, except increase security goal, large MPOs include more goals than medium and small size MPOs. Except efficient system management, the percent of medium MPOs that include planning goals is higher than small MPOs. Mobility is the most frequent goals for all three categories of MPOs. Efficient system management and climate change mitigations are less frequent goals in medium and large MPOs. However, environmental equity and climate change mitigation are the less frequent goals considered by small MPOs.

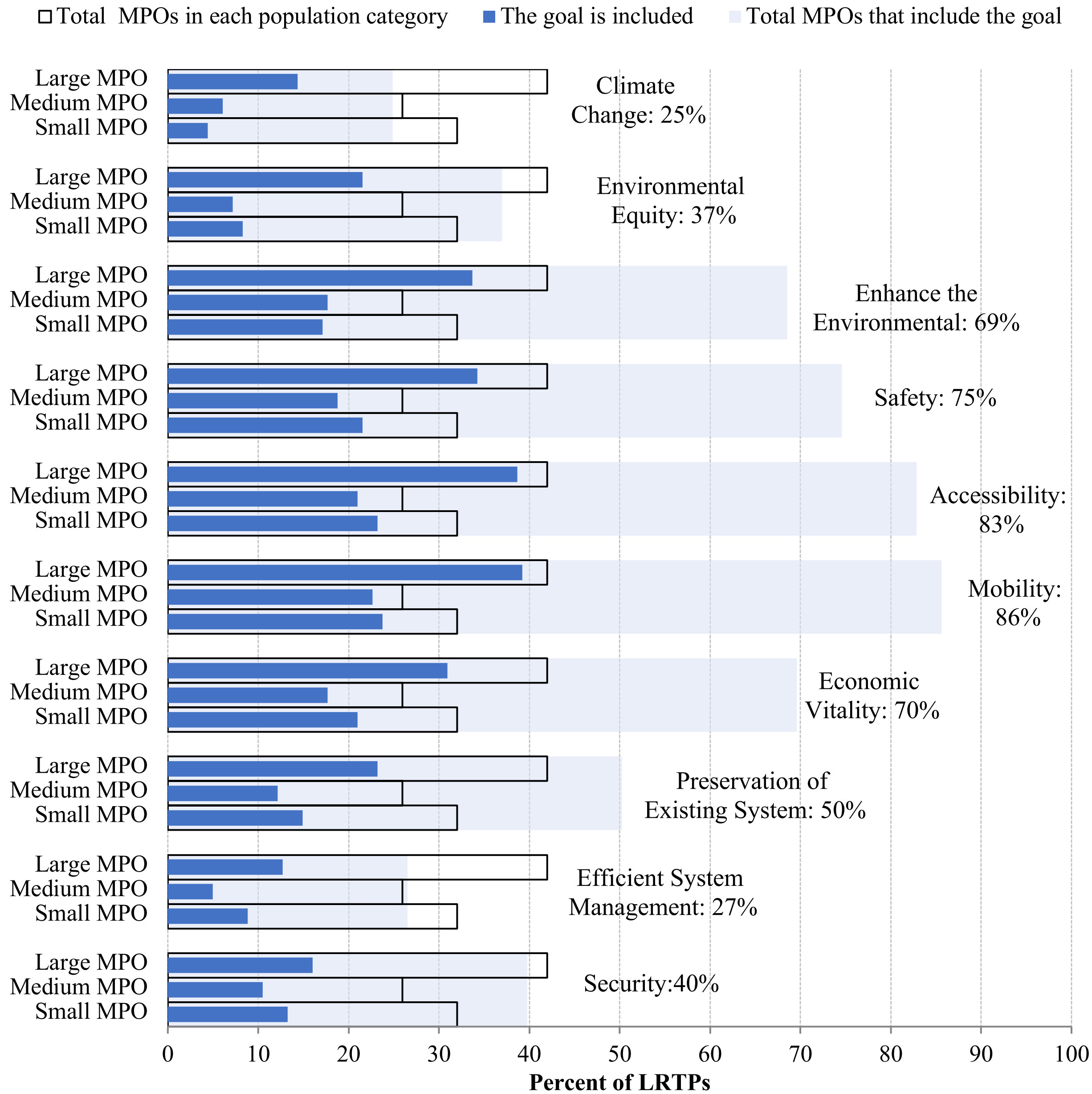


Figure 4-3 The Percent of Goals That Are Considered in LRTPs Based on Their Size

Table 4-2 shows the number and percent of most universal performance measures that are included in the reviewed LRTPs. Number of car accidents, travel mode share, and the amount of air pollution are the most frequent performance measures which are mentioned in 63%, 51%, and 47% of LRTPs. Transit passenger miles traveled, number of transit accidents, and number of telecommuting trips are the less frequent performance measures.

Table 4-2 The Number and Percent of Performance Measures That Are Considered in LRTPs

Performance Measure	Small	Medium	Large	Total
Car Accidents	33 (56.90%)	27 (57.45%)	54 (71.05%)	114 (62.98%)
Mode Share	25 (43.10%)	19 (40.43%)	49 (64.47%)	93 (51.38%)
Air Pollution	17 (29.31%)	18 (38.30%)	51 (67.11%)	86 (47.51%)
Vehicle Mile Traveled	17 (29.31%)	17 (36.17%)	34 (44.74%)	68 (37.57%)
Bike Accidents	14 (24.14%)	16 (34.04%)	37 (48.68%)	67 (37.02%)
Average Trip Travel Time	11 (18.97%)	15 (31.91%)	39 (51.32%)	65 (35.91%)
Pedestrian Accidents	14 (24.14%)	16 (34.04%)	34 (44.74%)	64 (35.36%)
Non-Motorized Lane Mile	24 (41.38%)	15 (31.91%)	20 (26.32%)	59 (32.60%)
Vehicle Hours of Delay	15 (25.86%)	9 (19.15%)	32 (42.11%)	56 (30.94%)
Investment in EJ Groups	15 (25.86%)	11 (23.40%)	30 (39.47%)	56 (30.94%)
Transit Ridership	15 (25.86%)	10 (21.28%)	30 (39.47%)	55 (30.39%)
Access to Transit	10 (17.24%)	10 (21.28%)	32 (42.11%)	52 (28.73%)
Traffic Volume and Capacity	12 (20.69%)	12 (25.53%)	23 (30.26%)	47 (25.97%)
Pavement Condition	9 (15.52%)	11 (23.40%)	23 (30.26%)	43 (23.76%)
Access to Jobs	10 (17.24%)	4 (8.51%)	27 (35.53%)	41 (22.65%)
Environmental Impacts	11 (18.97%)	9 (19.15%)	18 (23.68%)	38 (20.99%)
GHG Emission	7 (12.07%)	8 (17.02%)	21 (27.63%)	36 (19.89%)
Average Travel Speed	5 (8.62%)	6 (12.77%)	18 (23.68%)	29 (16.02%)
Vehicle Hours Traveled	7 (12.07%)	6 (12.77%)	15 (19.74%)	28 (15.47%)
Residential Density	10 (17.24%)	5 (10.64%)	12 (15.79%)	27 (14.92%)
Energy Usage	4 (6.90%)	8 (17.02%)	15 (19.74%)	27 (14.92%)
Job Housing Balance	1 (1.72%)	3 (6.38%)	13 (17.11%)	17 (9.39%)
Clearance Time After a Disaster	1 (1.72%)	4 (8.51%)	10 (13.16%)	15 (8.29%)
Number of Auto Trips	1 (1.72%)	2 (4.26%)	10 (13.16%)	13 (7.18%)
Accessibility of EJ Groups	1 (1.72%)	1 (2.13%)	10 (13.16%)	12 (6.63%)
Water Usage	1 (1.72%)	2 (4.26%)	8 (10.53%)	11 (6.08%)
Transit Passenger Miles Traveled	1 (1.72%)	3 (6.38%)	4 (5.26%)	8 (4.42%)
Impacts on EJ Groups	4 (6.9%)	0 (0.00%)	2 (2.63%)	6 (3.31%)
Transit Crashes	0 (0.00%)	0 (0.00%)	3 (3.95%)	3 (1.66%)
Telecommuting	1 (1.72%)	0 (0.00%)	1 (1.32%)	2 (1.10%)

Figure 4-4 depicts the number and percent of MPOs that include the performance measures based on their population. While the light blue colored bars show the total percent of MPOs that considered a specific performance measure, the navy, green, and blue bars split the percent of MPOs for each performance measure based on the MPOs size comparable to the total MPOs shown with the black outline. For all performance measures, except non-motorized lane miles, large MPOs include more performance measures than medium and small size MPOs. Same as total MPOs, in all large, medium, and small MPOs, the number of car accidents, air pollution, and travel mode share are the most frequent performance measures.

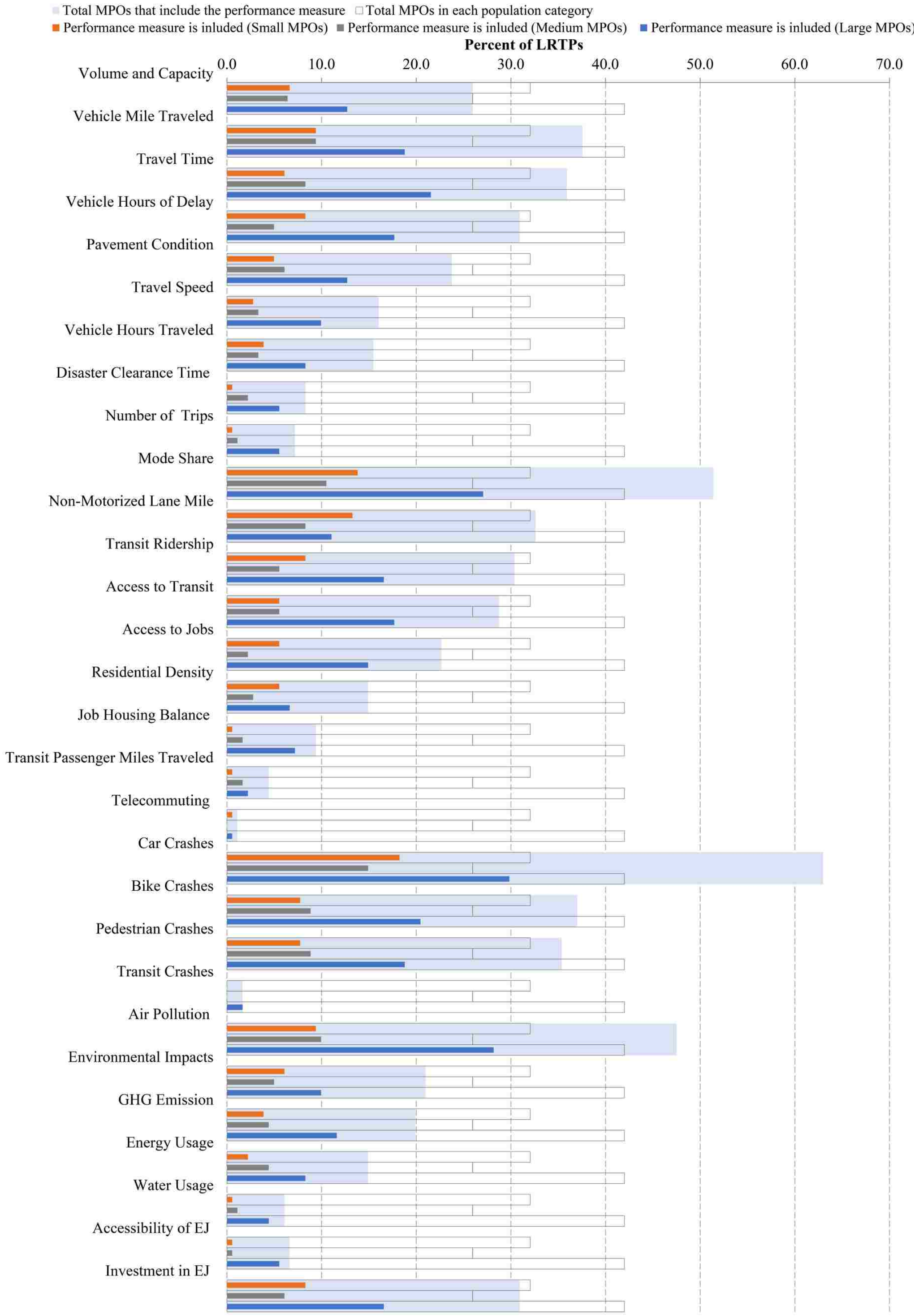


Figure 4-4 Percent of Performance Measures That Are Considered in The MPOs Based on Their Size

I then evaluated the consistency of stated performance measures as the policy guidance versus the measured performance measures for the base condition and future (Table 4-3). Group 1 represents the number of performance measures that are mentioned as policy guidance and they are measured for the base and future conditions. Vehicle miles traveled, and air pollution inventory are the most frequent performance measures in this group which are included in 29% and 25% of LRTPs, respectively. Group 2 represents the performance measures that are mentioned as policy guidance and measured for the base year but not predicted for the planning horizon year. The number of car accidents and travel mode share are the most frequent performance measures in this group. Group 3 shows the performance measures that are mentioned in the LRTPs, while they are measured for neither base nor future year. The most frequent performance measures in this group are investment in EJ communities and number of non-motorized accidents. Group 4 represents performance measures that are mentioned as the policy but only measured for future condition. Number of plans in this category is almost zero. Group 5 represents the performance measures that are not mentioned as the policy guidance while their numeric values are provided for base and future years. Traffic volume and capacity have the highest percentage as 31% of MPOs estimated traffic volume and capacity for base and future, while it is not mentioned as a performance measure (Figure 4-5). Group 6 represents performance measures that are not mentioned at all, and not measured for base and future scenarios. Transit ridership and environmental impacts are the most frequent performance measures in this category.

Table 4-3: Number and Percent of Stated vs Measured Performance Measures

Performance Measure	Group 1[a]	Group 2[b]	Group 3[c]	Group 4[d]	Group 5[e]	Group 6[f]	Others
Traffic Volume and Capacity	49 (26.92%)	4 (2.20%)	17 (9.34%)	1 (0.55%)	56 (30.77%)	21 (11.54%)	34 (18.68%)
Vehicle Mile Traveled	52 (28.57%)	9 (4.95%)	7 (3.85%)	1 (0.55%)	51 (28.02%)	21 (11.54%)	41 (22.53%)
Average Trip Travel Time	20 (10.99%)	15 (8.24%)	29 (15.93%)	1 (0.55%)	14 (7.69%)	52 (28.57%)	51 (28.02%)
Vehicle Hours of Delay	21 (11.54%)	7 (3.85%)	25 (13.74%)	3 (1.65%)	30 (16.48%)	60 (32.97%)	36 (19.78%)
Pavement Condition	3 (1.65%)	20 (10.99%)	20 (10.99%)	0 (0.00%)	1 (0.55%)	75 (41.21%)	63 (34.62%)
Average Travel Speed	10 (5.49%)	6 (3.30%)	13 (7.14%)	0 (0.00%)	36 (19.78%)	82 (45.05%)	35 (19.23%)
Vehicle Hours Traveled	16 (8.79%)	1 (0.55%)	10 (5.49%)	1 (0.55%)	33 (18.13%)	88 (48.35%)	33 (18.13%)
Clearance Time After a Disaster	0 (0.00%)	2 (1.10%)	13 (7.14%)	0 (0.00%)	0 (0.00%)	138 (75.82%)	29 (15.93%)
Number of Auto Trips	4 (2.20%)	1 (0.55%)	8 (4.40%)	0 (0.00%)	37 (20.33%)	72 (39.56%)	60 (32.97%)
Mode Share	24 (13.19%)	34 (18.68%)	35 (19.23%)	0 (0.00%)	9 (4.95%)	33 (18.13%)	47 (25.82%)
Non-Motorized Lane Mile	33 (18.13%)	17 (9.34%)	9 (4.95%)	1 (0.55%)	49 (26.92%)	26 (14.29%)	47 (25.82%)
Transit Ridership	17 (9.34%)	25 (13.74%)	13 (7.14%)	0 (0.00%)	21 (11.54%)	37 (20.33%)	69 (37.91%)
Access to Transit	11 (6.04%)	8 (4.40%)	33 (18.13%)	0 (0.00%)	12 (6.59%)	79 (43.41%)	39 (21.43%)
Access to Jobs	7 (3.85%)	0 (0.00%)	34 (18.68%)	0 (0.00%)	13 (7.14%)	94 (51.65%)	34 (18.68%)
Residential Density	11 (6.04%)	4 (2.20%)	13 (7.14%)	0 (0.00%)	24 (13.19%)	79 (43.41%)	51 (28.02%)
Job Housing Balance	4 (2.20%)	3 (1.65%)	10 (5.49%)	0 (0.00%)	1 (0.55%)	130 (71.43%)	34 (18.68%)
Transit Passenger Miles Traveled	3 (1.65%)	3 (1.65%)	3 (1.65%)	0 (0.00%)	8 (4.40%)	112 (61.54%)	53 (29.12%)
Telecommuting	0 (0.00%)	0 (0.00%)	2 (1.10%)	0 (0.00%)	0 (0.00%)	153 (84.07%)	27 (14.84%)
Car Crashes	10 (5.49%)	74 (40.66%)	31 (17.03%)	0 (0.00%)	3 (1.65%)	13 (7.14%)	51 (28.02%)
Bike Crashes	3 (1.65%)	25 (13.74%)	40 (21.98%)	0 (0.00%)	0 (0.00%)	68 (37.36%)	46 (25.27%)
Pedestrian Crashes	3 (1.65%)	22 (12.09%)	40 (21.98%)	0 (0.00%)	0 (0.00%)	66 (36.26%)	51 (28.02%)
Transit Crashes	0 (0.00%)	1 (0.55%)	2 (1.10%)	0 (0.00%)	0 (0.00%)	146 (80.22%)	33 (18.13%)
Air Pollution	45 (24.73%)	10 (5.49%)	32 (17.58%)	1 (0.55%)	23 (12.64%)	41 (22.53%)	30 (16.48%)
Environmental Impacts	8 (4.40%)	10 (5.49%)	20 (10.99%)	0 (0.00%)	3 (1.65%)	71 (39.01%)	70 (38.46%)
GHG Emission	17 (9.34%)	7 (3.85%)	13 (7.14%)	0 (0.00%)	20 (10.99%)	93 (51.10%)	32 (17.58%)
Energy Usage	3 (1.65%)	5 (2.75%)	19 (10.44%)	0 (0.00%)	9 (4.95%)	115 (63.19%)	31 (17.03%)
Water Usage	2 (1.10%)	0 (0.00%)	9 (4.95%)	0 (0.00%)	3 (1.65%)	139 (76.37%)	29 (15.93%)
Accessibility of EJ Groups	3 (1.65%)	2 (1.10%)	6 (3.30%)	1 (0.55%)	17 (9.34%)	99 (54.40%)	54 (29.67%)
Investment in EJ Groups	0 (0.00%)	1 (0.55%)	51 (28.02%)	5 (2.75%)	0 (0.00%)	88 (48.35%)	37 (20.33%)

[a] A performance measure is mentioned in the policy statements. It is measured for the base condition. It is predicted for the future planning scenario.

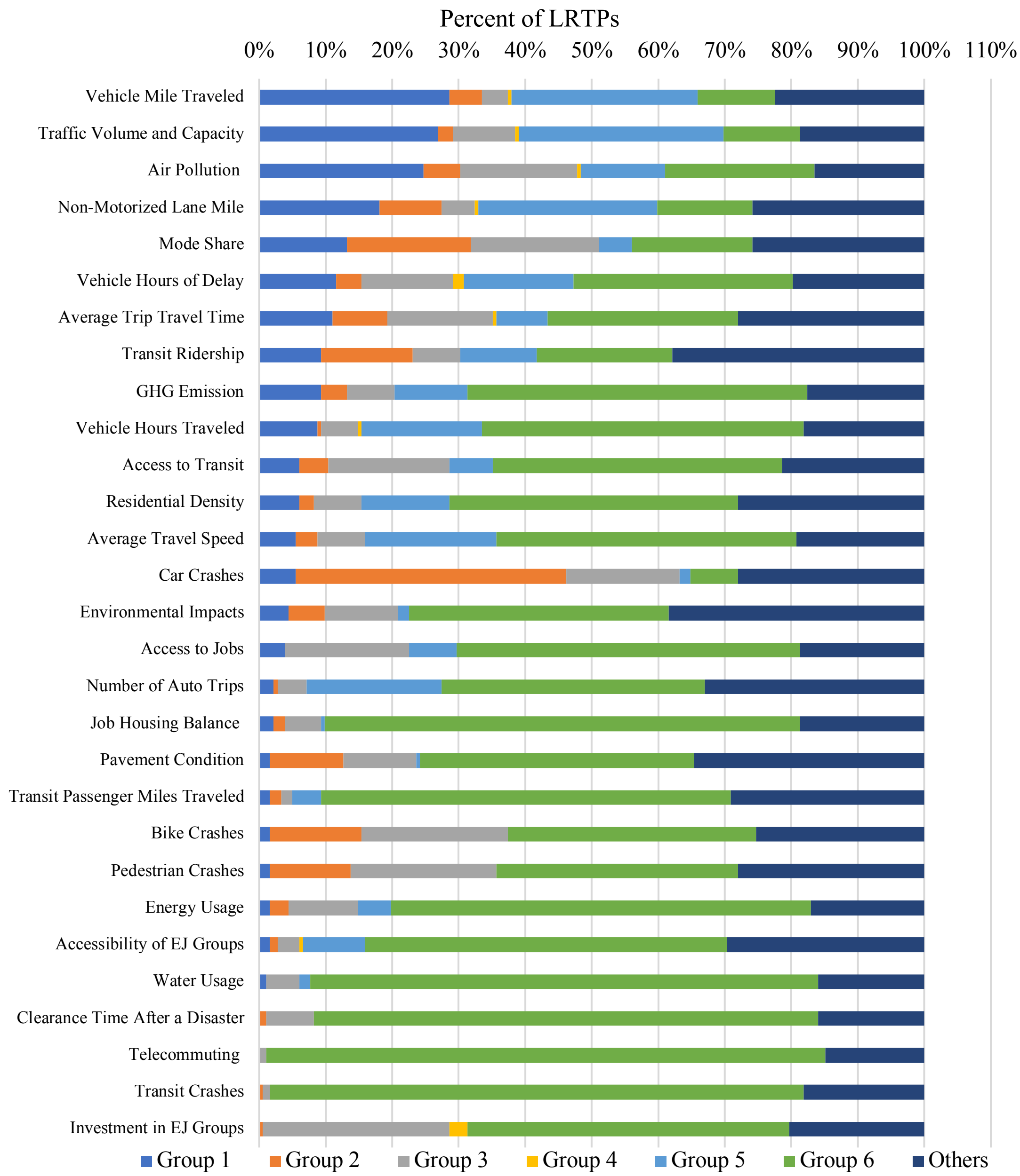
[b] A performance measure is mentioned in the policy statements. It is measured for the base condition. It is **NOT** predicted for the future planning scenario.

[c] A performance measure is mentioned in the policy statements. It is **NOT** measured for the base condition. It is **NOT** predicted for the future planning scenario.

[d] A performance measure is mentioned in the policy statements. It is **NOT** measured for the base condition. It is predicted for the future planning scenario.

[e] A performance measure is **NOT** mentioned in the policy statements. It is measured for the base condition. It is predicted for the future planning scenario.

[f] A performance measure is **NOT** mentioned in the policy statements. It is **NOT** measured for the base condition. It is **NOT** predicted for the future planning scenario.



Group 1: A performance measure is mentioned in the policy statements. It is measured for the base condition. It is predicted for the future planning scenario.
Group 2: A performance measure is mentioned in the policy statements. It is measured for the base condition. It is **NOT** predicted for the future planning scenario.
Group 3: A performance measure is mentioned in the policy statements. It is **NOT** measured for the base condition. It is **NOT** predicted for the future planning scenario.
Group 4: A performance measure is mentioned in the policy statements. It is **NOT** measured for the base condition. It is predicted for the future planning scenario.
Group 5: A performance measure is **NOT** mentioned in the policy statements. It is measured for the base condition. It is predicted for the future planning scenario.
Group 6: A performance measure is **NOT** mentioned in the policy statements. It is **NOT** measured for the base condition. It is **NOT** predicted for the future planning scenario.

Figure 4-5: Percent of Stated vs Measured Performance Measures

4.5 Discussion and Conclusion

The results show that mobility and accessibility are two goals considered by many MPOs. It appears that increasing mobility, in particular, relieving traffic congestion and increasing travel speed is considered by many MPOs mainly because the required information to assess mobility is available by most of them. Travel demand model at the core of transportation planning of MPOs provides the fundamental information on mobility performance measures such as speed, delay, and congestion. As Handy (2008) argues, goals which are measurable with the information provided by travel demand models are in the center of attention while other goals which are hard to define, and measure are overlooked. Thus, it might be helpful if MPOs be provided with the tools required to measure other performance measures rather than mobility. For example, an analytical framework which MPOs can use to measure the impacts of each panning scenario on environment (such as air quality), public health, climate change, and environmental justice.

The results show that larger MPOs consider more goals than small MPOs. Prior studies acknowledged that including more goals in the planning process requires resources such as data, funding, and staff. Thus, small MPOs may need more resources to improve their planning process. Small MPOs have limited technical abilities to collect or develop the required data, tools and models required to evaluate the achievement to a broad range of goals. The number of an MPO's staff is based on its size and small MPOs receive a small amount of federal funding which has direct effects on the number of staff and their knowledge. A nationwide survey of MPOs shows that number of MPOs staff is correlated with the MPOs population and MPOs planning area and large MPOs have the largest staff size undoubtedly (Bond, et al., 2010).Therefore, MPOs generally apply transferrable parameters developed by other studies or for other regions which are similar in terms of size and population to evaluate the changes in transportation system. The majority of small MPOs are dependent on the state DOTs for tools and models development.

It appears that planning factors of MAP-21 influenced the regional planning policy to include more comprehensive goal statements rather than congestion relief. However, the goals like security, equity, and climate change are the less frequent goals. This occurs due to lack of resources such as data and staff time or planners do not think that these goals are as important as general goals like mobility.

The findings imply that many of the performance measures are stated at the beginning of the planning document to guide the planning process, but they are not followed up in designing planning scenarios since their numeric values are not provided or are not mentioned in the planning document. Number of car accidents is the most frequent performance measure that is stated in the LRTPs. In general, it is measured for the base condition but not predicted for the future planning scenario. These results also agree with prior research that found that the data collection, analytical methods, and decision making in the long-range transportation planning do not adequately include safety (Washington et al. 2006). While methods for accurately predicting safety related performance measures are not well developed for regional scale analysis, statistical models can be used to make rough predictions (Washington et al., 2006).

The results also show that planning goals are generally linked to appropriate performance measures, some goals remain untracked by performance measures.. In some cases, performance measures are stated in an LRTP but are not used to monitor the performance of a plan; performance measures are partly measured for either the baseline or future but not both. The failure to consistently measure goals and performance metrics might limit the identification of potentially more effective plans.

CHAPTER 5
PLANNING PERFORMANCE OUTCOMES

5.1 Introduction

LRTPs provide quantitative information about the performance of each planning scenario as well as the baseline condition, most of which is derived from travel demand modeling output. The planning scenarios generally include build or adopted scenario and trend or no build scenario which is considered but not adopted.

The existing literature presents a limited evaluation of the outcomes of LRTPs. One study that does address this need is that of Bartholomew and Ewing (2008), whose work is built upon in the current study. The purpose of the current study was to examine the existing gaps in scenario planning approaches by using a methodology that evaluated scenario planning outcomes. Eighty planning scenarios spanning 50 MPOs were selected for the purpose of this study. Each scenario was evaluated against the vehicle miles traveled (VMT), emission of oxides of nitrogen (NOx), and population density performance measures. The study aimed to generate quantitative data by which it is possible to determine how variations in the performance measures that are employed to define the effectiveness of a plan influence the extent to which it is effective in generating a desirable future scenario. A scenario is considered effective if VMT and NOx emissions decrease, and density increases as a result of the implementation of the plan when compared to the predicted trends if no plan at all is implemented. The results reveal that the VMT and NOx are lower than the trend data following the implementation of most plans. In terms of population density, a comparison of the planning scenarios and the business-as-usual model indicates that there is a higher population density for future development. However, it is important to note that the current study was limited to an evaluation of a small number of performance measures. Moreover, although the outcomes of the plan versus business as usual were evaluated, the difference between the base condition and the future of the transportation system was not taken into consideration.

In this chapter, I quantitatively evaluate the difference between the current and future conditions in terms of after a plan has been implemented, the difference between the future with and without a plan, and whether plans are being developed to achieve better outcomes. Therefore, the effectiveness of the plan is quantified as follows: A plan that achieves greater progress towards goals is considered more effective than a plan that shows little or no progress towards the achievement of goals. If a plan undermines the achievement of long-term goals, it is considered to be ineffective. In light of my hypothesis, a systematic evaluation can provide a basis for assessing the extent to which plans achieve the required outcomes. This study focused on the use of substantive data to evaluate the change in performance measures.

5.2 Methodology

I scanned each plan and its appendices for the use of quantitative measurements applied to evaluate the performance of the transportation system under current and future circumstances with a plan and without a plan. Collected data on performance measures are entered into the database.

I also reviewed conformity reports associated with the plans in non-attainment and maintenance areas for ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide to extract air pollution emissions data. The conformity analysis is required in maintenance and non-attainment areas since the emissions from transportation cause poor air quality and health (Pan et al. 2017). The federal government does not require MPOs to examine the effects of transportation plans on the climate change (except California adopted SB 375), however, several MPOs incorporated GHG emission consideration into the planning process. I scanned each plan and its appendices for the use of quantitative prediction of GHG emission. In the absence of quantitative data on GHG emission, I supplement this data by estimating GHG emission for the base and future scenarios for which LRTPs that required inputs for calculation such as VMT and speed are available. The on-road transportation sector's contribution to GHG emission can be modeled by using the Environmental Protection Agency's Motor Vehicle Emissions Simulator (MOVES). MOVES is able to estimate GHG emissions at a variety of geographic scales for various years (U.S. Environmental Protection Agency 2016). I take one of two approaches to estimate the GHG emission. The first approach is calculating "emission rate" for those LRTPs that contain daily VMT and travel speed data. In this approach, VMT is manually applied to the MOVES generated emission rates output table to calculate the inventories for different travel speeds. Output data includes emissions per unit of distance for both base and future scenarios for each metropolitan region. Total GHG emission is generated by multiplying these rates by the appropriate VMT. "Emission inventory" approach is applied for LRTPs which do not have any data about travel speed. In this process, MOVES is run by using the national scale, including local VMT information, and relying on the model's default speed assumptions

MPOs used a wide variety of performance measures to evaluate planning scenarios, which makes the comparison between plans of different MPOs difficult. In this chapter, I only focus on the most universally reported quantitative performance measures. The most frequent performance measures are total and per capita VMT, average travel speed, vehicle hour of delay (VHD) per capita, single occupancy vehicle mode share, trip length in distance, air pollution emission, and total and per capita GHG emission. Quantitative data for safety is almost unavailable and environmental justice is discussed separately in the next section. Table 5-1 shows the list of key performance measures and their definitions. In the case of lacking data, I used other available variables to obtain these performance measures. Average travel speed is VMT divided by the vehicle hours traveled (VHT). Average vehicle trip length is VMT divided by the total number of auto trips.

A plan that brings about change is an indication of effectiveness. Effectiveness is measured in two ways: the change between the baseline condition and the adopted scenario and the change between the adopted scenario and the trend scenario. I measure effectiveness as the range of each performance measure across each MPO's planning scenarios and also as the change in each performance measure from current conditions. Equation 1 is applied to calculate the percent change between scenarios. The results would identify the amount of change in the performance measures and provide some evidence to answer whether some MPOs are more effective than others. The desired change direction of key performance measures is illustrated in Table 5-1.

$$\%\text{ change of scenario b from scenario a of MPO 1} : \frac{\text{value of scenario b of MPO1-value of scenario a of MPO1}}{\text{value of scenario a of MPO1}} \times 100$$

Equation 2

Table 5-1 Universally Reported Quantitative Performance Measures

Key Performance Measures	Desired Change Direction	Source of Data
Total Vehicle Miles Traveled The total length of daily motorized trips.	Decrease	Travel Demand Modeling
Vehicle Miles Traveled per Capita The total length of daily motorized trips divided by population.	Decrease	
Single Occupancy Vehicle Mode Share Percentage of daily trips carried by car.	Decrease	
Trip Length The average length of each trip in distance.	Decrease	
Travel Speed Daily average speed on all links of the network.	Increase	
Vehicle Hours of Delay per Capita The difference between predicted travel time and travel time under free-flow condition divided by population.	Decrease	
Total Air Pollution Emission (PM10, PM2.5, CO, Ozone) A daily ton of pollution emitted by on-road vehicles.	Decrease	Pollution Emission Modeling
Air Pollution Emission (PM10, PM2.5, CO, Ozone) per Capita A daily gram of pollution emitted by on-road vehicles divided by population.	Decrease	
Total GHG Emission An annual ton of CO2 emitted by on-road vehicles.	Decrease	
GHG Emission per Capita A daily gram of CO2 emitted by on-road vehicles divided by population.	Decrease	

5.3 Equity

MPOs receive federal funding, thus, they are responsible for involving the communities of concern including low-income people and people of color in the transportation planning (Karner and Niemeier 2013). Each LRTP has a separate chapter/document/appendix for environmental justice analysis. In the absence of a clear place for justice studies, I scanned the entire plan and appendices of each LRTP to find data on environmental justice. Our initial review shows that a specific analytical standard to guide MPOs on environmental justice has not been established (Karner and Niemeier 2013). However, some general patterns exist. In general, justice analyses hold a spatial review of environmental exposures that start by identifying the target population and defining a particular percentage as a threshold for determining whether an areal unit is considered to be a group of concern. A set of metrics then determines if an action supports equity or has any impact on justice groups. Communities of concerns can be heavily influenced by transportation plans in terms of safety, accessibility (Karner and Niemeier 2013; Preston and Rajé 2007), mobility (Manaugh et al., 2015; Preston & Rajé, 2007), and air and noise pollution (Maantay, 2001; Tayarani, Poorfakhraei, Nadafianshahamabadi, & Rowangould, 2016). I extracted quantitative data on environmental justice when it is available. For LRTPs which have a qualitative analysis on environmental justice, I review them to see whether MPOs include a demographic profile of the communities of concern; if they use an analytical process, for example, ArcGIS and mapping; whether they illustrate how their proposed plan affects the low-income population and other protected groups; and if they consider mobility, accessibility, and safety effects of planning scenarios on these communities. The results provide evidence on whether, and how, MPOs consider social equity in their LRTPs.

5.4 Results

5.4.1 Planning Performance Outcomes

5.4.1.1 Value of Performance Measures

Table 5-2 provides the summary statistics of key performance measures for each planning scenarios: base, adopted, and trend; showing considerable diversity in both current and future values. In general, transportation systems are not expected to perform better than the baseline condition with respect to VMT per capita, trip length, and travel speed. However, the adopted scenarios do better than the baseline conditions with respect to GHG emission per capita, air pollution per capita, VHD per capita, and share of car use. Adopted scenarios also work better than no build scenarios with respect to all performance measures except the average trip length that is diminished in the trend scenario compared to the adopted scenario. Overall, total VMT is about 2.35 billion in the current term which will be increased to 3.16 and 3.17 billion in the adopted and trend scenarios. Total GHG emissions are around 284.7 million tons per year in the current condition and will slightly decrease to 273.9 million under the adopted scenarios but will increase to 312.4 million under the no-build scenarios.

Table 5-2 Value of Performance Measures

Performance Measures	Scenario	Mean	Median	Standard Deviation	Interquartile Range	Total
VMT per Capita	Base	24.35	24.74	6.29	7.98	-
	Adopted	25.45	25.70	6.55	8.39	-
	Trend	25.45	25.65	6.55	8.60	-
GHG Emission per Capita (Kg/Day)	Base	14.19	13.83	5.86	5.78	-
	Adopted	10.21	9.55	4.81	3.95	-
	Trend	11.76	10.43	6.52	4.40	-
Trip Length (Mile)	Base	7.88	7.30	1.77	2.15	-
	Adopted	8.15	7.90	2.08	2.68	-
	Trend	8.00	7.93	2.32	2.04	-
Travel Speed (MPH/Hour)	Base	38.99	38.23	7.38	11.24	-
	Adopted	35.92	35.58	7.91	11.32	-
	Trend	33.99	34.02	8.77	10.51	-
Car Use (% Mode Share)	Base	74.31	81.00	15.20	12.46	-
	Adopted	62.19	50.45	21.40	44.03	-
	Trend	62.52	52.77	21.63	42.73	-
VHD per Capita (Minutes/Day)	Base	9.00	4.39	19.50	6.10	-
	Adopted	8.75	6.70	9.81	9.80	-
	Trend	13.50	9.30	16.10	11.90	-
Ozone[c] per Capita (Gram/Day)[a]	Base	36.55	21.87	53.02	22.40	-
	Adopted	14.31	7.44	27.39	8.59	-
PM10 per Capita (Gram/Day)[a]	Base	21.96	10.01	26.87	16.14	-
	Adopted	18.01	7.18	20.50	14.32	-
PM2.5 per Capita (Gram/Day)[a]	Base	1.41	1.24	1.04	0.68	-
	Adopted	0.67	0.62	0.42	0.39	-
CO per Capita (Gram/Day)[a]	Base	36.55	21.87	53.02	22.40	-
	Adopted	14.31	7.44	27.39	8.59	-
Total VMT/Day	Base	33,088,951	-	-	-	2,350,930,000[b]
	Adopted	46,898,494	-	-	-	3,160,292,781[b]
	Trend	47,399,607	-	-	-	3,170,714,191[b]
	Base	6,169,433	-	-	-	284,697,579[b]

Total GHG Emission (Annual Metric Ton)	Adopted	5,857,134	-	-	-	273,891,425[b]
	Trend	5,880,853	-	-	-	312,431,490[b]
Total Ozone[c] (Ton/Day)[a]	Base	53.00	-	-	-	2,650
	Adopted	22.10	-	-	-	1,105
Total PM10 (Ton/Day)[a]	Base	20.93	-	-	-	293
	Adopted	26.37	-	-	-	369
Total PM2.5 (Ton/Day)[a]	Base	2.29	-	-	-	82
	Adopted	1.51	-	-	-	54
Total CO (Ton/Day)[a]	Base	272.97	-	-	-	7,097
	Adopted	172.41	-	-	-	4,483

[a]Air pollution emissions are taken from conformity reports which typically include adopted scenarios, not trend scenarios.
[b] Only include LRTPs which have information for all three scenarios: base, trend, adopted.
[c]NOx

5.4.1.2 Change in Performance Measures

Table 5-3 presents the relative change of key performance measures between different planning scenarios which is supplemented by a set of charts. Two charts are shown for each key performance measure: %change between the adopted scenario and the base condition and %change between the adopted scenario and the trend scenario. Each bar represents one MPO, and the value shows the percentage difference between the two scenarios. The color and width of each bar show the quartile of the performance measure at the baseline and current population, respectively.

Table 5-3 Percent Change of Key Performance Measures Between Planning Scenarios

Performance Measures	Scenarios	Mean	Median	Standard Deviation	Interquartile Range
VMT per Capita	Adopted-Base	3.03	1.86	11.80	14.28
	Trend-Base	5.71	2.61	12.03	15.21
	Adopted-Trend	-0.66	-0.08	4.50	2.39
GHG Emission per Capita	Adopted-Base	-25.9	-26.34	14.45	18.03
	Trend-Base	-19.82	-20.69	21.52	26.81
	Adopted-Trend	-5.53	-1.09	12.54	6.37
Trip Length	Adopted-Base	1.70	1.35	7.74	6.94
	Trend-Base	0.13	-0.61	4.96	8.14
	Adopted-Trend	-0.33	0.12	3.69	2.78

Travel Speed	Adopted-Base	-6.71	-5.09	8.66	6.78
	Trend-Base	-11.71	-6.76	14.26	14.40
	Adopted-Trend	6.68	3.31	13.57	8.86
Car Use	Adopted-Base	-2.24	-1.35	10.01	3.47
	Trend-Base	-0.60	-0.45	9.73	2.47
	Adopted-Trend	-1.15	-0.45	1.86	1.21
VHD per Capita	Adopted-Base	109.58	59.81	134.19	141.65
	Trend-Base	170.17	127.31	168.25	173.6
	Adopted-Trend	-19.08	-16.90	17.85	29.19
Ozone[b] per Capita[a]	Adopted-Base	-65.55	-64.24	12.8	14.25
PM10 per Capita (Gram/Day)[a]	Adopted-Base	-16.95	-17.02	14.08	10.79
PM2.5 per Capita (Gram/Day)[a]	Adopted-Base	-49.01	-53.96	19.4	29.3
CO per Capita (Gram/Day)[a]	Adopted-Base	-53.92	-53.88	17.88	21.87
Total VMT/Day	Adopted-Base	38.08	33.27	27.59	30.65
	Trend-Base	40.2	35.69	29.31	27.06
	Adopted-Trend	-0.65	-0.15	4.49	2.59
Total GHG Emission (Annual Metric Ton)	Adopted-Base	0.82	-2.84	28.00	31.63
	Trend-Base	8.72	0.07	34.58	42.77
	Adopted-Trend	-4.16	-1.09	10.22	4.86
Total Ozone[b] (Ton/Day)[a]	Adopted-Base	-54.9	-53.96	15.86	20.77
Total PM10 (Ton/Day)[a]	Adopted-Base	28.64	24.24	26.26	16.74
Total PM2.5 (Ton/Day)[a]	Adopted-Base	-33.39	-37.9	27.12	39.54
Total CO (Ton/Day)[a]	Adopted-Base	-33.86	-35.5	31.37	36.19

[a]Air pollution emissions are taken from conformity reports which typically include adopted scenarios not trend scenarios.
[b] NOx

5.4.1.2.1 Vehicle Miles Traveled per Capita

VMT per capita, on average, is projected to increase under the adopted scenarios by 3% from the baseline (Table 5-3). Only 43% of LRTPs result in lower VMT per capita and 57% of LRTPs lead to higher VMT per capita than today's (Figure 5-1). Table 5-3 shows that the adopted scenarios work better than the trend scenarios by generating 0.6% less VMT per capita, on average. Figure 5-1B shows that 41% of the adopted scenarios result in higher VMT per capita when compared to the trend scenarios. VMT per capita is expected to reduce in the adopted scenarios over the trend scenarios by 59% of LRTPs.

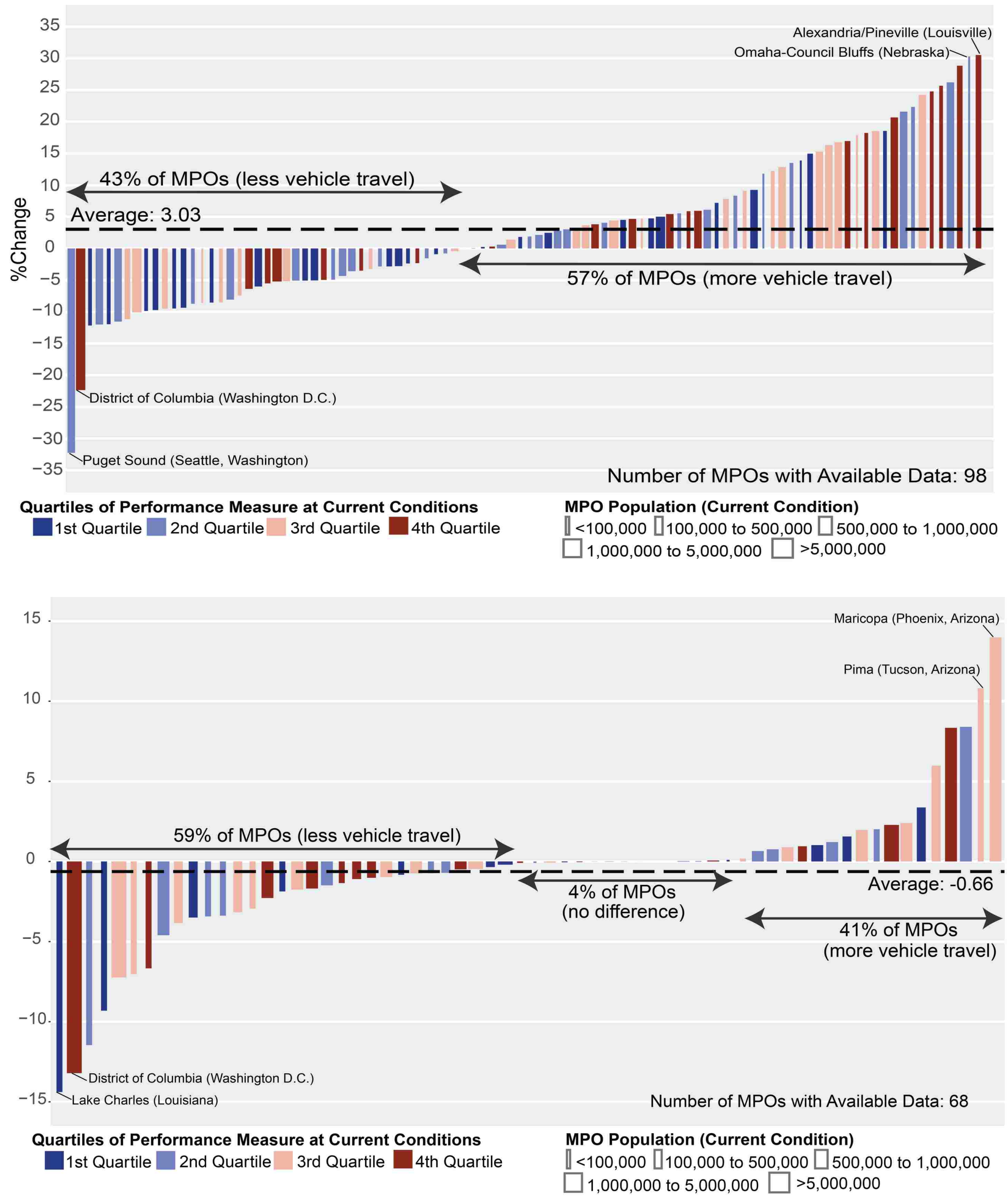
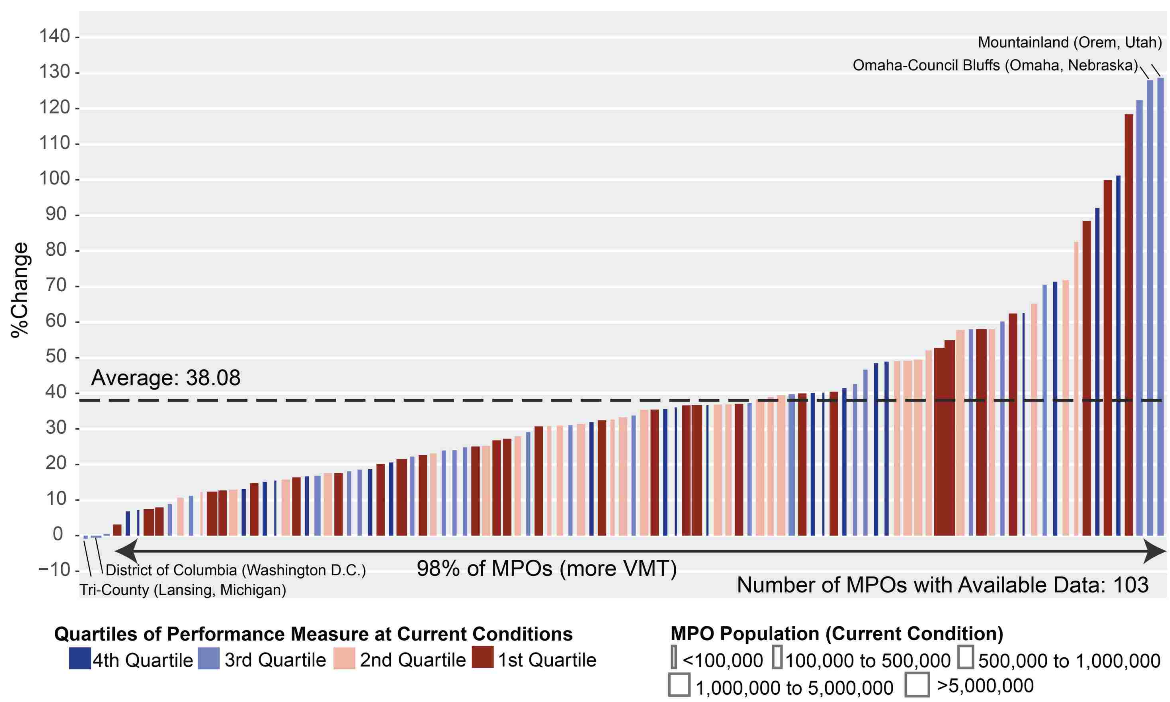


Figure 5-1 Percent Change in VMT per Capita: A) Adopted-Base, B) Adopted-Trend

5.4.1.2.2 Total Vehicle Miles Traveled

Based on Table 5-3, looking ahead to the future, total VMT is expected to increase significantly with a mean of 38%. Figure 5-2A shows that the predominant direction of the percent of change in total VMT from base to adopted scenarios is upward and except two LRTPs, 98% of LRTPs which of VMT data is available result in more congestion. The percent change in total VMT is above 100% for four LRTPs. The adopted scenario results in a 128% increase in total VMT compared to the current condition while it shows only a 1.1% improvement over the do-nothing scenario. Based on Table 5-3, the adopted scenarios will lessen the total VMT by only 0.65% compared to the trend scenarios, on average. However, Figure 5-2B shows that the results are mixed. Some MPOs achieve lower total VMT (61%), some achieve small and even zero reduction and some MPOs achieve larger total VMT under their adopted scenarios compared to the trend scenarios (39%).



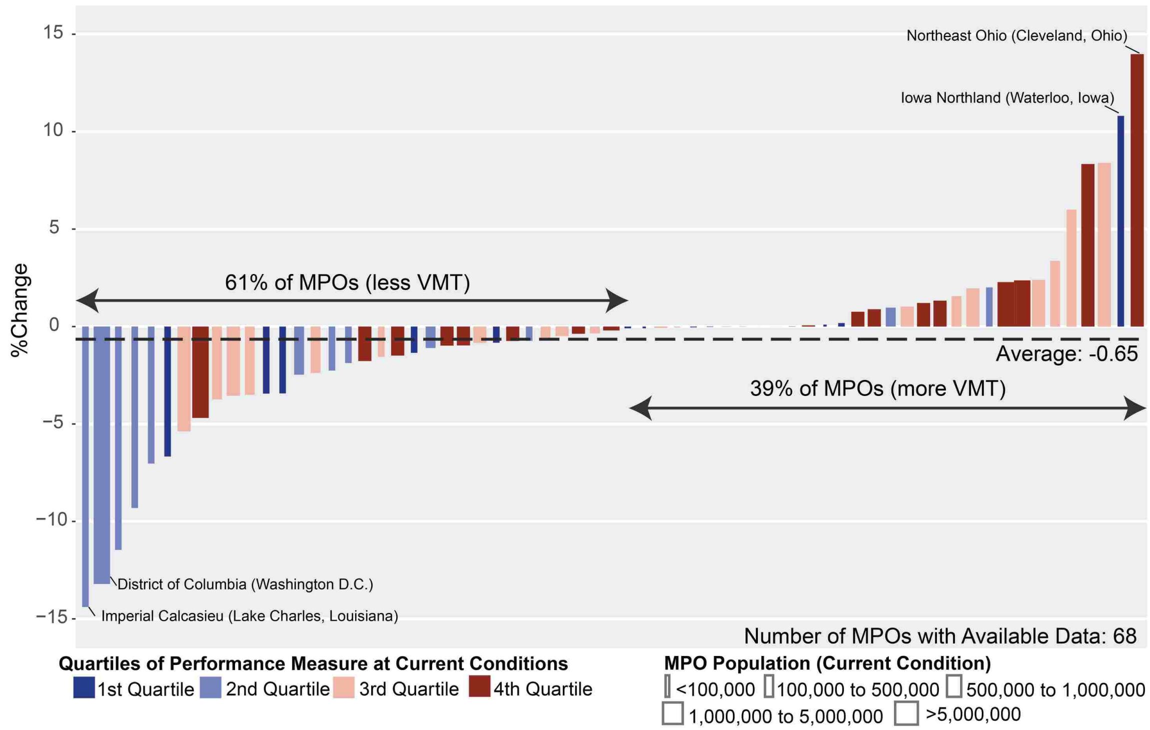


Figure 5-2 Percent Change in Total VMT: A) Adopted-Base, B) Adopted-Trend

5.4.1.2.3 Greenhouse Gas Emission per Capita

Based on Table 5-3, the adopted scenarios make a significant improvement in GHG emission per capita, by a mean of 26% reduction over the status quo. However, the do-nothing scenarios also result in a 20% reduction in GHG emission per capita in average, reveals that these reductions are mostly attributed to the new fuel and vehicle technologies instead of strategies adopted in the regional transportation plans. As Figure 5-3A illustrates, 98% of MPOs create plans that will avoid more GHG emission per capita and only two scenarios result in higher levels than today. My analysis supports that GHG per capita will reduce by a norm of 5.5% under the adopted scenarios compared to the trend scenarios (Table 5-3). Figure 5-3B shows that 75% of LRTPs result in fewer GHG emission than the no-build scenarios while 25% of LRTPs result in higher GHG emission.

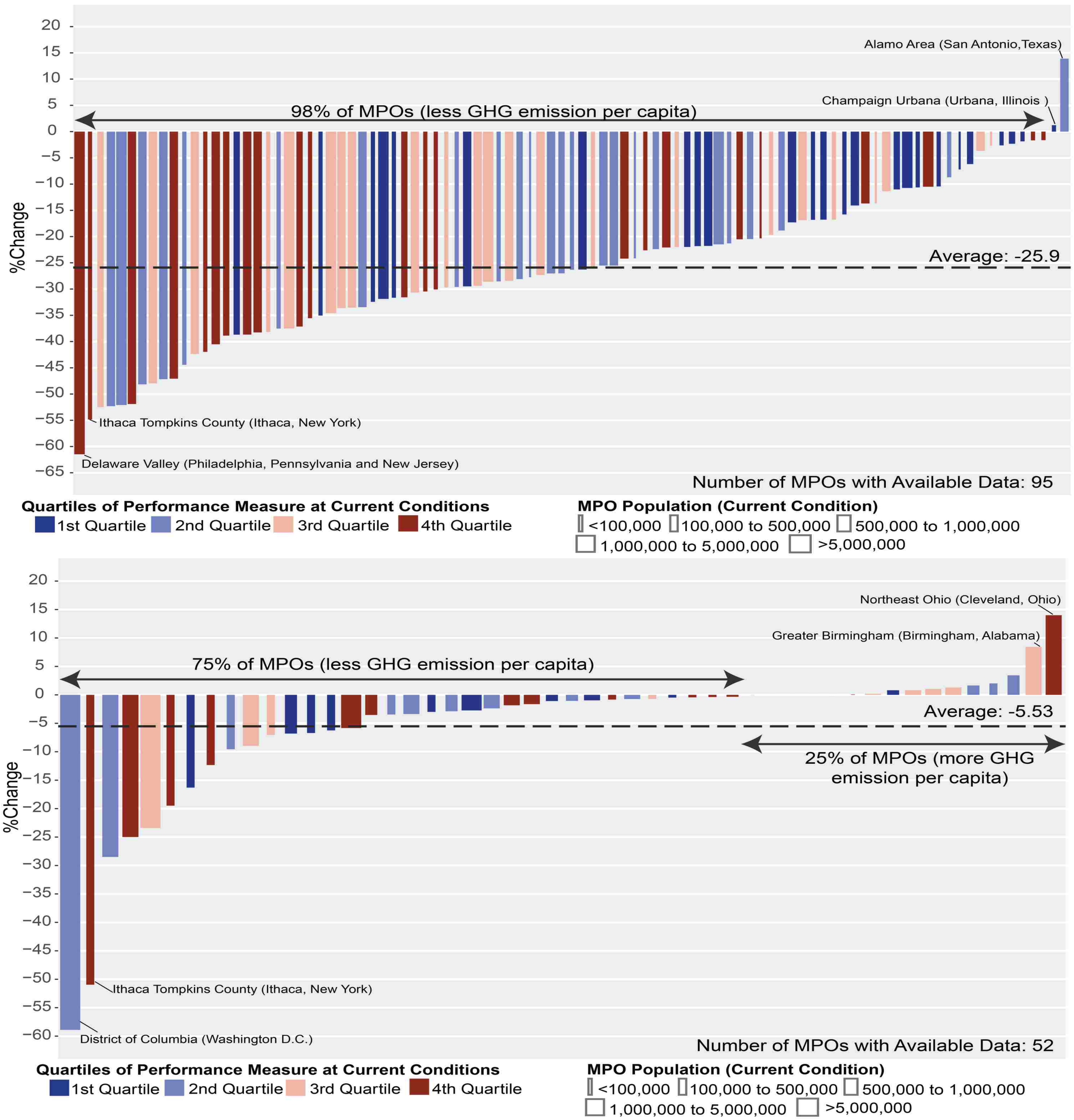
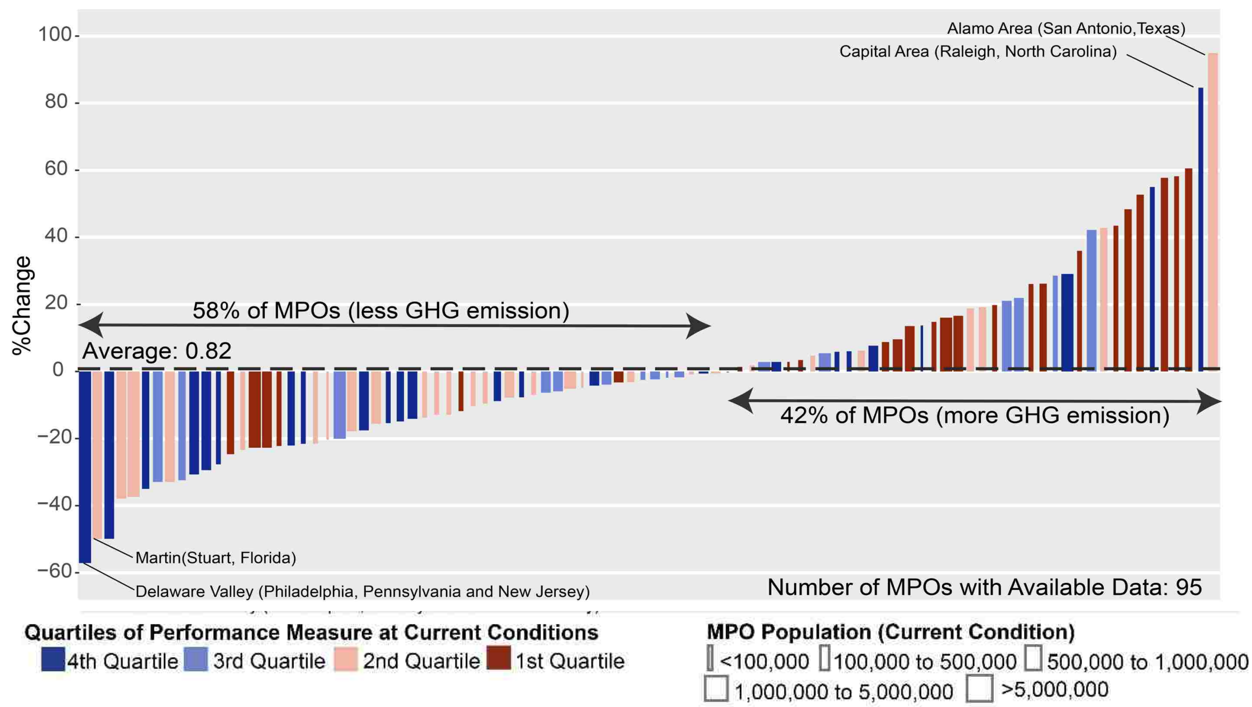


Figure 5-3 Percent Change in GHG Emission per Capita: A) Adopted-Base, B) Adopted-Trend

5.4.1.2.4 Total Greenhouse Gas Emission

As shown in Table 5-3, the adopted plans result in a 0.82% growth in total GHG emission as compared to the base condition, on average. Nevertheless, based on Figure 5-4A, the percent change between base and build scenarios is mixed. Some MPOs achieve total

GHG reductions over adopted scenarios, i.e. negative percent change (58%), and a significant portion of others expect increases (42%). Adopted scenarios show 4% lower total GHG emission as compared to the trend scenarios, based on Table 5-3. As Figure 5-4B shows, 75% of adopted scenarios generate less total GHG emission than the no-build scenarios while 25% of them attain a higher level of GHG emissions.



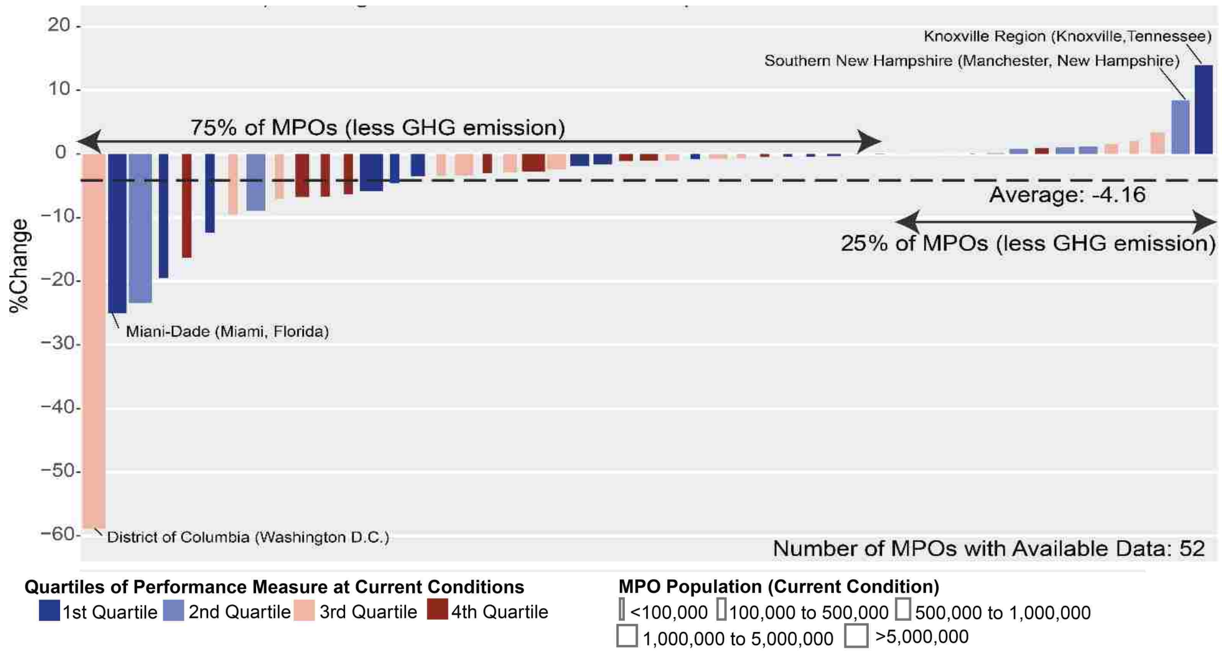
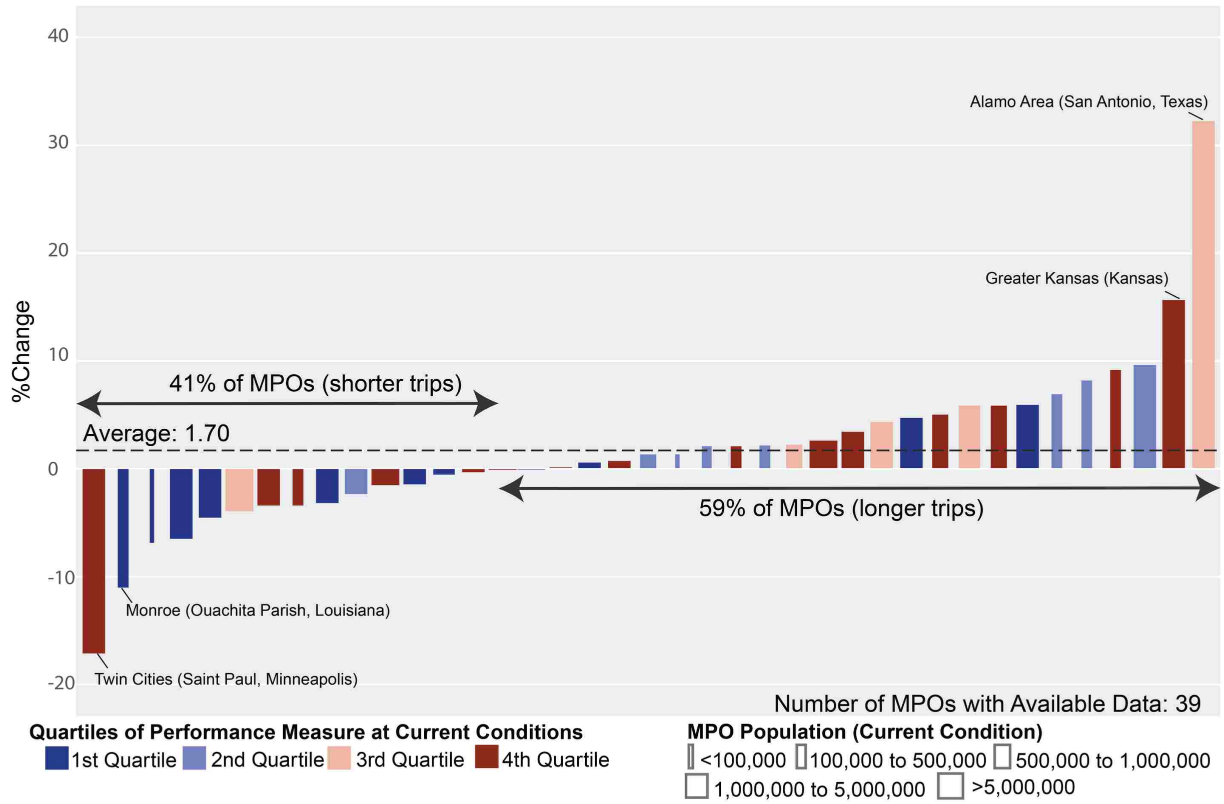


Figure 5-4 Percent Change in Annual GHG Emission: A) Adopted-Base, B) Adopted-Trend

5.4.1.2.5 Trip Length

With respect to average trip length, the adopted scenarios are expected to increase the length of trips by 1.7 percent as compared to the current conditions. Figure 5-5A indicates that 59 percent of the adopted scenarios lead to longer trips in the future by a percent change range between 0.2% to 32%. The adopted scenarios show a 0.33% reduction in trip length as compared to the trend scenarios. Nevertheless, 55% of plans result in longer trips than do nothing scenarios (Figure 5-5B).



40
30
20
10
0
-10
-20
%Change
Alamo Area (San Antonio, Texas)
Greater Kansas (Kansas)
41% of MPOs (shorter trips)
Average: 1.70
59% of MPOs (longer trips)
Monroe (Ouachita Parish, Louisiana)
Twin Cities (Saint Paul, Minneapolis)
Number of MPOs with Available Data: 39
Quartiles of Performance Measure at Current Conditions
1st Quartile
2nd Quartile
3rd Quartile
4th Quartile
MPO Population (Current Condition)
<100,000
100,000 to 500,000
500,000 to 1,000,000
1,000,000 to 5,000,000
>5,000,000

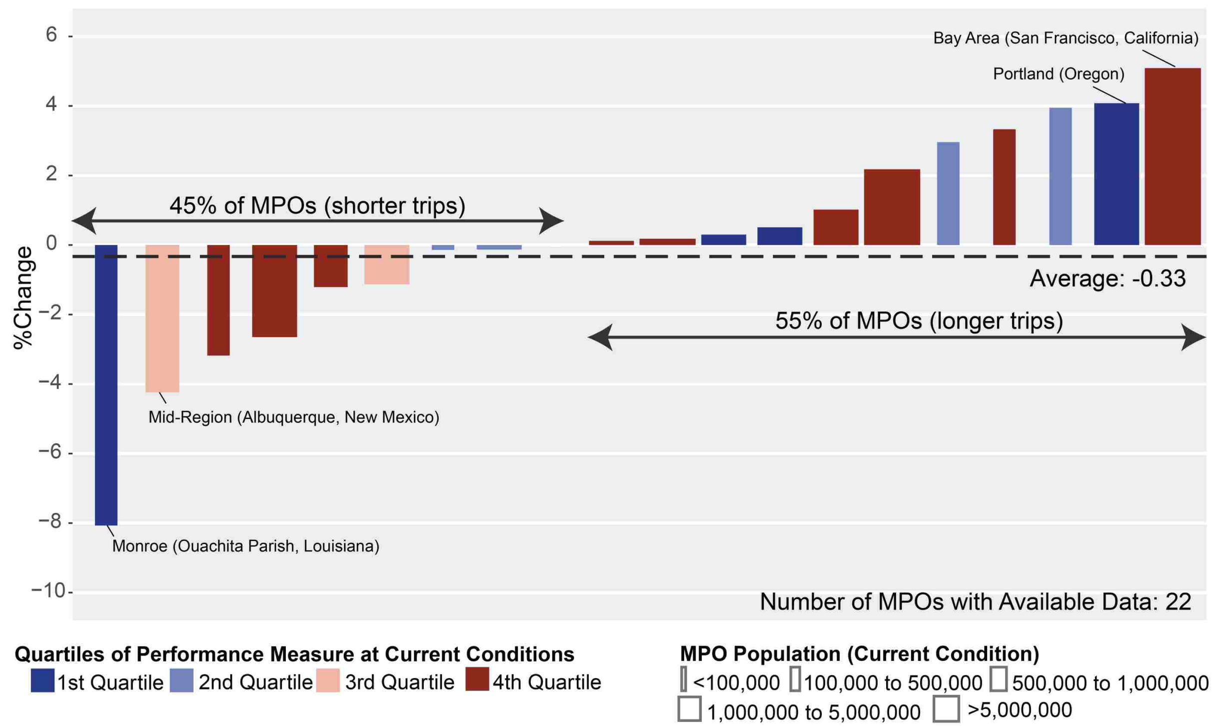


Figure 5-5 Percent Change in Trip Length: A) Adopted-Base, B) Adopted-Trend Scenario

5.4.1.2.6 Vehicle Hours of Delay per Capita

Table 5-3 shows that VHD per capita will increase by nearly 110% over the current conditions. Figure 5-6A indicates the expected VHD per capita for the adopted scenarios compared to the baseline scenarios. The figure shows that few MPOs (17%) include scenarios that have fewer hours of delay than the baseline and 83% of scenarios result in an increase of travel delay ranging from 1% to 550%. As Table 5-3 shows, adopted scenarios are projected to reduce VHD per capita by 19% compared to the trend scenarios. Based on Figure 5-6B, all but three plans represent an improvement over the trend scenarios.

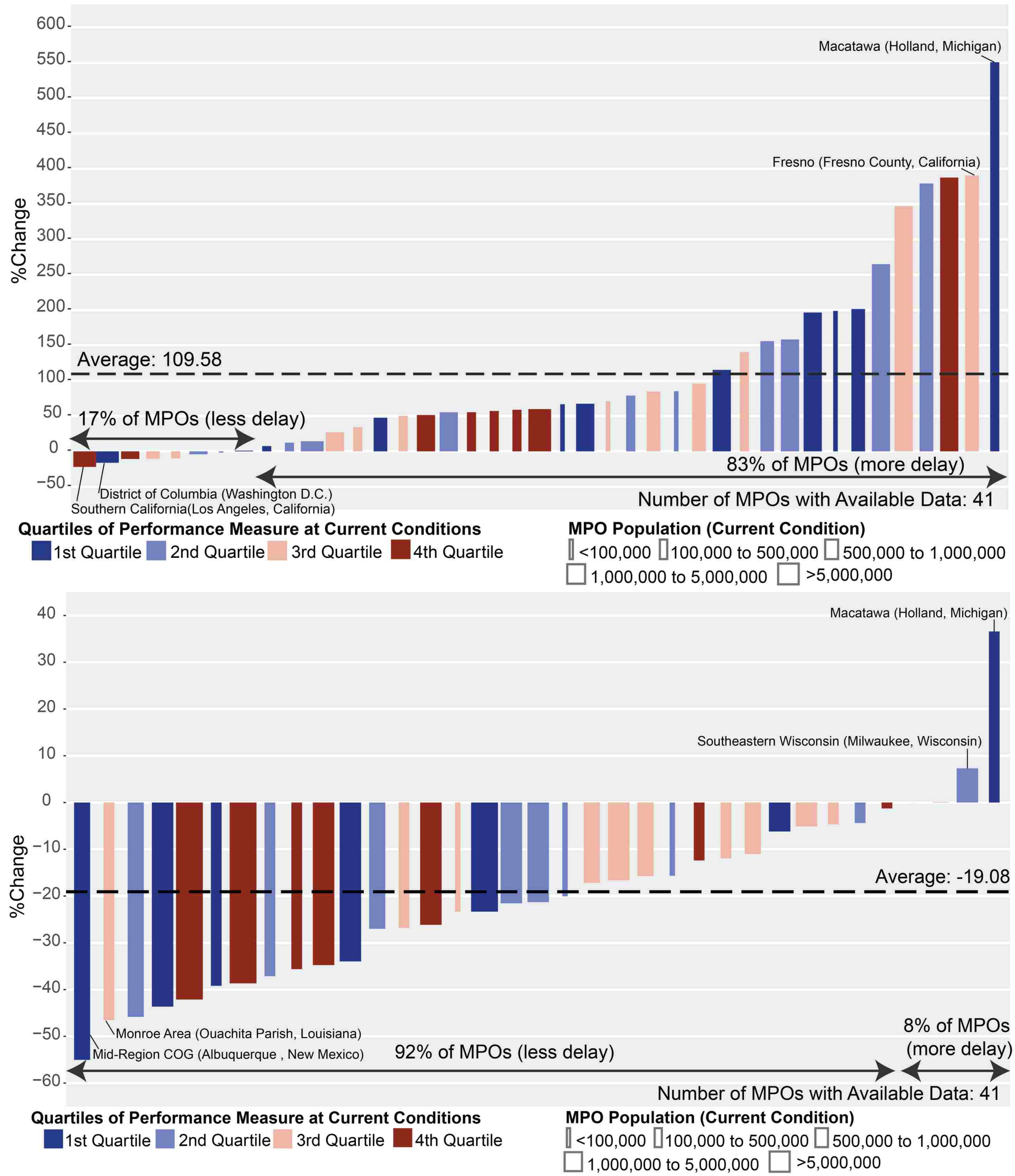
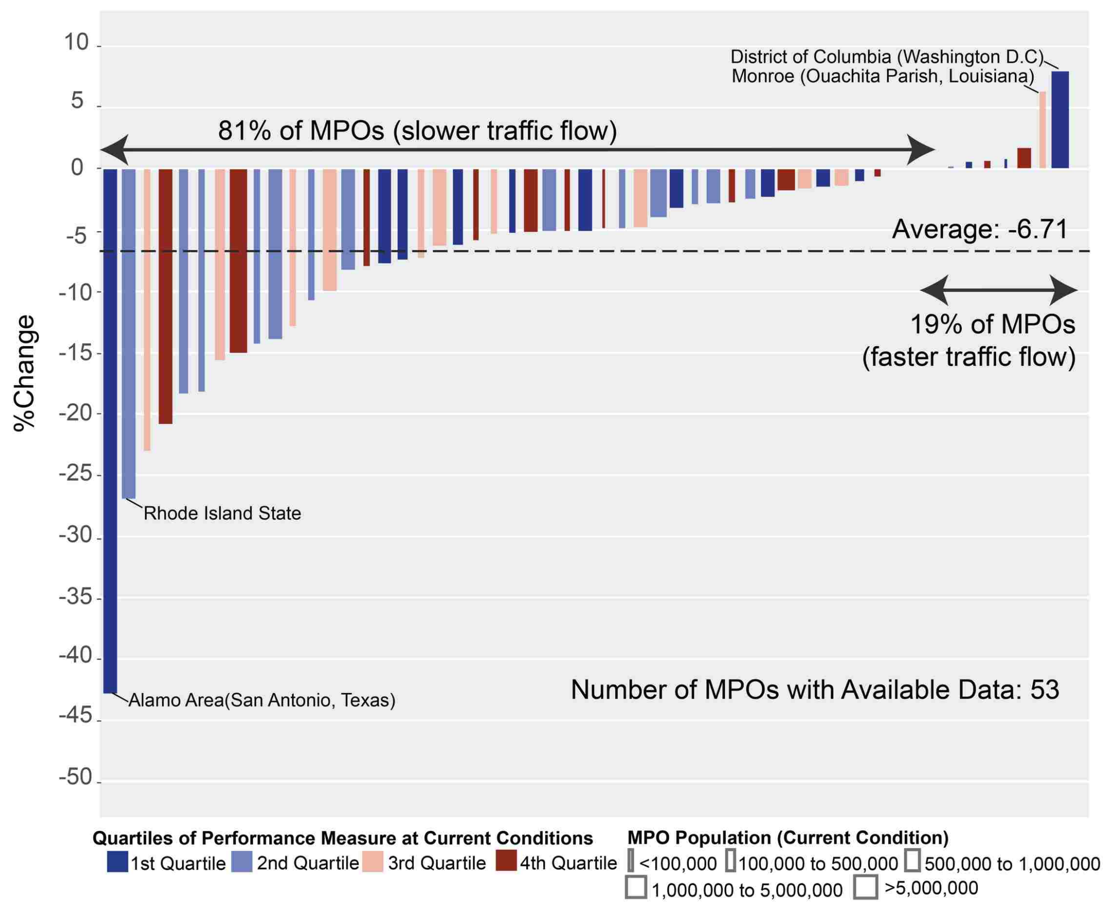


Figure 5-6 Percent Change in VHD per Capita: A) Adopted-Base, B) Adopted-Trend Scenario

5.4.1.2.7 Average Travel Speed

Table 5-3 indicates that average travel speed declines by nearly 7 percent under the adopted scenarios over the current condition. Figure 5-7A represents the variation in a percent difference between adopted and base scenarios across MPOs. Although 19% of LRTPs indicated increased speed, the predominant direction of speed change is downward and 81% of MPOs prepared a plan with slower traffic flow ranging from 0.04% to 42% decrease. Based on Table 5-3, average travel speed is projected to increase by nearly 7.5% in the adopted scenarios compared to the trend scenarios.



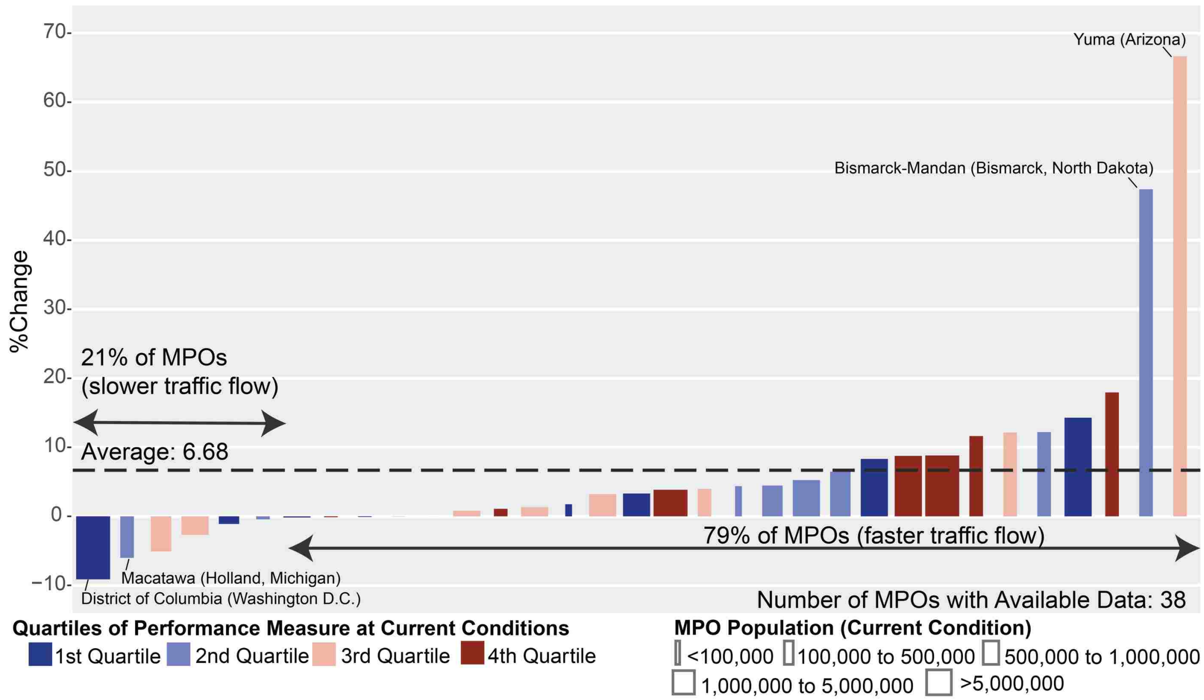


Figure 5-7 Percent Change in Average Travel Speed: A) Adopted-Base, B) Adopted-Trend Scenario

5.4.1.2.8 Car Use

The adopted plans would result in a 3.4% reduction in driving alone mode share, compared to current levels (Table 5-3). Except for 20% of LRTPs, the car mode share would improve under 80% of the adopted scenarios. Ideally, less car use share shows that more commuters choose the options over driving alone, further reducing VMT and air pollution (Figure 5-8). Table 5-3 indicates that a moderate 1.2% decrease in driving alone mode share is expected in the adopted scenarios as compared to the trend scenarios. Figure 5-8 shows that 77% of the adopted scenarios result in less car use share and 16 percent of them are not different than the trend scenarios.

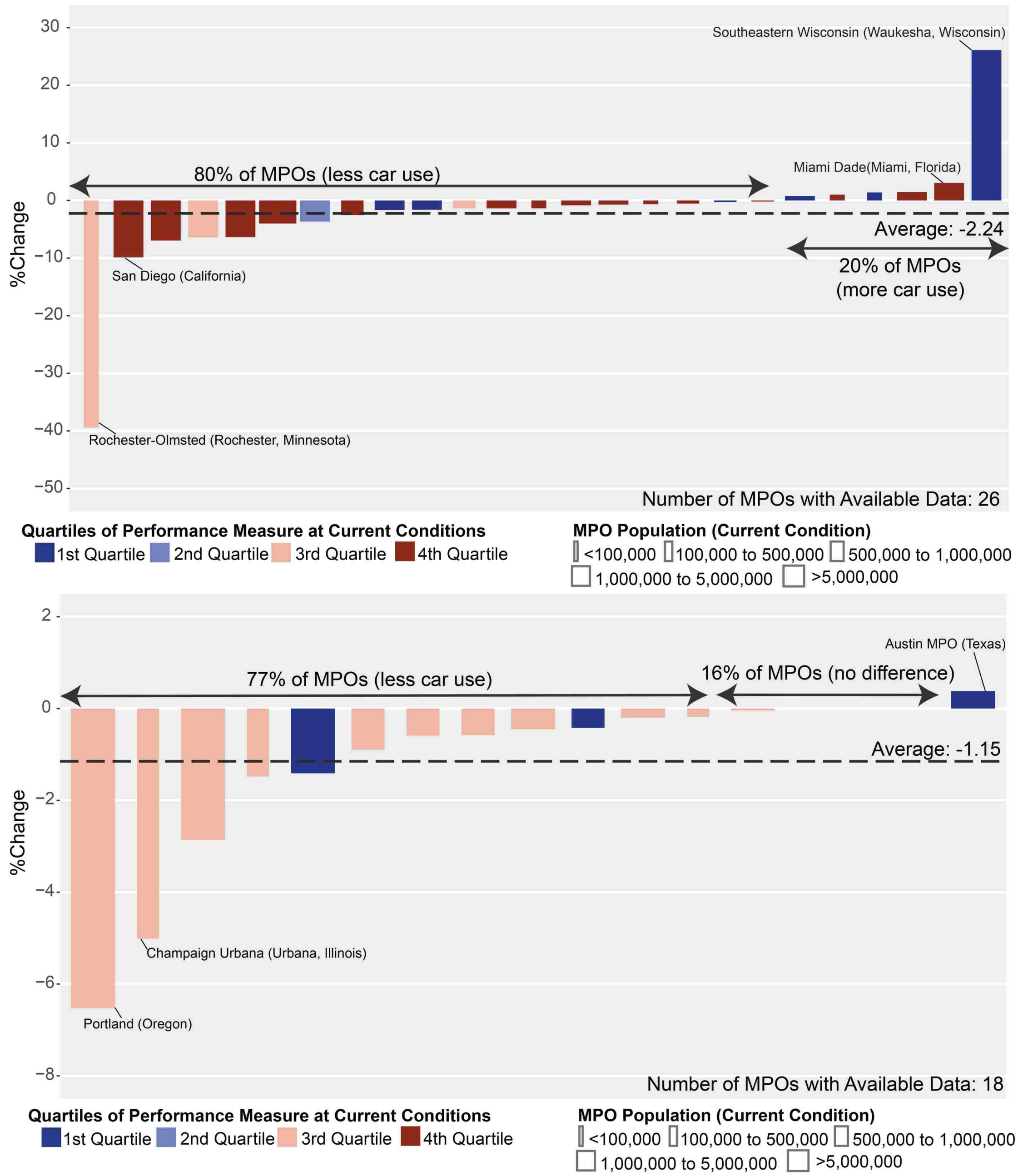


Figure 5-8 Percent Change in Car Use Share: A) Adopted-Base, B) Adopted-Trend Scenario

5.4.1.2.9 Criteria Air Pollution

Table 5-3 shows that total ozone emission will reduce in the future by an average of 55%, and per capita ozone decline by 65%. Figure 5-9 shows the range of variation in ozone emission, compared to the base condition which is all positive.

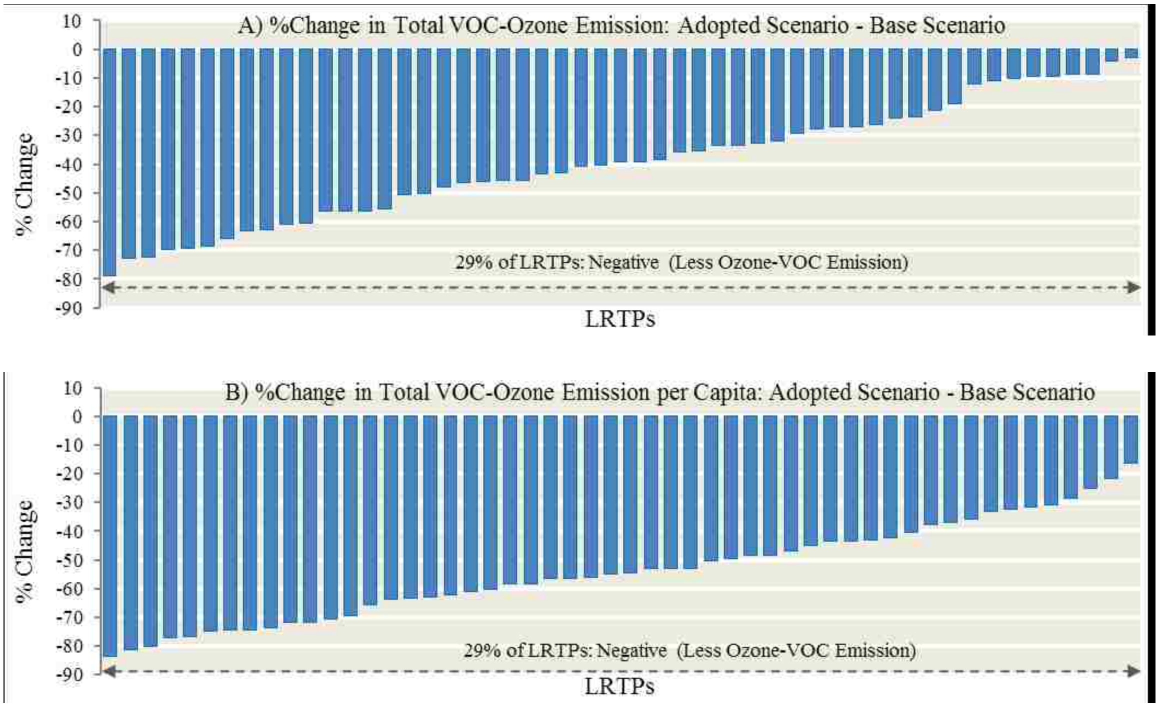
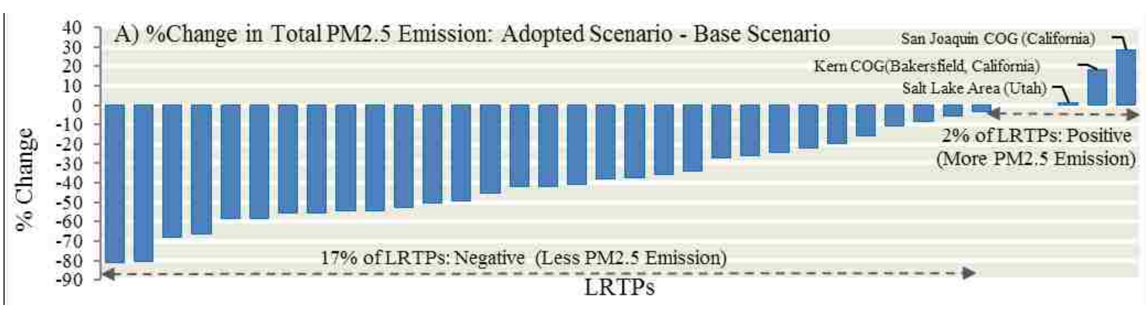


Figure 5-9: Percent Change in Ozone Emission: A) Total, B) per capita

Table 5-3 shows that total PM2.5 reduces by an average of 49% in the future. PM2.5 per capita decreases by an average of 33%. Based on Figure 5-10, except three MPOs which result in higher total PM2.5 emission (though less than emission budget), all others show a reduction. Emission of PM2.5 per capita would also decrease for all adopted scenarios.



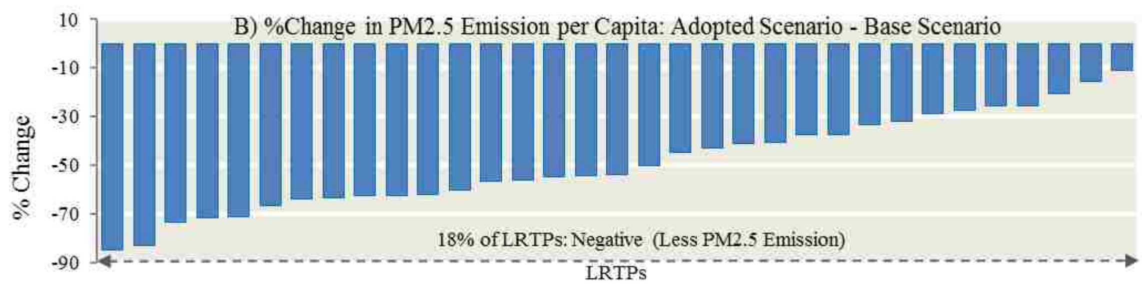
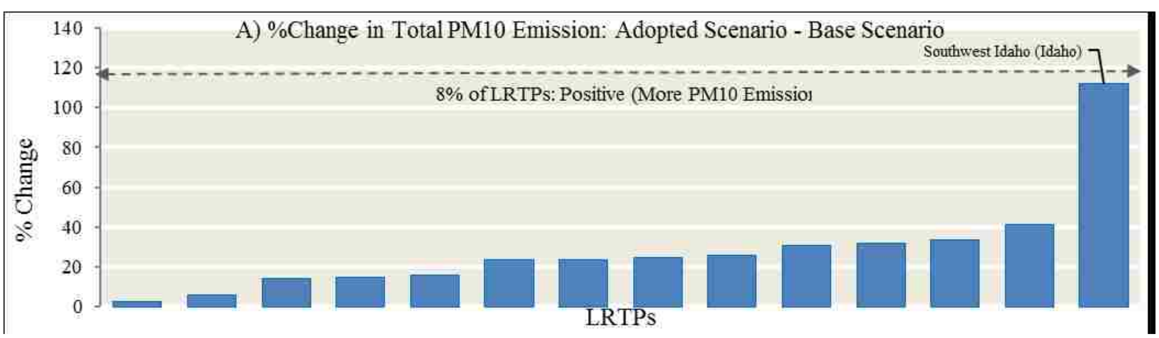


Figure 5-10: Percent Change in PM2.5 Emission: A) Total PM2.5, B) PM2.5 per capita

PM10 emission per capita will be decreased by about 17% on average under the adopted scenarios compared to the base conditions (Table 5-3). Based on Figure 5-11, PM10 per capita decreases under all MPOs adopted plans except one MPO. Total PM10 emission will increase by about 28.6% on average under the adopted scenarios compared to the baseline. Figure 5-11 represents the range of variation in total PM10 emission, compared to the baseline. The predominant direction is upward (more PM10 emission in the future), while all MPOs meet the budget line.



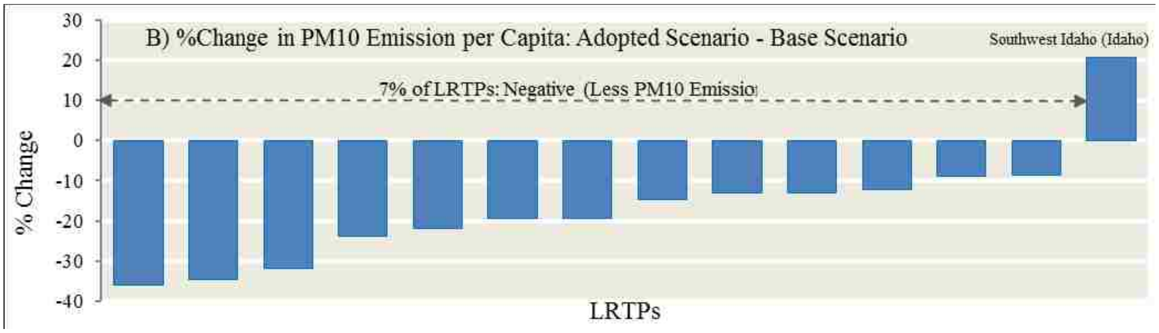
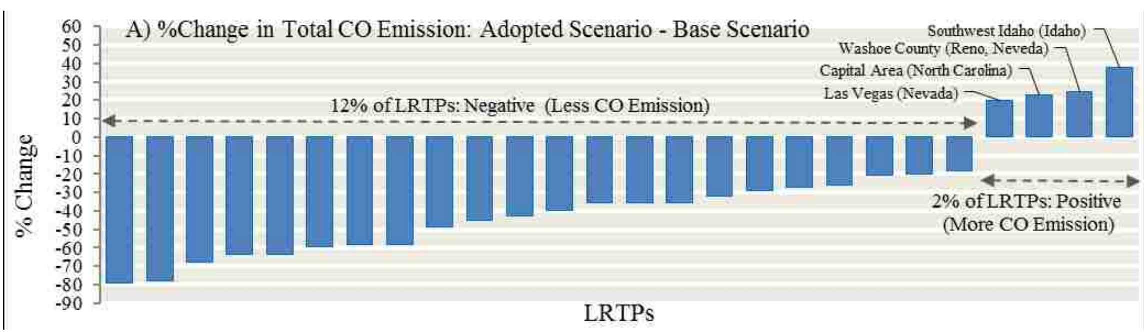


Figure 5-11: Percent Change in PM10 Emission: A) Total PM10, B) PM10 per Capita

Table 5-3 shows that the adopted scenarios make improvement in total CO emission by 33.9% reduction relative to the status quo. Figure 5-12 shows that 12% of LRTPs reduce total CO emission while 2% of LRTPs make an increase ranging from 20% to 38%. CO per capita will reduce by 54% in the future, on average. CO per capita will reduce under all MPOs' future plans.



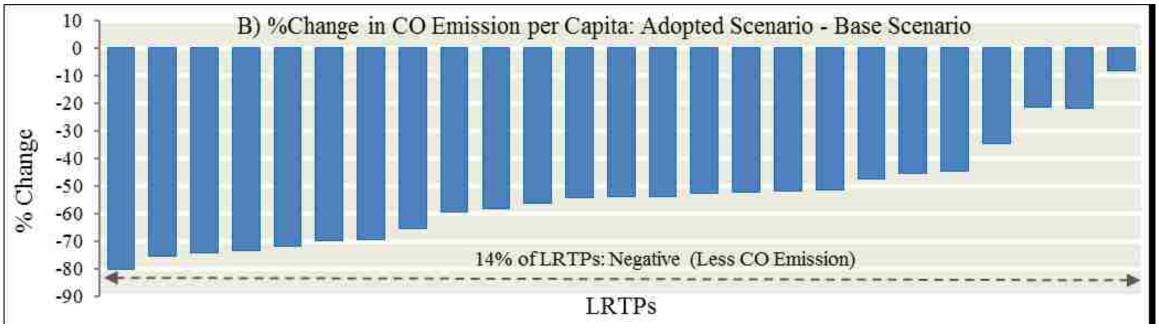


Figure 5-12: Percent Change in CO Emission: A) Total CO, B) CO per Capita

5.4.1.2.10 Equity

I find that 86 percent of MPOs analyzed environmental justice, in their plans, in which 78 percent of them include a demographic profile of EJ groups such as age, race, ethnic, and income. Mobility measures like the difference in travel time, accessibility measures like access to transit, safety measures such as number of accidents, and sustainability measures such as air pollution are considered by 52%, 49%, 12%, and 11% of MPOs, respectively. To evaluate how new plans could affect communities of concern, 77% of MPOs map where the disadvantaged population lives and where the proposed transportation projects will be located. Only 32 percent of LRTPs include a quantitative analysis to measure the difference in effects on EJ groups vs non-EJ groups.

Figure 5-13 shows the average travel time for EJ groups versus non-EJ groups under base, trend, and adopted scenarios for the LRTPs that this information is available. Overall, average trip travel time is lower for EJ groups versus other people based on eight LRTPs while in three LRTPs of San Antonio in Texas, Oahu in Hawaiian, and Greater Kansas, EJ groups have higher travel time. Comparing different planning scenarios shows that the average travel time for EJ groups decreases in only two LRTPs and increases in six LRTPs and remains constant in the rest of LRTPs under the adopted scenarios compared to the base condition. Figure 5-14 shows the average transit travel time for EJ groups compared to other people. Out of seven MPOs, four MPOs result in longer transit travel time for EJ groups versus non-EJ or all groups in base condition. Comparing the adopted scenarios to the base condition shows that average transit travel time will increase under two LRTPs and will decrease under three LRTPs. Results also show that jobs are more accessible for EJ groups compared to non-EJ groups under six LRTPs out of seven LRTPs. In addition, Figure 5-15 indicates that while four adopted scenarios increase job accessibility, three adopted scenarios result in lower accessibility compared to the base condition. Based on Figure 5-16, the percent of congested VMT is higher for EJ groups compared to others and two out of four MPOs result in higher congestion under the adopted scenarios compared to the base condition while one MPO keeps both base and future values constant.

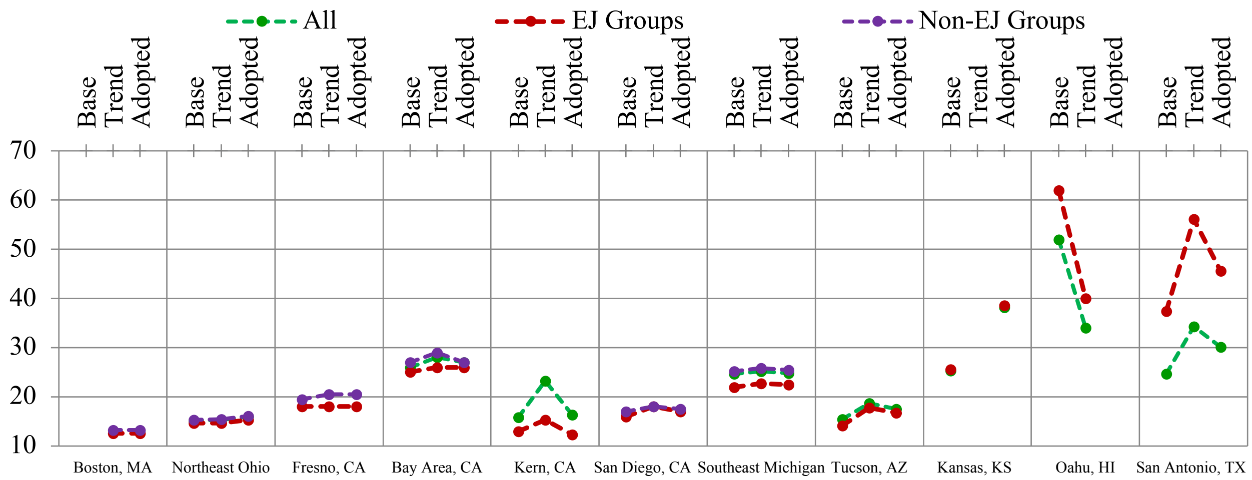


Figure 5-13: Average Car Travel Times (Minutes) for EJ and non-EJ Groups

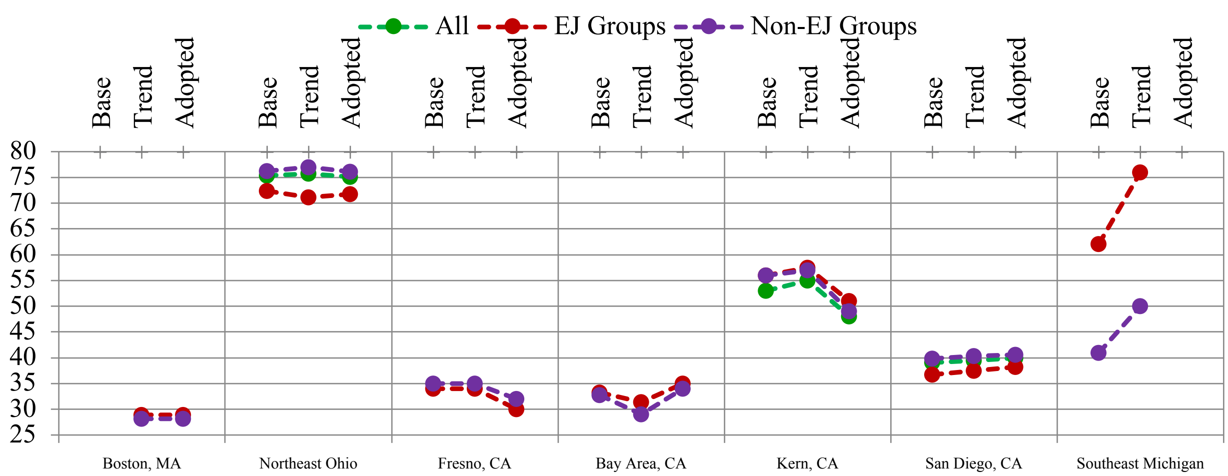


Figure 5-14: Average Transit Travel Times (Minutes) for EJ and non-EJ Groups

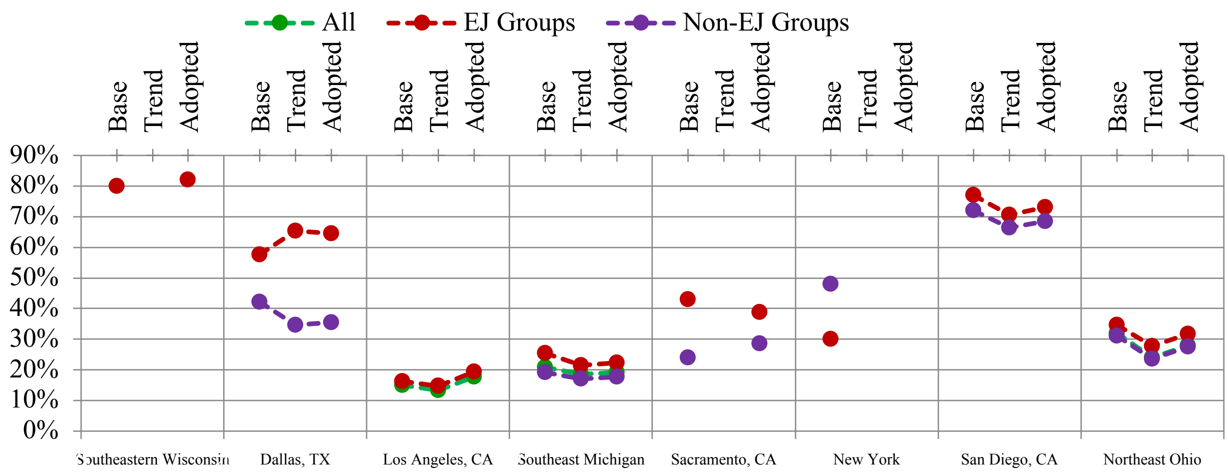


Figure 5-15: Percent of Jobs Within 20-30 Minutes by Automobile for EJ and non-EJ Groups

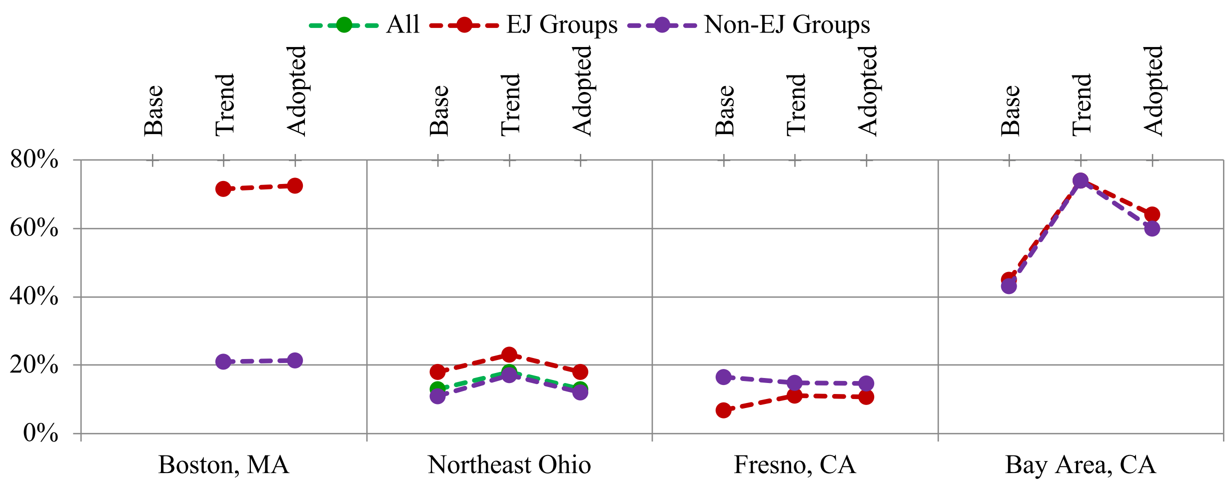


Figure 5-16: Percent of Congested Vehicle Miles Traveled for EJ and non-EJ Groups

5.5 Discussion and Conclusion

In this chapter, I evaluated the effectiveness of regional transportation plans on achieving long-term planning goals. I reviewed a large set of most recent long-range regional plans created by MPOs across the United States, one of the most important policy tools which determine the future investments in the transportation system, a vital element of the daily life of 86% of US population who live in metropolitan areas. I asked one rarely considered, yet critical question: do MPOs create effective long-range transportation plans? Results demonstrate that the current LRTP process often results in plans that are not expected to make much progress towards achieving common goals. In some case, there is no progress at all, for example, most plans predict more congestion in the future than today. This study, in many ways, highlights that the LRTPs established by most metropolitan planning organizations in the United States will result in neither more effective nor more sustainable transportation system than today.

Reviewing LRTPs with the highest growth in VMT per capita shows that their jurisdictions are confronting severe traffic congestion. These MPOs create plans that reduce congestion by a small amount from a do-nothing future scenario, but they do not reduce congestion from today's level. The highest declines in VMT per capita in the future are related to the Puget Sound MPO (Seattle, Washington), District of Columbia, and Chittenden County Regional Planning Commission, by 32%, 22%, and 12%, respectively. The Puget Sound MPO will achieve this benchmark through applying four strategies: land use actions such as job-housing balance, user fees, and roadway pricing, improving accessibility and multimodal transportation, and vehicle and fuel technology. District of Columbia focused on the multimodal transportation infrastructures, programs, and services through the adopted scenario to reduce VMT per capita. In a similar way, the Chittenden County Commission plans to increase transit services via bus and rail in order to enhance the positive trend of 60% increase in transit ridership in the past decade.

32 LRTPs result in under one percent (whether positive or negative) change of VMT per capita between adopted and trend scenarios. For example, Kalamazoo County Transportation Study in Michigan designed a scenario which improves the VMT per capita by only 0.006% over the no-build scenario. This scenario also improves total VHT by only 0.07%. Another example is Greenville-Pickens Area Transportation Study in South Carolina which shows that, except delay, there is almost zero improvements in VMT per capita and VHT comparing no build scenario to build scenarios.

It appears that the highest growth in total VMT in the future as compared to the base year is related to the LRTPs with rapid population growth. For example, Southwest Idaho region serving Ada and Canyon counties in Idaho will experience a 122% growth in total VMT from the base condition and about zero improvements over the trend scenario if all currently funded and unfunded projects were completed while the population will grow by 70%. This scenario also results in a 740% increase in VHD with daily hours of delay going from 27,000 in the base condition to 430,000 hours in the future. The Capital Area (Austin metro area) in Texas will experience 134% growth in population, while total VMT will increase by 118% and VMT per capita will decrease from 25.15 to 23.12 between base condition (2010) and 2040.

Higher total VMT in the future in comparison with trend scenario is related to the LRTPs which proposed adding capacity projects or building new transportation network. For example, the Knoxville Region in Tennessee will experience higher total VMT in the build scenario than no build scenario. The reason is additional system capacity projects which are proposed to reduce VHT and VHD by 9% and 11% and increase average travel speed by 5% while increasing total VMT by 3.4%.

Population growth is attributed to the LRTPs with the highest growth in GHG per capita in the future. MPO of San Antonio and MPO of Urbana Champaign are the MPOs with the highest increase in GHG emission per capita in future. San Antonio in Texas will experience 70% growth in population by 2040. The adopted plan to address this growth leads to a significant increase in total VMT, total VHT, and total VHD by 100%, 251%, and 735% respectively, and a significant decrease in the average travel speed by 43% compared to the baseline condition. This huge increase in the congestion indicators causes 14% increment in GHG emission per person. The adopted scenario developed by the "Champaign Urbana Urbanized Area Transportation Study (CUUATS)" also results in a 1.2% increase in GHG emission over the base condition. According to this plan, the higher GHG emissions are attributed to the higher growth rate of economic activities in the region than both base and trend scenarios.

MPOs which considered strategies to reduce the demand for travel will experience a reduction in GHG per capita in the future. Delaware Valley commission serving Philadelphia in Pennsylvania achieves the highest amount of reduction in GHG per capita by 61% in future over the baseline condition. The plan sets a benchmark of decreasing 2005 GHG emission reduction by 50% by the year 2035 through utilizing strategies such as promoting energy efficiency and reducing the demand for travel.

Total GHG emission increases in the regions that will experience an increase in VMT. Percentage change of total GHG between the base and adopted scenarios is highest in San Antonio in Texas, Capital area in North Carolina, and Omaha-Council Bluffs in Nebraska. The Capital area in North Carolina shows that both total VMT and percent of congested VMT increase while average travel speed decreases in the future which leads to higher total GHG emission. Reduction in GHG emission is highest for Delaware Valley in Pennsylvania, Martin-St. Lucie in Florida, and Hampton Roads MPO serving Chesapeake in Virginia. While total VMT increases in both Martin-St. Lucie and Chesapeake regions, total GHG emissions decrease due to lower emission rate per distance. At the highest level, GHG emission is anticipated to increase in the Knoxville region in Tennessee and Manchester region in New Hampshire by 8% and 15% over the trend scenarios, respectively.

MPOs which emphasize adding capacity projects or building new roadways will experience an increase in VHD while MPOs that focus on non-motorized trips and smart growth strategies will experience a decrease in VHD. Macatawa MPO serving Holland in Michigan has the highest increase in VHD per capita. It proposed a transit scenario with emphasis on non-motorized facilities and transit service areas in addition to capacity enhancement projects to address current congestion. Even after carrying out capacity-enhanced projects, Holland area will see 13% increase in total VMT, 38% increase in total VHT in congestion, 550% increase in VHD per capita, and the number of congested miles continues to increase while average congested travel speed declines by 19%. This scenario also results in a 36% increase in VHD per capita as compared to the trend scenario. The second highest change in VHD per capita belongs to Fresno County in California, which results in a 390% gain over current conditions while it works better in terms of VMT per capita and average travel speed. At the opposite way, Southern

California, serving Los Angles in California proposed a plan to improve daily per capita delay from 11.8 minutes under baseline condition to over 9 minutes under the adopted scenario which focuses on improved transit service and more transit-oriented development patterns. Mid-Region Council of Government serving Albuquerque in New Mexico has the highest reduction in VHD per capita in the adopted scenario over trend scenario. Under the trend scenario, average speed decreases and VHT and VHD increase substantially while the adopted scenario reaches to 55% decline in VHD per capita by focusing on the infill, mixed-use, and transit-oriented development near the existing developed area.

The highest change in car use is related to the LRTPs which include projects on increasing transit and non-motorized trips. Rochester-Olmsted COG serving Rochester in Minnesota proposed a plan which focuses on improving non-motorized and transit trips in downtown. The adopted plan shifts single occupant vehicle mode share from 70% in the status quo to 40% over 20 years and 40% increase in transit trips, 24% increase in biking trips and 16% increase in walking trips. Portland in Oregon shows a 6.5% decrease in car use share under the adopted scenario over the trend scenario. The status quo in the region shows a huge shift in the travel modes towards more transit and non-motorized trips from 1994 to 2011 and the adopted scenario will continue this trend by a set of policies such as reducing transit fares and providing biking and walking facilities. Three MPOs developed their adopted scenarios with zero change over the trend scenarios in terms of driving alone mode share such as Boston MPO serving Boston urban area in Massachusetts. Comparing indicators of the adopted scenario versus no build scenario of Boston LRTP shows only a marginal benefit for the system performance. For example, the percent change of mode share, number of trips, transit trips and auto VMT is zero between build and no build scenario and build scenario improves VHT, speed, congested VMT, and air quality by only 0.1%, 0.1%, 1%, and up to 0.08%, respectively.

The results show that the main difference in the level of effectiveness between MPOs is related to the projects that they proposed. MPOs which mainly focused on the strategies which remove the need for travel by car is shown to be more effective than the MPOs which focused on the adding capacity and building highway projects. While the first type of projects result is less VMT, congestion, delay, and ultimately GHG emission. the second group of projects will result in more car use, more traffic congestion, and higher VMT and GHG emission.

While there is an emerging consensus that the time is right for shifting from mobility-centered planning to planning for broader goals, this study shows that current regional transportation planning cannot even effectively pursue it's aimed congestion relief goal. I find that LRTPs do not result in better mobility by having a transportation network with less delay, less congestion and faster movement in the future than the current condition. The LRTPs created by most MPOs fail to provide a transportation system that performs better than today in terms of mobility. For many MPOs delay, total VMT, and VMT per capita all increase substantially while average speed decreases. There is generally a small decrease in single occupancy vehicle mode share, reflecting higher shares of transit, walking, bicycling or carpooling. Higher use of transit can reduce the external cost of the emission in the urban region (Amirgholy, Shahabi, and Gao 2017). My analysis finds that all studied MPOs except for two propose a network with higher total VMT than today, even more than doubling in some regions. While a portion of this increase comes from population growth in the future, in more than half MPOs, VMT growth will outstrip population growth and VMT per capita will increase. VMT as a primary indicator of travel demand by itself can reflect different aspects of the policies that MPOs take. Higher VMT might reflect less attractive alternatives to driving alone, low-density land use patterns, more vehicles on the road and more congestion, higher frequency of traffic incidents, and more air pollution and GHG emission. However, other mobility indicators also show a significant deviation of LRTPs' from effectiveness. The results show delay per capita will be skyrocketed in the future, indicating how a region is addressing traffic congestion in light of population growth. Similar to other mobility indicators, average travel speed decreases under most LRTPs and only a few bring average speed above the current condition, which is a sign of the limitations of current planning practice so that it.

While planning for accessibility is seen as an alternative approach of planning for mobility, and metropolitan areas are pursuing accessibility-based initiatives such as infill and smart growth policies, results show that the plans will worsen the current accessibility condition. For instance, the average trip length, an indicator of accessibility, is longer than the status quo in the majority of LRTPs and even longer than the no-build scenario in some regions, which also affect other measures since as trip lengths become longer, travelers are more likely to use car rather than transit, bike, or walk (Rowangould and Tayarani 2016) .

The analysis of the long-range transportation plans finds that while GHG emissions per capita decrease under most plans in the future transportation plan, overall GHG emissions will be reduced by less than 5%. While not many MPOs achieve large GHG emission reductions, under several MPOs' plans GHG emission will experience a negligible decline or even will increase. The results, even in those plans that reduce GHG emissions, are far less than the 40% to 70% GHG reductions required by the latest IPCC assessment to avoid the severe climate change impacts. However, the promising GHG reduction is mostly because of fuel and vehicle improvements expected from stringent federal regulation rather than regional planning policies since the corresponding VMT will be increased and travel speed will be decreased under LRTPs. Criteria air pollutant emissions also do improve significantly thanks to stricter federal vehicle emission standards and turn over in the vehicle fleet.

Similar to prior studies by analyzing the changes in total and per capita VMT and GHG emission, I find that a significant portion of the future scenarios deviates very little over 20-30 years, from the no-build scenarios, while the cost of implementing these scenarios is several billion dollars. Even if it were possible to invest more on infrastructure and road capacity expansions, it is evidence that such a "predict and provide" not only never resolves mobility problems in a long term, but also it works against long term regional goals. In this study, I find that LRTPs with the highest improvements in key indicators are designed based on solutions such as strengthening infill and mixed-use developments, supporting non-motorized and transit mode shares, and emphasizing on the travel demand and congestion management solutions.

I also find that although environmental justice seems to be ubiquitous in most reviewed LRTPs and many plans present demographic characteristics of communities of concern within their jurisdictions, there was little analysis of how justice concerns would be measured. These findings are similar to what has been found in prior studies (Bocarejo and Oviedo 2012; Duthie, Cervenka, and Waller 2007; Karner and Niemeier 2013; Manaugh, Badami, and El-Geneidy 2015; Singleton and Clifton 2017). Most MPOs do not examine how their plans affect mobility, accessibility, safety, and air quality impacts on the EJ groups. Ideally, MPOs showed how proposed projects or allocated funds are spatially distributed regarding the location of protected populations; or they made a set of spatial buffers around the projects and compared the demographic features of populations within these buffers to the whole population while defining buffer thresholds is problematic by itself. My review of available environmental justice data, however, shows that under near half of the LRTPs, EJ groups would experience lower accessibility which is the most reported environmental justice concern.

CHAPTER 6
FACTORS ASSOCIATED WITH PLANNING EFFECTIVENESS

6.1 Introduction

Prior studies suggest that factors associated with planning effectiveness may include an MPO's organizational structure, regional challenges and characteristics, and components of the regional planning process. More effective transportation plans may also be associated with MPO characteristics, such as the number of staff and their knowledge, the type and size of MPO executive board, and how they prioritize local and regional concerns (Gerber and Gibson, 2009; Goetz, Dempsey, and Larson, 2002; Goode et al., 2001; Puentes and Bailey, 2003; Vanasse Hangen Brustlin, 2007). It is also likely that the socio-economic characteristics of metropolitan areas – such as the rate of population growth – influence the level of effectiveness that MPOs achieve in their LRTPs (Davidson et al., 2007; Goetz, Dempsey, and Larson, 2002). A discrepancy between goals and performance measures can also influence planning effectiveness (Hatzopoulou and Miller, 2009; Handy, 2008). Project prioritization methods may also be related to planning effectiveness (Kulkarni et al., 2004). The effectiveness of regional transportation planning is also a function of public participation (Grant et al., 2013; Willson, 2001). Previous studies show that the type of modeling system used to predict travel demand is associated with the effectiveness of LRTPs (Davidson et al., 2007; Algers, Eliasson, and Mattsson, 2005; Vanasse Hangen Brustlin, 2007). The effectiveness of regional transportation planning is also a function of public participation (Grant et al., 2013; Willson, 2001; Allison and Davidson, 2008).

Prior research focusing on the impact that external factors have on the ability of MPOs to create more effective plans has generally elicited perceived measures of effectiveness from practicing planners by conducting surveys, interviews, and focus groups. A few quantitative studies investigate how these factors actually impact plan effectiveness. Most prior research has also been limited to small samples of plans, typically selecting those created by the largest MPOs and with a lack of systematic research methods and sampling frame. While there are many factors that may affect the ability of MPOs to create more effective plans, there has been little, if any, quantitative research investigating them. Prior research has generally elicited perceived barriers from practicing planners, but it is unclear how these actually influence planning outcomes.

In this chapter, I fill this gap by evaluating factors that might influence the process of creating more effective transportation plans using statistical analysis. In particular, I will evaluate the association between effectiveness and various factors using regression models, such as the political structure of MPOs, the budget and size of MPOs, and the geography of the region.

6.2 Background

There might be a correlation between creating more effective transportation plans and the characteristics of MPOs, for example, budget, the number of staff and their knowledge, structure and size of MPO executive boards, and how they prioritize local and regional concerns. A study of four MPOs shows that the share of state funding has positive effects on the level of satisfaction in addressing regional challenges such as high vehicle miles traveled VMT per capita (Goetz, Dempsey, and Larson, 2002). Another review of LRTPs shows that the biggest concern of MPOs when trying to improve their current planning process is the lack of budget, which translates into reduced number of staff, their capabilities, and the number of planning scenarios they design and evaluate (Vanasse Hangen Brustlin, 2007). For example, Kansas City's Mid-America Regional Council expressed concerns over recruiting and retaining modeling staff due to the low pay of the position (Goode et al., 2001). Another study also suggests that increasing allocated money to the metropolitan levels will increase the ability of the MPOs to meet key regional challenges (Puentes and Bailey, 2003). In addition, the effectiveness of the process might be a function of the geographical and institutional makeup of the MPO's executive board (Gerber and Gibson, 2009; Goetz, Dempsey, and Larson, 2002). For example, one study found that elected officials mostly focus on locally-oriented policies, while non-elected public managers mostly focus on those that are regionally-oriented (Gerber and Gibson, 2009).

It is likely that the socio-economic characteristics of the metropolitan areas, such as the rate of population growth, influence the level of effectiveness that MPOs achieve in their LRTPs. Significant population growth and expected congestion growth, probably combined with a greater sense of urgency, might increase the severity and complexity of the problems that MPOs confront (Davidson et al., 2007; Goetz, Dempsey, and Larson, 2002). In addition, it might be reasonable to assume that the size of the region that an MPO serves relates to its effectiveness. However, there is no strong evidence suggesting that the planning process is influenced by metropolitan characteristics, so a more in-depth investigation is needed.

A discrepancy between goals and performance measures can also influence planning effectiveness (Hatzopoulou and Miller, 2009; Handy, 2008). A review of four LRTPs suggests that travel-demand models have an influential role in selecting and applying performance measures in the planning process. Goals and their performance measures that are taken from travel-demand models receive more attention than those goals with performances not definable or measurable by travel-demand models (Handy, 2008). Jeon et al. (2013) mentioned that only a few MPOs have applied planning tools for capturing transportation system effectiveness metrics in the regional planning process and many planners do not know how to define performance measures for sustainability and effectiveness (Jeon, Amekudzi, and Guensler, 2013). The sustainability and effectiveness of a transportation plan may be measured by the following performance measures: freeway/arterial congestion, vehicle-miles traveled, freight ton-miles, transit passenger miles traveled, mode share (percentage of travelers using a particular type of transportation), CO2 emission, criteria pollutants emission (ozone, VOC, NOx, CO, PM2.5, PM10), traffic noise levels, fuel consumption, land requirements, equity of welfare changes, travel time and cost, increased employment, equity of exposure to emissions and noise, accidents per VMT, crash disabilities and fatalities, and access to activity centers and major services (Litman and Burwell, 2006; Jeon, Amekudzi, and Guensler, 2013).

It is also plausible to see the effects of project prioritization methods on generating more effective plans. The project selection process provides a systematic approach to ranking projects, which is required for developing a financially-constrained regional transportation plan. While the project selection process and its evaluation criteria should be based on the planning goals and performance measures, as well as the modeling results, it may also be based solely on the cost-effectiveness of the projects (Ram B. Kulkarni et al., 2004).

The effectiveness of regional transportation planning is also a function of public participation. One study shows that developing a collaborative interaction between planning actors makes a transportation plan more effective (Grant et al., 2013, Nadafianshahamabadi et al., 2017). Communicative transportation planning leads to more planning goals achievements and a better match between goals and planning outcomes in comparison with a non-collaborative planning process (Willson, 2001). A study of five MPOs of California shows that collaborative planning, including innovative public engagement methods, resulted in mutual acceptance between regional authorities and local residents on providing more sustainable transportation plans (Allison and Davidson, 2008).

Previous studies show that the type of modeling system used to predict travel demand is associated with the effectiveness of LRTPs. Travel-demand modeling lies at the core of the regional transportation planning process, providing the data needed to measure the effectiveness of planning scenarios. Although travel-demand modeling advanced substantially in the 1960s, it continues to provide the same basic information used for plan evaluation: traffic volumes, speed, and mode share. These outputs are used directly or as inputs to additional models and calculations that evaluate the performance of alternative planning scenarios and their effectiveness. While literature shows that the activity-based models and tour-based models represent a significant improvement over the four-step trip models (Davidson et al., 2007; Algers, Eliasson, and Mattsson, 2005), a review of about 200 LRTPs shows that more than 80% of MPOs are using the four-step travel-demand model, while only 2.7% are using tour-based or activity-based models and the remainder do not use any travel-demand modeling (Vanasse Hangen Brustlin, 2007).

6.3 Methodology

Together with MPOs' websites, I scanned each plan and its appendices to find information on the following factors that might influence planning effectiveness:

- **Population and population growth**: MPOs' population for the base and future conditions are provided by most MPOs in a chapter dedicated to socio-economic data.
- **Funding per capita**: In general, each plan has a chapter that describes the funding plan and the fiscal-constrained list of projects. The total amount of funding and funding per capita are extracted and entered into the database.
- **Number of planning scenarios**: Most LRTPs have a chapter for scenario planning that introduces planning scenarios and the evaluation process to find the best plan.
- **Census Bureau Regions:** The US Census Bureau website provides information on the Census Regions and Divisions of the United States.
- **Political Composition:** The political compositions of MPOs are determined based on the voting data of the U.S. states in the 2016 presidential election.

As mentioned above, while there are other variables that might affect planning efficiency, I only focused on data that was readily available for this analysis. Evaluating other factors is beyond the scope of my current study. A set of analysis of covariance

(ANCOVA) models are then applied to understand the relationship between the above factors and planning effectiveness.

The indicators of effectiveness – as the dependent variables – are those factors that are considered in Chapter Five and include the percent of change between the future scenario and base condition in terms of the following performance measures: vehicle miles traveled per capita, total vehicle miles traveled, greenhouse gas emission per capita, total greenhouse gas emission, trip length, vehicle hours of delay per capita, average travel speed, car use. The number of goals and performance measures that are included in the planning process are considered as well, to understand if there is a relationship between including goals and performance measures and the independent variables that are mentioned above.

6.4 Results

6.4.1 Impacts of MPOs' Population on Effectiveness

Comparing the effectiveness based on MPO size reveals interesting findings. Generally, medium-sized MPOs behave differently compared to small and large MPOs. The most significant differences are in VHD and VHT, where the plans created by medium-sized MPOs are expected to result in smaller increases, possibly indicating more effective planning.

Table 6-1: Mean Change[a] in Performance Measures Based on MPO Size

Size based on Population	Large MPOs	Medium MPOs	Small MPOs
Number of MPOs	78	44	60
Average of Percentage Change in Total VMT	40.05%	32.01%	38.80%
Average of Percentage Change in VMT per Capita	2.59%	1.14%	6.17%
Average of Percentage Change in Trip Length	1.91%	1.34%	0.47%
Average of Percentage Change in VHD per Capita	121.50%	36.63%	123.56%

Average of Percentage Change in VHT per Capita	17.49%	9.54%	20.45%
Average of Percentage Change in Travel Speed	-7.49%	-3.29%	-7.54%
Average of Percentage Change in Car Use	-0.85%	-0.33%	-19.02%
Average of Percentage Change in GHG per Capita	-28.29%	-20.61%	-23.59%
Average of Percentage Change in Total GHG	-1.15%	5.15%	2.49%
Number of Goals	6.33	5.50	4.75
Number of Performance Measures	9.15	6.39	5.32

[a] Percentage change between adopted scenario and base condition which is considered the indicator of effectiveness.

6.4.2 Political Composition and Effectiveness

A region's political affiliation is associated with many measures of effectiveness. Based on 2016 presidential election results, MPOs in regions that voted Republican appear to be less effective. In Republican-voting regions, there is a larger increase in VMT, VMT per capita, trip distance, passenger vehicle mode share, and a smaller decrease in per capita GHG emissions than in regions voting Democrat.

Table 6-2: Mean Change[a] in Performance Measures Based on Political Composition

2016 Presidential Election	Democratic	Republican
Number of MPOs	71	111
Average of Percentage Change in Total VMT	27.13%	45.02%
Average of Percentage Change in VMT per Capita	-3.14%	6.77%
Average of Percentage Change in Trip Length	-0.03%	3.51%
Average of Percentage Change in VHD per Capita	86.84%	119.00%
Average of Percentage Change in VHT per Capita	18.63%	16.17%
Average of Percentage Change in Travel Speed	-4.58%	-7.72%
Average of Percentage Change in Car Use	-5.95%	2.47%
Average of Percentage Change in GHG per Capita	-28.12%	-24.48%
Average of Percentage Change in Total GHG	-3.74%	3.68%
Number of Goals	6.38	5.11
Number of Performance Measures	8.18	6.62

[a] Percentage change between adopted scenario and base condition which is considered the indicator of effectiveness.

6.4.3 Impacts of Geographical Location on MPOs' Effectiveness

The effectiveness of MPOs regarding geographical location is controversial. While MPOs in the West will see a higher change in their total VMT, they will also see a reduction in their change of VMT per capita. This happens because of the significantly higher population growth among the MPOs in the West regions.

Table 6-3: Mean Change[a] in Performance Measures Based on Geographical Location

Region	Midwest	Northeast	South	West
Number of MPOs	59	34	67	32
Average of Percentage Change in Total VMT	33.30%	15.62%	42.50%	47.42%
Average of Percentage Change in VMT per Capita	6.71%	1.99%	4.60%	-2.19%
Average of Percentage Change in Trip Length	0.79%	0.99%	2.42%	1.53%
Average of Percentage Change in VHD per Capita	141.18%	39.82%	107.07%	112.65%
Average of Percentage Change in VHT per Capita	13.44%	1.43%	24.71%	11.23%
Average of Percentage Change in Travel Speed	-4.28%	-7.50%	-8.11%	-5.07%
Average of Percentage Change in Car Use	-4.65%	-3.66%	0.13%	-3.04%
Average of Percentage Change in GHG per Capita	-27.15%	-35.80%	-25.63%	-20.21%
Average of Percentage Change in Total GHG	-7.70%	-20.49%	2.58%	16.49%
Number of Goals	5.12	6.47	5.28	6.12
Number of Performance Measures	5.92	8.12	6.63	9.53

[a] Percentage change between adopted scenario and base condition which is considered the indicator of effectiveness.

6.4.4 Impacts of Funding on MPOs' Effectiveness

As funding per capita increased, the number of included goals in the planning increased also. MPOs with higher funding, however, work worst in terms of VMT, VHD, and GHG per capita.

Table 6-4: Mean Change[a] in Performance Measures Based on Funding

Funding per Capita	Less than 4,000	between $4,000 and $8,000	More than $8,000
Number of MPOs	44	43	82
Average of Percentage Change in Total VMT	37.67%	32.88%	40.65%
Average of Percentage Change in VMT per Capita	2.01%	2.90%	2.37%
Average of Percentage Change in Trip Length	-0.73%	4.33%	1.42%
Average of Percentage Change in VHD per Capita	96.42%	95.88%	127.20%
Average of Percentage Change in VHT per Capita	3.50%	25.17%	16.23%
Average of Percentage Change in Travel Speed	-4.79%	-4.92%	-8.55%
Average of Percentage Change in Car Use	7.20%	0.14%	-4.72%
Average of Percentage Change in GHG per Capita	-26.40%	-30.66%	-24.02%
Average of Percentage Change in Total GHG	1.74%	-7.30%	4.84%
Number of Goals	6.16	7.07	7.98

Number of Performance Measures	5.43	6.16	5.57

[a] Percentage change between adopted scenario and base condition which is considered the indicator of effectiveness.

6.4.5 Number of Planning Scenarios and MPOs' Effectiveness

As **Error! Not a valid bookmark self-reference.** shows, it seems that there is not any certain impact regarding the number of planning scenarios on planning effectiveness.

Table 6-5: Mean Change[a] in Performance Measures and Planning Scenarios

Planning Scenario	1	2	3	4	5	7
Number of MPOs	15	13	8	3	2	2
Average of Percentage Change in Total VMT	38.58%	39.86%	34.68%	37.70%	47.92%	2.99%
Average of Percentage Change in VMT per Capita	5.69%	5.59%	0.81%	-5.67%	3.56%	-3.42%
Average of Percentage Change in Trip Length	-1.13%	2.34%	4.19%	-2.85%	1.62%	NaN
Average of Percentage Change in VHD per Capita	37.75%	104.59%	168.35%	60.51%	193.18%	7.44%
Average of Percentage Change in VHT per Capita	10.92%	21.04%	22.23%	-0.99%	-3.94%	-1.53%
Average of Percentage Change in Travel Speed	-3.36%	-6.79%	-9.57%	-5.62%	-1.01%	-0.64%
Average of Percentage Change in Car Use	-1.11%	-1.16%	-2.56%	-10.26%	12.92%	NaN
Average of Percentage Change in GHG per Capita	-30.12%	-25.45%	-25.28%	-28.07%	-15.23%	-31.78%
Average of Percentage Change in Total GHG	-9.87%	0.80%	0.92%	7.30%	16.00%	2.51%
Number of Goals	4.65	8.20	8.12	8.85	10.00	3.00
Number of Performance Measures	4.48	6.11	5.79	5.95	7.25	6.00

[a] Percentage change between adopted scenario and base condition which is considered the indicator of effectiveness.

6.4.6 Analysis of Covariance (ANCOVA)

Independent variables in the ANCOVA include population, population growth, funding per capita, number of planning scenarios, geographical region, and political composition. Population, population growth rate, funding, and the number of scenarios are continuous variables, while the geographical region and political party (election) are categorical variables. Geographical region includes four categories, and election includes two. Before starting the ANCOVA, multicollinearity is checked to ensure that independent variables are independent. Collinearity of Variables

Table 9-1, in Appendix 2, shows that the correlation between independent variables is not high and that multicollinearity should not be a concern.

6.4.6.1 Total Vehicle Miles Traveled

My model incorporates both continuous and categorical variables. Thus, the Analysis of Covariance (ANCOVA) is applied to understand the relationship between the dependent variable, which is the percent change in VMT per capita, and quantitative variables, including population in base condition, population growth, funding per capita, and number of planning scenarios. The analysis also includes two categorical variables, including census bureau regions (South, West, Northeast, and Midwest) and political composition (Democrat and Republican).

First, I created some plots to provide me with a general overview of the data. The box plots and interaction plots can be found in Figure 9-1and Figure 9-2 in Appendix 2. A scatter plot of all variables in the model can be found in Figure 9-3, Appendix 2. The boxplots show that the change average in VMT is higher for MPOs located in the West and lowest for MPOs located in the Northeast. In addition, the change in VMT is higher in MPOs with a Republican attitude. The interaction plots show some interaction effects.

Next, I fitted the full model with the interactions – the analysis of variance of the full model can be found in Table 9-2, Appendix 2. Population growth, funding per capita, region, election, and population growth: region has a statistically significant association with the change in total VMT. The diagnostic plots for the full model can be found in Figure 9-4, Appendix 2. Then, I evaluated the appropriateness of the statistical model by two diagnostic plots: residual vs fitted values and Normal QQ plot. If the plot of residuals vs fitted values presents a cone shape, it might indicate the existence of substantially unequal error variances. If the points of the QQ plot deviate severely from the line, it might indicate a deviation from normality. These diagnostic plots alerted me to the fact that observations 125, 168, and 182 might be severe outliers, well outside the range of any of the other observations. This was confirmed by the student outlier test that observations 125, 168, 66, and 94 are outliers (Figure 9-5 in Appendix 2). However, I double checked the values provided by MPOs to ensure that these outliers are not recording errors. Thus, the outliers are kept in the database and used in the modeling process.

I then proceeded to reduce the model to its final form, each step of which can be seen in Table 9-3 to Table 9-7 in Appendix 1. With each step, I removed the least significant variable (highest p-value) and ran a generalized linear test to ensure that the new model was better than the previous. Variables that have been dropped include 'planning scenario: election,' 'funding per capita: election,' 'population, growth: election,' 'planning scenarios, and funding per capita: region,' respectively, at each step of model selection. I did this until only significant effects were left.

My final model found that population growth, funding per capita, geographical location, political party and interaction of population growth, and geographical region were significant. The ANCOVA table of the final model can be seen in the appendix as well as the final diagnostics (Table 9-8 and Figure 9-6 in Appendix 2). I retested for outliers, as well as for normality and constant variance, which were both satisfied. Finally, to analyze the treatment effects of the interaction term, I obtained pairwise comparisons with 95 percent family confidence coefficients, utilizing the Tukey procedure (Figure 9-7 and Table 9-9 in Appendix 2).

Table 6-6: Coefficients Table of Final Model: Change in Total VMT

Variables	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	23.19077	11.8986	1.949	0.0543	.
Population Growth	-0.00725	0.103273	-0.07	0.94421	
Funding per Capita	-0.02755	0.049414	-0.557	0.57854	
Northeast	-6.12927	15.97733	-0.384	0.70213	
South	-7.81318	13.07698	-0.597	0.55164	
West	-23.1507	17.4094	-1.33	0.18684	
Republican	15.59849	6.200428	2.516	0.01359	*
Population Growth: Northeast	0.008077	0.170825	0.047	0.96239	
Population Growth: South	0.184652	0.12761	1.447	0.15126	
Population Growth: West	0.417212	0.15008	2.78	0.00658	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 23.16 on 93 degrees of freedom
Multiple R-squared: 0.3574, Adjusted R-squared: 0.2953
F-statistic: 5.748 on 9 and 93 DF, p-value: 2.541e-06

Based on My model incorporates both continuous and categorical variables. Thus, the Analysis of Covariance (ANCOVA) is applied to understand the relationship between the dependent variable, which is the percent change in VMT per capita, and quantitative variables, including population in base condition, population growth, funding per capita, and number of planning scenarios. The analysis also includes two categorical variables, including census bureau regions (South, West, Northeast, and Midwest) and political composition (Democrat and Republican).

First, I created some plots to provide me with a general overview of the data. The box plots and interaction plots can be found in Figure 9-1and Figure 9-2 in Appendix 2. A scatter plot of all variables in the model can be found in Figure 9-3, Appendix 2. The boxplots show that the change average in VMT is higher for MPOs located in the West and lowest for MPOs located in the Northeast. In addition, the change in VMT is higher in MPOs with a Republican attitude. The interaction plots show some interaction effects.

Next, I fitted the full model with the interactions – the analysis of variance of the full model can be found in Table 9-2, Appendix 2. Population growth, funding per capita, region, election, and population growth: region has a statistically significant association with the change in total VMT. The diagnostic plots for the full model can be found in Figure 9-4, Appendix 2. Then, I evaluated the appropriateness of the statistical model by two diagnostic plots: residual vs fitted values and Normal QQ plot. If the plot of residuals vs fitted values presents a cone shape, it might indicate the existence of substantially unequal error variances. If the points of the QQ plot deviate severely from the line, it might indicate a deviation from normality. These diagnostic plots alerted me to the fact that observations 125, 168, and 182 might be severe outliers, well outside the range of any of the other observations. This was confirmed by the student outlier test that observations 125, 168, 66, and 94 are outliers (Figure 9-5 in Appendix 2). However, I double checked the values provided by MPOs to ensure that these outliers are not recording errors. Thus, the outliers are kept in the database and used in the modeling process.

I then proceeded to reduce the model to its final form, each step of which can be seen in Table 9-3 to Table 9-7 in Appendix 1. With each step, I removed the least significant variable (highest p-value) and ran a generalized linear test to ensure that the new model was better than the previous. Variables that have been dropped include 'planning scenario: election,' 'funding per capita: election,' 'population, growth: election,' 'planning scenarios, and funding per capita: region,' respectively, at each step of model selection. I did this until only significant effects were left.

My final model found that population growth, funding per capita, geographical location, political party and interaction of population growth, and geographical region were significant. The ANCOVA table of the final model can be seen in the appendix as well as the final diagnostics (Table 9-8 and Figure 9-6 in Appendix 2). I retested for outliers, as well as for normality and constant variance, which were both satisfied. Finally, to analyze the treatment effects of the interaction term, I obtained pairwise comparisons with 95 percent family confidence coefficients, utilizing the Tukey procedure (Figure 9-7 and Table 9-9 in Appendix 2).

Table 6-6, population growth, geographical region, and political position significantly affect the total VMT. Leaning toward Republican attitudes increases the change in the total VMT by 15.6 and being an MPO in the West decreases the change in total VMT by 23.15. While the average percentage change in VMT for Democratic MPOs is -3.14, the Republican MPOs will see a positive change of 6.77 in their VMT per capita.

6.4.6.2 Vehicle Miles Traveled Per Capita

Figure 9-8 in Appendix 2 shows the interaction plots between political party and geographical location, indicating that some interactions might exist. Figure 9-9 in Appendix 2 shows that the average change in VMT per capita is higher for MPOs located in the South and is lower for those located in the West. In addition, MPOs located in Republican states will experience a higher change in VMT per capita compared with MPOs in Democrat states.

Table 9-10 in Appendix 2 shows the full ANCOVA model for change in VMT per capita. It suggests that population growth, funding, geographical region, and the election party are significant. The diagnostic plots in Figure 9-10, Appendix 2, shows that the model meets the assumptions. Figure 9-11 in Appendix 2 shows that there is not an outlier in the model.

I then proceeded to reduce the model to its final form. In each step, I removed the least significant variable (highest p-value) and ran a generalized linear test to ensure the new model was better than the previous. Variables including 'planning scenario: region,' 'population, planning scenarios: election,' 'funding per capita: region,' 'funding per capita: election,' 'planning scenarios, population growth: region,' and 'population growth: election' have been dropped respectively, at each step of model selection. I did this until only significant effects were left. The analysis of variance of the final reduced model is shown in Table 9-11 and the diagnostic plots can be found in Figure 9-12, both in Appendix 2.

Based on **Error! Not a valid bookmark self-reference.**, funding and political composition have a significant role in effectiveness in terms of VMT per capita. If funding per capita increases by one dollar, the change in VMT per capita decreases by 0.05, showing that MPOs that spend more will see less change in their VMT per capita under their adopted scenario compared to their base scenario. The political attitude has a statistically significant impact on the future change of VMT. Having Republican attitudes versus Democrat increases the change in the VMT per capita by 9.98 – this is a shift from a negative change that saw less VMT per capita in future for Democrat attitudes, versus more VMT per capita in future for Republican attitudes.

Table 6-7: Coefficients Table of Final Model: Change in VMT Per Capita

Variables	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	5.86473	3.81167	1.539	0.127366	
Population growth	-0.03747	0.02316	-1.618	0.109197	
Funding per capita	-0.05809	0.02176	-2.67	0.008995	**
Region (Northeast)	3.21421	4.27828	0.751	0.454419	
Region (South)	-1.90614	2.75802	-0.691	0.491246	
Region (West)	-2.24424	3.34543	-0.671	0.504022	
Election (Republican)	9.98041	2.68857	3.712	0.000354	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 10.23 on 91 degrees of freedom
Multiple R-squared: 0.2955, Adjusted R-squared: 0.2491
F-statistic: 6.363 on 6 and 91 DF, p-value: 1.277e-05

6.4.6.3 Greenhouse Gas Emission per Capita

Figure 9-13 in Appendix 2 indicates that some interaction effects might exist between geographical location and political party. Thus, the interaction terms are included in the formulated model. Figure 9-14 in Appendix 2 shows that the average change in GHG per capita is higher for MPOs in the West and for MPOs in the Republican states. The model (Table 9-12 in Appendix 2) shows that the geographical location is the only explanatory variable that significantly affects the GHG emissions per capita. Figure 9-15 in Appendix 2 shows all of the good behavior, meaning that the model fits well with no outliers, and the error variances are constant.

Table 6-8: Coefficients Table of Full Model: Change in GHG Emission Per Capita

Variables	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-23.35863	15.28862	-1.528	0.131
Population Growth	-0.11541	0.10664	-1.082	0.283
Fund Per Capita	-0.04544	0.08196	-0.554	0.581
Planning Scenarios	2.96318	3.79193	0.781	0.437
Region Northeast	12.14752	16.7139	0.727	0.47
Region South	7.7227	10.44208	0.74	0.462
Region West	-1.6416	17.88896	-0.092	0.927
Election Republican	-12.30445	14.49816	-0.849	0.399
Population Growth:Region Northeast	0.18203	0.19992	0.91	0.365
Population Growth:Region South	0.04117	0.08812	0.467	0.642
Population Growth: Region West	0.06931	0.10728	0.646	0.52
Fund Per Capita:Region Northeast	-0.11008	0.16421	-0.67	0.505
Fund Per Capita:Region South	-0.09069	0.07544	-1.202	0.233
Fund Per Capita:Region West	-0.04343	0.09658	-0.45	0.654
Planning Scenarios:Region Northeast	-7.97317	4.84199	-1.647	0.104
Planning Scenarios:Region South	-1.03076	2.53912	-0.406	0.686
Planning Scenarios:Region West	1.96002	3.80891	0.515	0.608

Population Growth:Election Republican	0.12335	0.08506	1.45	0.151
Fund Per Capita:Election Republican	0.1215	0.08087	1.502	0.137
Planning Scenarios:Election Republican	-1.91166	3.72444	-0.513	0.609

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Multiple R-squared: 0.2528, Adjusted R-squared: 0.06345
F-statistic: 1.335 on 19 and 75 DF, p-value: 0.188

6.4.6.4 Total Greenhouse Gas Emission

Figure 9-16 in Appendix 2 shows the possible interactions between two factors: political party and geographical region. The boxplot in Figure 9-17, Appendix 2, shows that the average change in total GHG is higher for MPOs in the West and for MPOs in the Republican states. Analysis of variance of the full model (Table 9-13 in Appendix 2) shows that both population growth and geographical regions are significantly associated with the change in total GHG emission. Full model meets the goodness of fit assumptions based on the diagnostic plots in Figure 9-18, Appendix 2. The model reduction is proceeded to reduce the model to its final form. With each step, I removed the least significant variable (highest p-value) and ran a generalized linear test to ensure the new model was better than the previous. An analysis of variance table of final reduced model is shown in Table 9-14, and the diagnostic plots are shown by Figure 9-19, both in Appendix 2.

The reduced model in **Error! Not a valid bookmark self-reference.** shows that changes in the total GHG emission, similar to the total VMT, depends on population growth and geographical region. The change in total GHG emissions increases by 0.12 percent if the population grows by 1 percent. Geographical region also significantly increases the total GHG emissions. The MPOs in the West will have higher total GHG emissions in the future, while the MPOs in the Northeast will have lower GHG emissions in the future compared to the base condition.

Table 6-9: Coefficients Table of Final Model: Change in Total GHG Emission

Variables	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-18.22826	10.7479	-1.696	0.0934 .
Population Growth	0.12098	0.10901	1.11	0.2701
Region Northeast	-7.83143	16.60742	-0.472	0.6384
Region South	-3.84834	13.79698	-0.279	0.781
Region West	-1.90687	16.71993	-0.114	0.9095
Population Growth:Region Northeast	-0.03122	0.20343	-0.153	0.8784
Population Growth:Region South	0.14608	0.13756	1.062	0.2912
Population Growth:Region West	0.2209	0.15535	1.422	0.1586

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 23.72 on 88 degrees of freedom
Multiple R-squared: 0.3353, Adjusted R-squared: 0.2824
F-statistic: 6.341 on 7 and 88 DF, p-value: 4.861e-06

6.4.6.5 Trip Length

Figure 9-20, Appendix 2, shows the potential interaction between the factors in the model, whereas Figure 9-21, also Appendix 2, shows that the higher change in trip length is related to the MPOs located in the Midwest or the states with Republican attitudes. The analysis of the full model in Table 9-15, Appendix 2, shows that population growth and political party are significant factors on the change in trip length. While the full model shows the lack of fit (Figure 9-22), the reduced model, which also excludes outliers (MPO number 163), meets the assumptions of goodness of fit.

The percentage change in the trip length is significantly affected by the population growth, funding per capita, and political attitudes (**Error! Not a valid bookmark self-reference.**). The change in trip length will increase in the future by 0.47 percent for one increase in population growth. More importantly, the average trip length per capita in the future will increase as funding per capita increases. One-dollar increases in funding per capita will increase the change in average trip length by 0.20. Having Republican attitudes will increase the change in average trip length by 60.20 percent, showing less effectiveness in planning.

Table 6-10: Coefficients Table of Final Model: Change in Trip Length

Variables	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	-63.4342	14.12968	-4.489	0.000166	***
Population Growth	0.47207	0.14134	3.34	0.002843	**
Election Republican	60.20332	11.97565	5.027	4.36E-05	***
Fund Per Capita	0.20391	0.061	3.343	0.002824	**
Region Northeast	63.56836	14.55238	4.368	0.000225	***
Region South	-2.83151	6.04819	-0.468	0.644078	
Region West	47.88308	14.22025	3.367	0.002661	**
Population Growth:Election Republican	-0.21261	0.08289	-2.565	0.01731	*
Election Republican:Fund Per Capita	-0.26395	0.06692	-3.944	0.000646	***
Population Growth:Region Northeast	-0.44313	0.15055	-2.943	0.007295	**
Population Growth:Region South	-0.20867	0.1137	-1.835	0.079424	.
Population Growth: Region West	-0.36772	0.13696	-2.685	0.013225	*
Fund Per Capita:Region Northeast	-0.21492	0.08303	-2.588	0.016433	*
Fund Per Capita:Region South	0.08577	0.05642	1.52	0.142079	
Fund Per Capita:Region West	-0.11855	0.07399	-1.602	0.12278	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 4.309 on 23 degrees of freedom
Multiple R-squared: 0.676, Adjusted R-squared: 0.4787
F-statistic: 3.427 on 14 and 23 DF, p-value: 0.004362

6.4.6.6 Vehicle Hours of Delay per Capita

Possible interactions between political attitude and the geographical location of MPOs are shown in Figure 9-25, Appendix 2. MPOs in the Republican states have a higher VHD per capita in the future on average (Figure 9-26, Appendix 2). The analysis of variance of the full model can be found by Table 9-17, Appendix 2. Funding per capita and location are two significant factors. More population growth will result in a lower change in the VHD in the future compared to the base condition.

Table 6-11: Coefficients Table of Final Model: Change in VHD Per Capita

Variables	Estimate	Std. Error	T value	Pr(>|t|)	
(Intercept)	2730.16	1715.55	1.59	0.13	
Population	-8.45	5.58	-1.52	0.15	
Population Growth	-4.53	2.82	-1.60	0.13	
Fund Per Capita	6.10	2.22	2.75	0.01	*
Planning Scenarios	-900.79	657.64	-1.37	0.19	
Region Northeast	-3515.66	2197.94	-1.60	0.13	
Region South	108.31	202.34	0.54	0.60	
Region West	-3262.53	1799.02	-1.81	0.09	.
Election Republican	-2768.30	1705.86	-1.62	0.12	
Population: Region Northeast	41.99	25.97	1.62	0.12	
Population: Region South	-1.26	1.46	-0.86	0.40	

Population: Region West	8.79	5.47	1.61	0.12	
Population Growth: Region South	5.65	2.00	2.83	0.01	*
Population Growth: Region West	7.70	2.66	2.89	0.01	**
Fund Per Capita:Region South	-4.18	1.59	-2.63	0.02	*
Fund Per Capita:Region West	-5.26	1.91	-2.75	0.01	*
Planning Scenarios: Region South	-21.49	28.80	-0.75	0.46	
Planning Scenarios:Region West	961.63	646.66	1.49	0.15	
Population: Election Republican	9.13	5.40	1.69	0.11	
Population Growth: Election Republican	-0.59	2.09	-0.28	0.78	
Fund Per Capita:Election Republican	-1.59	1.66	-0.96	0.35	
Planning Scenarios: Election Republican	929.05	657.43	1.41	0.17	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 110.7 on 19 degrees of freedom
Multiple R-squared: 0.6769, Adjusted R-squared: 0.3198
F-statistic: 1.895 on 21 and 19 DF, p-value: 0.08317

6.4.6.7 Average Travel Speed

The interaction terms are included in the model based on Figure 9-28 in Appendix 2, which shows the potential interaction terms. The MPOs in the Democrat states work better than the MPOs in the Republican states in terms of travel speed (Figure 9-29, Appendix 2). The population of the base year, population growth, and funding per capita are significant factors on the change in travel speed (Table 9-18, Appendix 2). The population growth and funding per capita both significantly reduce the percentage change in average travel speed from its mean value (**Error! Not a valid bookmark self-reference.**). A one percent increase in population growth would decrease the change in travel speed by 0.04 percent. Even the increase in funding per capita will result in lowering the change in average travel speed in the future.

Table 6-12: Coefficients Table of Final Model: Change in Travel Speed

Variables	**Estimate**	**Std. Error**	**t value**	**Pr(>|t|)**	
(Intercept)	-3.50879	3.07945	-1.139	0.2601	
Population	0.04865	0.01977	2.461	0.0174	*
Population Growth	-0.02832	0.02268	-1.249	0.2177	
Fund Per Capita	-0.0605	0.02506	-2.414	0.0196	*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 7.823 on 49 degrees of freedom
Multiple R-squared: 0.2304, Adjusted R-squared: 0.1833
F-statistic: 4.889 on 3 and 49 DF, p-value: 0.004729

6.4.6.8 Number of Goals

MPOs in Democrat states include more goals in their planning process on average (Figure 9-32 in Appendix 2). As fund per capita increases, MPOs tend to include more goals in their plans (**Error! Not a valid bookmark self-reference.**).

Table 6-13: Coefficients Table of Final Model: Number of Included Goals in the Planning Process

Variables	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.6361175	1.9553396	1.86	0.06482	.
Population	0.0100204	0.0112663	0.889	0.37514	
Population Growth	0.0012803	0.0134769	0.095	0.92444	
Fund Per Capita	0.0202314	0.0104319	1.939	0.05425	.
Planning Scenarios	-0.1020875	0.4326508	-0.236	0.81377	
Region Northeast	3.5455065	2.5038598	1.416	0.15875	
Region South	-0.3030426	1.5670765	-0.193	0.84691	
Region West	3.7007186	2.4788289	1.493	0.13746	
Election Republican	0.1360819	1.9061363	0.071	0.94318	
Population: Region Northeast	-0.0147584	0.0149894	-0.985	0.32634	
Population: Region South	-0.0066553	0.0097901	-0.68	0.49763	
Population: Region West	-0.0050368	0.0131428	-0.383	0.70206	
Population Growth: Region Northeast	0.0058517	0.0155698	0.376	0.70754	
Population Growth: Region South	0.0022555	0.0103734	0.217	0.82815	
Population Growth: Region West	0.0002357	0.0137267	0.017	0.98632	
Fund Per Capita: Region Northeast	-0.0381921	0.0141385	-2.701	0.00767	**
Fund Per Capita: Region South	-0.0024393	0.0094949	-0.257	0.79759	
Fund Per Capita: Region West	-0.0166214	0.0137542	-1.208	0.22869	
Planning Scenarios: Region Northeast	0.44996	0.5416971	0.831	0.40743	
Planning Scenarios: Region South	0.4961105	0.347936	1.426	0.15589	
Planning Scenarios: Region West	-0.4615113	0.2757453	-1.674	0.09618	.
Population: Election Republican	-0.0040971	0.0107882	-0.38	0.70463	
Population Growth: Election Republican	-0.0016913	0.0123607	-0.137	0.89134	
Fund Per Capita: Election Republican	-0.0185796	0.0104032	-1.786	0.07604	.
Planning Scenarios: Election Republican	0.3115606	0.4093658	0.761	0.44775	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 2.601 on 157 degrees of freedom
Multiple R-squared: 0.1747, Adjusted R-squared: 0.04858
F-statistic: 1.385 on 24 and 157 DF, p-value: 0.122

6.4.6.9 Number of Performance Measures

MPOs in the West and MPOs in Democrat states include more performance measures in the planning process (Figure 9-33, Appendix 2). The number of included performance measures increases by 0.03 by 1 percent increase in funding per capita (**Error! Not a valid bookmark self-reference.**).

Table 6-14: Coefficients Table of Final Model: Number of Included Performance Measures in the Planning Process

Variables	Estimate	Std. Error	T value	Pr(>|t|)	
(Intercept)	0.6370586	3.2165892	0.198	0.84326	
Population	-0.0038222	0.0187154	-0.204	0.83844	
Population Growth	0.0333505	0.0222637	1.498	0.13616	
Fund Per Capita	0.0303181	0.017161	1.767	0.07924	.
Planning Scenarios	0.4403579	0.7116991	0.619	0.53699	
Region Northeast	9.2866909	4.1189322	2.255	0.02555	*
Region South	-0.9828318	2.5782083	-0.381	0.70357	
Region West	3.4879401	4.0788075	0.855	0.39379	
Election Republican	5.4617763	3.1356783	1.742	0.08351	.
Population: Region Northeast	-0.0016265	0.0247981	-0.066	0.94779	
Population: Region South	0.0032326	0.0165485	0.195	0.84538	
Population: Region West	0.0308801	0.0218766	1.412	0.16007	
Population Growth: Region Northeast	-0.0020421	0.0256976	-0.079	0.93676	
Population Growth: Region South	-0.0066975	0.0172583	-0.388	0.69849	
Population Growth: Region West	-0.0034368	0.0227277	-0.151	0.88	
Fund Per Capita: Region Northeast	-0.0746431	0.0232589	-3.209	0.00162	**
Fund Per Capita: Region South	-0.0006958	0.0156197	-0.045	0.96453	
Fund Per Capita: Region West	-0.0289947	0.0226252	-1.282	0.20191	
Planning Scenarios: Region Northeast	-0.316039	0.8910807	-0.355	0.72332	
Planning Scenarios: Region South	0.8498849	0.5731949	1.483	0.14017	
Planning Scenarios: Region West	-0.370214	0.4547851	-0.814	0.41686	
Population: Election Republican	-0.0131542	0.0177958	-0.739	0.46091	
Population Growth: Election Republican	-0.0128144	0.0203415	-0.63	0.52964	
Fund Per Capita: Election Republican	-0.0393689	0.0171177	-2.3	0.02278	*
Planning Scenarios: Election Republican	-0.2943489	0.674634	-0.436	0.66322	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 4.279 on 156 degrees of freedom
Multiple R-squared: 0.2627, Adjusted R-squared: 0.1493
F-statistic: 2.316 on 24 and 156 DF, p-value: 0.001128

6.5 Discussion

In this chapter, I presented the key characteristics that are different among MPOs and their role in planning effectiveness. The regression analysis allowed us to evaluate the relationship between each of these factors and effectiveness in terms of changes in key performance measures. The results suggest that there is an association between planning effectiveness and the level of funding, political attitudes, population growth, and geography.

Population growth has a significant effect on the change in total VMT, VMT per capita, total GHG, trip length, and travel speed. As population increases, the number of trips will increase which ultimately increases total GHG emission and decreases travel speed as congestion increses. As population increases, trips will be longer as well. As Goetz, et al. (2002) argued, a high rate of population growth in the future can also increase the severity and complexity of the challenges MPOs confront.

Political attitudes are significantly associated with the change in VMT per capita, total VMT, total GHG, and trip length. MPOs located in states that voted Republican is the last presidential election have higher VMT per capita, higher total VMT, higher GHG emission, and longer trips by car. This shows that MPOs located in states with democratically controlled state legislature are expected to be more effective than the MPOs in the Republican states in terms of planning. Grossman (2018) found that Democratic MPOs are collecting fewer MAP-21 required measures. I also found that MPOs in areas that vote Democrats include more goals than MPOs with Republican attitudes. One possible explanation for the different performance of MPOs based on voting preferences is that Democratic and Republicans have two very different visions for the future of infrastructure. The differences may be caused by different transportation infrastructure and climate change priorities of each political party. In addition, the political party might be an effective factor on the governance of MPOs. The governance of MPOs is various across the country in terms of number and structure of committees, voting scheme, approaches of involving the public, how to prioritize problems, public inputs, and means for collaboration with local, state, and federal agencies such as state DOTs and municipalities. However, further investigation is needed to understand the differences in planning practice between political groups.

The geographical location of MPOs has a significant impact on change of total VMT, VMT per Capita, total GHG, and the number of performance measures. MPOs which are located in the Western part of the country adopt scenarios with lower VMT, lower VMT per capita, and lower total GHG. The strong association between effectiveness and geography indicates that the neighboring regions might follow similar planning approaches which is referred as "regional ethos" (Goetz, 2002) or planning culture. Planning culture refers to a set of planning approaches and methods that are applied by the planners in a given location. In addition, as argued by Knieling and Othengrafen (2015), different cultural contexts result in different planning outcomes. In addition, the metropolitan areas in a region might have a similar built environment or similar socioeconomics, so the planning and policy responses and their effectiveness may also be similar.

The amount of funding is significantly associated with change in VMT per capita, total VMT, and GHG emission per capita. MPOs with more funding per capita proposed LRTPs which lead to lower VMT and lower GHG emission in the future. It is believed that one of the challenges in the 3C planning process is the limited control that MPOs have over federal funds. State DOTs and local agencies like cities not only have more control over federal, state, and local funds, they are also on the MPOs' boards and have significant rolls in the MPOs decision making process.

Future work directly building off of this study includes new data collection on other potential factors which are associated with planning effectiveness such as MPOs executive board composition, tools and models used in the planning process, and level of public participation and then evaluating the relationship between these factors and planning effectives.

CHAPTER 7
CONCLUSION

In this research, I evaluated the long-range plans adopted by more than 180 metropolitan areas in the United States by asking three research questions. Do MPOs create effective long-range transportation plans? What goals and performance measures are used in the planning process? And what factors are associated with the long-range transportation plans' effectiveness?

I found that MPOs largely fail to meet the long sought-after goals of traffic congestion relief, less automobile dependence, and fewer environmental impacts. In most cases, traffic is expected to much worse, greenhouse gas emissions will rise in many places, and fail to decline enough to meet widely recognized targets to minimize the rise in global temperature in the remainder, and single occupancy personal vehicles will continue to be the dominant mode of transportation. Over 20 to 30 years, almost half an average person's life, most plans are only marginally different than business as usual projections.

This study also shows that while more MPOs are considering new goals such as environment and justice, goals are not completely tracked in the planning process. In particular, performance measures related to these goals are not considered by many MPOs. In addition, the results show that not all defined performance measures are used in the planning process.

This study also shows that factors such as MPOs location, political attitudes, funding levels, and population growth rates are associated with planning effectiveness. For example, MPOs which are located in the states that voted for the democratic presidential candidate appear to create more effective plans than the MPOs in states that voted for the republican candidate.

The results suggest that the federally mandated planning process is ineffective and that it may be time to consider alternatives. There are a wide range of possible explanations for the apparent shortcomings of the current planning process that have been discussed elsewhere and include political constraints, lack of technical planning resources, and outdated and inflexible modeling tools. MPOs also have limited control over the funds for projects which limits their ability to create alterative plans. Most do not receive any source of revenue other than that required to carry out the planning process. MPOs do not collect tax revenue. Most funding is controlled by state DOTs and municipalities who use it support and develop the projects they want, often as matching funds for federal dollars. MPOs also have a limited role in land use planning, which is almost always a municipal function, limiting their ability to create coordinated transportation and land-use plans.

This research contributes to the field of urban and transportation planning and public policy in different ways. Results of this study are useful for planning policy practice and research in general and may start a new debate over the veracity of the current planning framework. Should MPOs be given more decision-making power, an ability to generate revenue, or have a say in land-use planning? Alternatively, if MPOs are largely ineffective, should a completely new approach be developed? This research also points to some smaller changes that could be made to improve the current process. For example, future legislation could define methods for evaluating progress towards equity and environmental justice goals, which are common in LRTPs but few MPOs measure theses.

The research framework that is offered here can be used to evaluate other plans as well, such as short-term transportation improvement programs (TIP), Statewide long-range transportation plans (SLRTP), statewide transportation improvement programs (STIP), and city comprehensive plans. In addition, this research provides the most current and comprehensive picture of the state of the practice in MPO planning practice.

The large database of LRTP planning outcomes could be used to and supplemented to evaluate many additional research questions. One might investigate the relationship between a larger set of independent factors that may affect planning effectiveness such as an MPO's governing board composition, the types of travel demand models and data used, and the number and training of MPO staff. The database could also be used to eventually evaluate how forecasted outcomes compare to actual outcomes in the future.

APPENDIX 1: GENERAL INFORMATION OF STUDIED MPOS

MPO ID	Area	State	Census Bureau Regions
MPO 1	Fresno County	California	West (Pacific)
MPO 2	Kern County	California	West (Pacific)
MPO 3	Merced County	California	West (Pacific)
MPO 4	Bay Area	California	West (Pacific)
MPO 5	Sacramento Area	California	West (Pacific)
MPO 6	San Diego	California	West (Pacific)
MPO 7	San Joaquin	California	West (Pacific)
MPO 8	San Luis Obispo	California	West (Pacific)
MPO 9	Columbia Area	Missouri	Midwest (West North Central)
MPO 10	St. Louis Region	Missouri	Midwest (West North Central)
MPO 11	Greater Kansas City	Missouri	Midwest (West North Central)
MPO 12	Ozarks	Missouri	Midwest (West North Central)
MPO 13	Berkeley-Charleston	South Carolina	South (South Atlantic)
MPO 14	Midlands	South Carolina	South (South Atlantic)
MPO 15	City of Anderson	South Carolina	South (South Atlantic)
MPO 16	Florence Area	South Carolina	South (South Atlantic)
MPO 17	Grand Strand Area	South Carolina	South (South Atlantic)
MPO 18	Greenville County	South Carolina	South (South Atlantic)
MPO 19	Rock Hill-Fort Mill Area	South Carolina	South (South Atlantic)
MPO 20	The Sumter Urban Area	South Carolina	South (South Atlantic)
MPO 21	Rapid City Area	South Dakota	Midwest (West North Central)
MPO 22	Sioux Falls	South Dakota	Midwest (West North Central)
MPO 23	Bristol Urban Area	Tennessee / Virginia	South (East South Central)
MPO 24	Chattanooga-Hamilton	Tennessee	South (East South Central)
MPO 25	Clarksville	Tennessee /Kentucky	South (East South Central)
MPO 26	JACKSON Area	Tennessee	South (East South Central)
MPO 27	Johnson City	Tennessee	South (East South Central)
MPO 28	Kingsport	Tennessee	South (East South Central)
MPO 29	Knoxville Region	Tennessee	South (East South Central)
MPO 30	Memphis	Tennessee	South (East South Central)
MPO 31	Nashville Area	Tennessee	South (East South Central)
MPO 32	Cache County	Utah	West (Mountain)
MPO 33	Provo/Orem	Utah	West (Mountain)
MPO 34	Salt Lake	Utah	West (Mountain)
MPO 35	Chittenden County	Vermont	Northeast (New England)
MPO 36	Central Virginia	Virginia	South (South Atlantic)
MPO 37	Charlottesville-Albemarle	Virginia	South (South Atlantic)
MPO 38	Fredericksburg	Virginia	South (South Atlantic)
MPO 39	Chesapeake	Virginia	South (South Atlantic)
MPO 40	Richmond	Virginia	South (South Atlantic)
MPO 41	Birmingham	Alabama	South (East South Central)
MPO 42	Dothan	Alabama	South (East South Central)
MPO 43	East Alabama	Alabama	South (East South Central)
MPO 44	Phoenix	Arizona	West (Mountain)
MPO 45	Tucson	Arizona	West (Mountain)

MPO ID	Area	State	Census Bureau Regions
MPO 46	Yuma	Arizona	West (Mountain)
MPO 47	Little Rock	Arkansas	South (West South Central)
MPO 48	West Memphis	Arkansas	South (West South Central)
MPO 49	Augusta	Georgia	South (South Atlantic)
MPO 50	Savannah Chatham	Georgia	South (South Atlantic)
MPO 51	Oahu	Hawaii	West (Pacific)
MPO 52	Bonneville	Idaho	West (Mountain)
MPO 53	Southwest Idaho	Idaho	West (Mountain)
MPO 54	Rock Island County	Illinois	Midwest (East North Central)
MPO 55	Chicago	Illinois	Midwest (East North Central)
MPO 56	Champaign County	Illinois	Midwest (East North Central)
MPO 57	Kankakee County	Illinois	Midwest (East North Central)
MPO 58	Mclean County	Illinois	Midwest (East North Central)
MPO 59	Rockford	Illinois	Midwest (East North Central)
MPO 60	Springfield	Illinois	Midwest (East North Central)
MPO 61	Tri-County Rpc	Illinois	Midwest (East North Central)
MPO 62	Bloomington County	Indiana	Midwest (East North Central)
MPO 63	Delaware-Muncie	Indiana	Midwest (East North Central)
MPO 64	Evansville	Indiana	Midwest (East North Central)
MPO 65	Lafayette	Indiana	Midwest (East North Central)
MPO 66	Indianapolis	Indiana	Midwest (East North Central)
MPO 67	Madison	Indiana	Midwest (East North Central)
MPO 68	Michiana	Indiana	Midwest (East North Central)
MPO 69	Northwest Indiana	Indiana	Midwest (East North Central)
MPO 70	West Central Indiana	Indiana	Midwest (East North Central)
MPO 71	Des Moines Area	Iowa	Midwest (West North Central)
MPO 72	Dubuque	Iowa	Midwest (West North Central)
MPO 73	Iowa Northland	Iowa	Midwest (West North Central)
MPO 74	Lawrence	Kansas	Midwest (West North Central)
MPO 75	Topeka	Kansas	Midwest (West North Central)
MPO 76	Wichita Falls	Texas	South (West South Central)
MPO 77	Green River	Kentucky	South (East South Central)
MPO 78	Louisville/Jefferson County	Kentucky	South (East South Central)
MPO 79	Lexington	Kentucky	South (East South Central)
MPO 80	Baton Rouge	Louisiana	South (West South Central)
MPO 81	Imperial Calcasieu Regional	Louisiana	South (West South Central)
MPO 82	North Delta	Louisiana	South (West South Central)
MPO 83	Northwest Louisiana	Louisiana	South (West South Central)
MPO 84	Alexandria	Louisiana	South (West South Central)
MPO 85	New Orleans	Louisiana	South (West South Central)
MPO 86	Houma-Thibodaux	Louisiana	South (West South Central)
MPO 87	Bangor	Maine	Northeast (New England)
MPO 88	Southern Maine	Maine	Northeast (New England)
MPO 89	Lewiston-Auburn	Maine	Northeast (New England)
MPO 90	Portland	Maine	Northeast (New England)
MPO 91	Allegany	Maryland	South (South Atlantic)
MPO 92	Baltimore	Maryland	South (South Atlantic)
MPO 93	Hagerstown	Maryland	South (South Atlantic)
MPO 94	Berkshire	Massachusetts	Northeast (New England)
MPO 95	Boston	Massachusetts	Northeast (New England)
MPO 96	Barnstable	Massachusetts	Northeast (New England)
MPO 97	Central Massachusetts	Massachusetts	Northeast (New England)
MPO 98	Merrimack Valley	Massachusetts	Northeast (New England)

MPO ID	Area	State	Census Bureau Regions
MPO 99	Montachusett	Massachusetts	Northeast (New England)
MPO 100	Northern Middlesex	Massachusetts	Northeast (New England)
MPO 101	Old Colony	Massachusetts	Northeast (New England)
MPO 102	Pioneer Valley	Massachusetts	Northeast (New England)
MPO 103	Ann Arbor	Michigan	Midwest (East North Central)
MPO 104	Battle Creek	Michigan	Midwest (East North Central)
MPO 105	Genesee	Michigan	Midwest (East North Central)
MPO 106	Grand Valley	Michigan	Midwest (East North Central)
MPO 107	Kalamazoo	Michigan	Midwest (East North Central)
MPO 108	Macatawa	Michigan	Midwest (East North Central)
MPO 109	St. Clair County	Michigan	Midwest (East North Central)
MPO 110	Southeast Michigan	Michigan	Midwest (East North Central)
MPO 111	Tri-County	Michigan	Midwest (East North Central)
MPO 112	Twin Cities, Benton	Michigan	Midwest (East North Central)
MPO 113	Muskegon	Michigan	Midwest (East North Central)
MPO 115	Twin Cities	Minnesota	Midwest (West North Central)
MPO 116	Olmsted	Minnesota	Midwest (West North Central)
MPO 117	St. Cloud	Minnesota	Midwest (West North Central)
MPO 118	Central Mississippi	Mississippi	South (East South Central)
MPO 119	Gulf Coast	Mississippi	South (East South Central)
MPO 120	Hattiesburg	Mississippi	South (East South Central)
MPO 121	St. Joseph	Missouri	Midwest (West North Central)
MPO 122	Great Fall	Montana	West (Mountain)
MPO 123	Missoula	Montana	West (Mountain)
MPO 124	Billings	Montana	West (Mountain)
MPO 125	Lincoln	Nebraska	Midwest (West North Central)
MPO 126	Omaha	Nebraska	Midwest (West North Central)
MPO 127	Las Vegas	Nevada	West (Mountain)
MPO 128	Tahoe	Nevada	West (Mountain)
MPO 129	Reno	Nevada	West (Mountain)
MPO 130	Nashua	New Hampshire	Northeast (New England)
MPO 131	Rockingham	New Hampshire	Northeast (New England)
MPO 132	Southern New Hampshire	New Hampshire	Northeast (New England)
MPO 133	Rochester	New Hampshire	Northeast (New England)
MPO 134	North Jersey	New Jersey	Northeast (Middle Atlantic)
MPO 135	South Jersey	New Jersey	Northeast (Middle Atlantic)
MPO 136	Las Cruces	New Mexico	West (Mountain)
MPO 137	Santa Fe	New Mexico	West (Mountain)
MPO 138	Albuquerque	New Mexico	West (Mountain)
MPO 139	Fort Edward	New York	Northeast (Middle Atlantic)
MPO 140	Binghamton	New York	Northeast (Middle Atlantic)
MPO 141	Albany	New York	Northeast (Middle Atlantic)
MPO 142	Elmira-Chemung	New York	Northeast (Middle Atlantic)
MPO 143	Genesee Finger Lakes	New York	Northeast (Middle Atlantic)
MPO 144	Buffalo	New York	Northeast (Middle Atlantic)
MPO 145	Herkimer Oneida	New York	Northeast (Middle Atlantic)
MPO 146	Ithaca Tompkins	New York	Northeast (Middle Atlantic)
MPO 147	New York	New York	Northeast (Middle Atlantic)
MPO 148	Orange County	New York	Northeast (Middle Atlantic)
MPO 149	Asheville	Tennessee	South (East South Central)
MPO 150	Burlington Graham	North Carolina	South (South Atlantic)
MPO 151	Cabarrus Rowan	North Carolina	South (South Atlantic)
MPO 152	North Carolina	North Carolina	South (South Atlantic)

MPO ID	Area	State	Census Bureau Regions
MPO 153	Durham Chapel Hill	North Carolina	South (South Atlantic)
MPO 154	Los Angeles	California	West (Pacific)
MPO 155	Dallas	Texas	South (West South Central)
MPO 156	Delaware Valley	Pennsylvania/NJ	Northeast (Middle Atlantic)
MPO 157	Houston	Texas	South (West South Central)
MPO 158	Washington	Washington DC	South (South Atlantic)
MPO 159	Miami	Florida	South (South Atlantic)
MPO 160	Atlanta	Georgia	South (South Atlantic)
MPO 161	Seattle	Washington	West (Pacific)
MPO 162	Southwestern Pennsylvania	Pennsylvania	Northeast (Middle Atlantic)
MPO 163	Portland	Oregon	West (Pacific)
MPO 164	San Antonio	Texas	South (West South Central)
MPO 165	Orlando	Florida	South (South Atlantic)
MPO 166	Cincinnati-Hamilton	Ohio	Midwest (East North Central)
MPO 167	Northeast Ohio	Ohio	Midwest (East North Central)
MPO 168	Southeastern Wisconsin	Wisconsin	Midwest (East North Central)
MPO 169	Austin	Texas	South (West South Central)
MPO 170	Broward	Florida	South (South Atlantic)
MPO 171	Mid-Ohio	Florida	South (South Atlantic)
MPO 172	Palm Beach	Florida	South (South Atlantic)
MPO 173	North Florida	Florida	South (South Atlantic)
MPO 174	Charlotte	North Carolina	South (South Atlantic)
MPO 175	Oklahoma	Oklahoma	South (West South Central)
MPO 176	Rhode Island	Rhode Island	Northeast (New England)
MPO 177	Tampa	Florida	South (South Atlantic)
MPO 178	Denver	Colorado	West (Mountain)
MPO 179	Greater Bridgeport	Connecticut	Northeast (New England)
MPO 180	Charleston	South Carolina	South (South Atlantic)
MPO 181	Casper	Wyoming	West (Mountain)
MPO 182	Anchorage	Alaska	West (Pacific)
MPO 183	Bismarck	North Dakota	Midwest (West North Central)

APPENDIX 2: STATISTICAL ANALYSES

9.1 Collinearity of Variables

Table 9-1: The Collinearity of Independent Variables

Variables	Population Base	Population Growth	Funding per Capita	Number of Scenarios	Region	Political Party
Population Base	1.00	0.02	-0.11	0.05	0.13	0.02
Population Growth	0.02	1.00	0.12	0.11	0.20	0.03
Funding per Capita	-0.11	0.12	1.00	0.02	0.07	-0.07
Number of Scenarios	0.05	0.11	0.02	1.00	0.02	0.04
Region	0.13	0.20	0.07	0.02	1.00	-0.04
Political Party	0.02	0.03	-0.07	0.04	-0.04	1.00

9.2 Total VMT

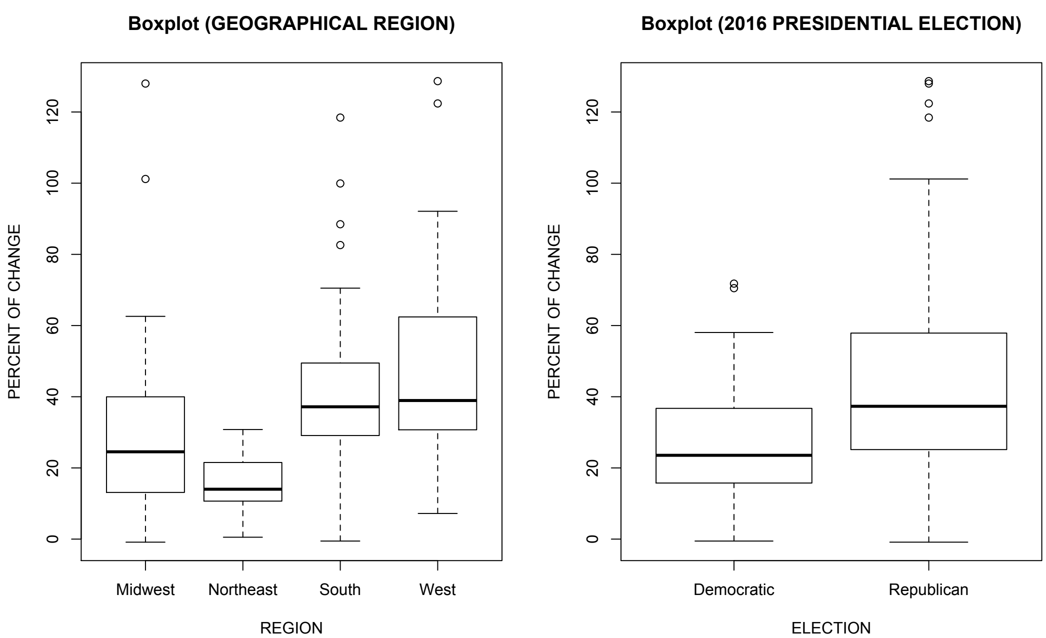


Figure 9-1: Boxplots for Categorical Variables and Percent of Change in Total VMT

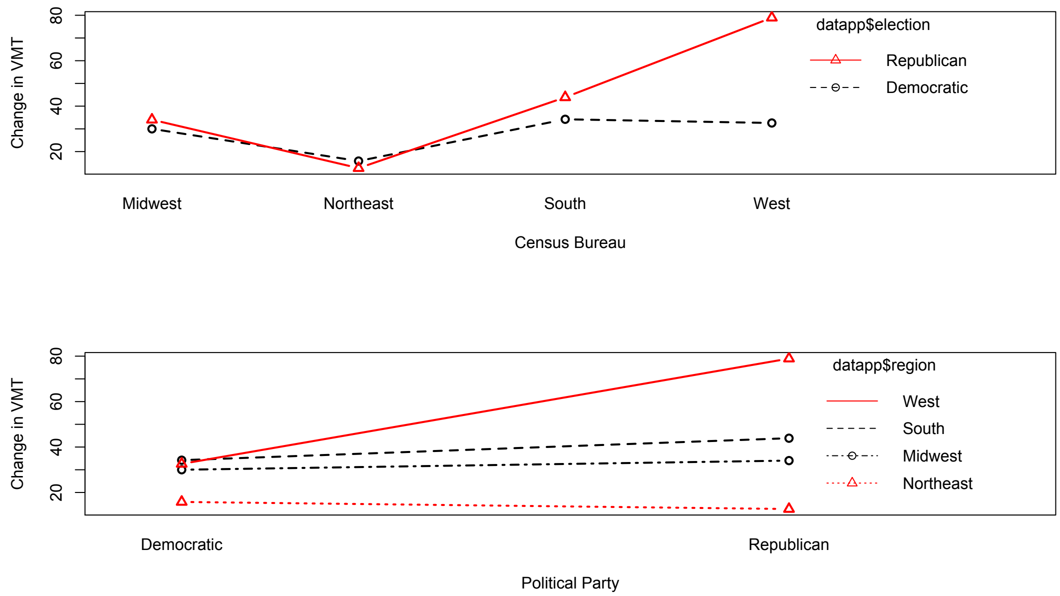


Figure 9-2: Interaction Plots (Change in Total VMT: Political Party and Change in Total VMT: Geographical Location)

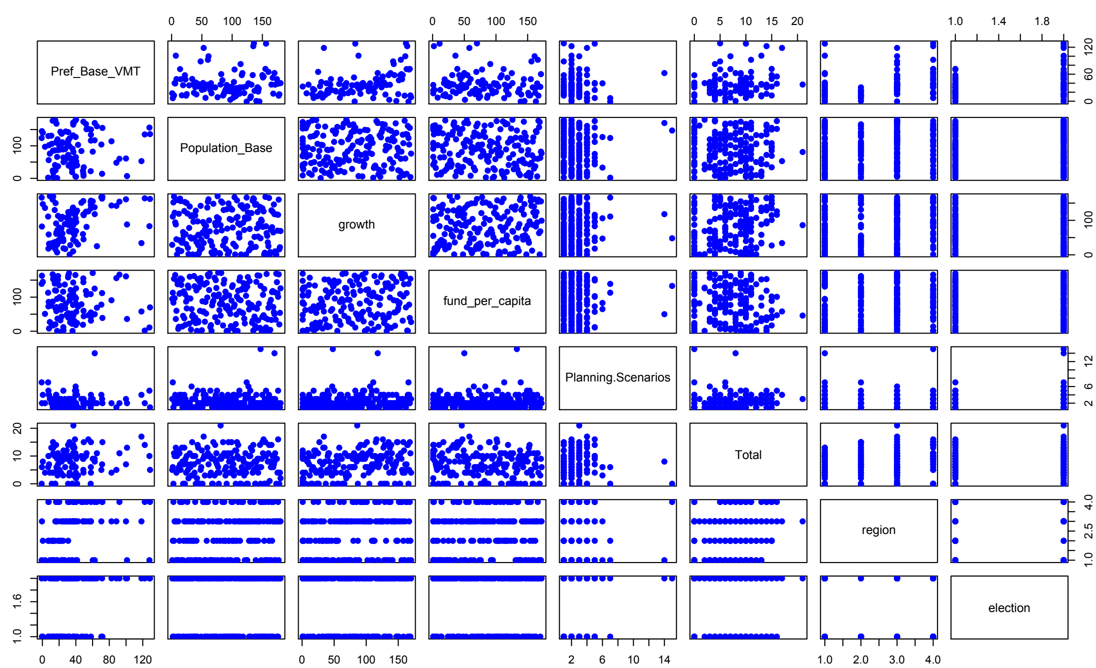


Figure 9-3: Scatter Plot of Change in VMT And Independent Variables

Table 9-2: Analysis of Variance Table of Full Model (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Base	135	135.3	0.2564	0.614021	
Population Growth	9162	9162	17.3576	7.94E-05	***
Funding per Capita	1971	1971.3	3.7347	0.056924	.
Planning Scenarios	205	204.6	0.3875	0.535414	
Region	6298	2099.2	3.9769	0.010832	*
Election	5218	5218.1	9.8859	0.002356	**
Population: Region	1472	490.8	0.9298	0.43045	
Population Growth: Region	5899	1966.3	3.7251	0.014695	*
Funding per Capita: Region	2565	855.1	1.62	0.191487	
Planning Scenarios: Region	2214	737.9	1.398	0.249713	
Population: Election	905	904.9	1.7144	0.194256	
Population Growth: Election	204	204.1	0.3866	0.53591	
Funding per Capita: Election	135	135.3	0.2563	0.614086	
Planning Scenarios: Election	64	64.3	0.1219	0.727956	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 22.97 on 78 degrees of freedom
Multiple R-squared: 0.4696, Adjusted R-squared: 0.3064
F-statistic: 2.877 on 24 and 78 DF, p-value: 0.0002368

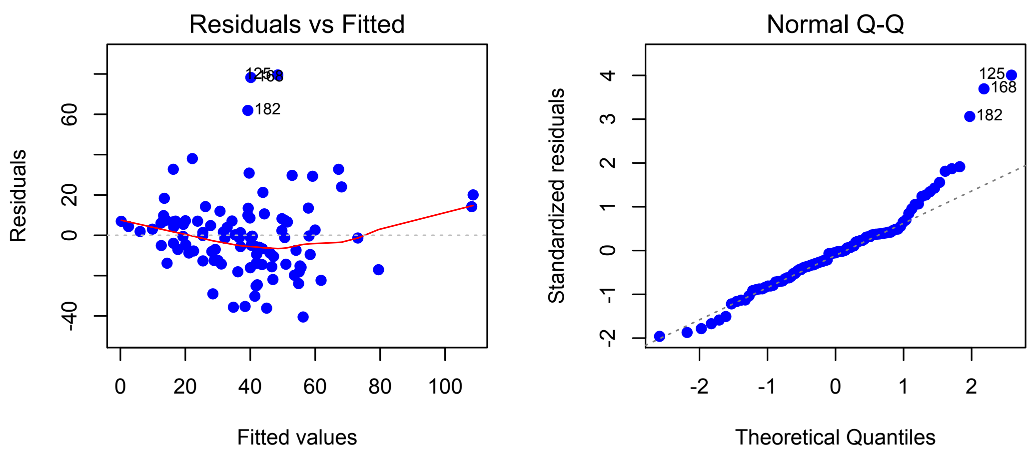


Figure 9-4: Diagnostic Plots for Full Model (Change in Total VMT)

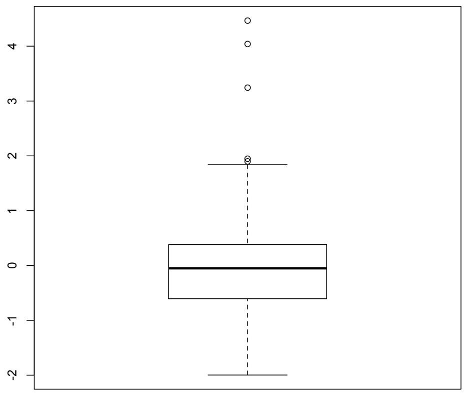


Figure 9-5: Boxplot of Rstudent to Check Outliers (Change in Total VMT)

Table 9-3: Analysis of Variance of First Model Reduction (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population	135	135.3	0.2593	0.612021	
Population Growth	9162	9162	17.5527	7.22E-05	***
Fund Per Capita	1971	1971.3	3.7767	0.055534	.
Planning Scenarios	205	204.6	0.3919	0.533112	
Region	6298	2099.2	4.0216	0.01022	*
Election	5218	5218.1	9.997	0.002224	**
Population:Region	1472	490.8	0.9402	0.425327	
Growth:Region	5899	1966.3	3.767	0.013917	*
Fund Per Capita:Region	2565	855.1	1.6382	0.187223	
Planning Scenarios:Region	2214	737.9	1.4137	0.244986	
Population:Election	905	904.9	1.7337	0.191746	
Growth:Election	204	204.1	0.3909	0.53361	
Fund Per Capita:Election	135	135.3	0.2592	0.612087	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 9-4: Analysis of Variance of Second Model Reduction (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population	135	135.3	0.2617	0.610348	
Population Growth	9162	9162	17.7168	6.66E-05	***
Fund Per Capita	1971	1971.3	3.812	0.054386	.
Planning Scenarios	205	204.6	0.3956	0.531186	
Region	6298	2099.2	4.0592	0.009726	**
Election	5218	5218.1	10.0904	0.002118	**
Population: Region	1472	490.8	0.949	0.421049	
Growth:Region	5899	1966.3	3.8022	0.013286	*
Fund Per Capita:Region	2565	855.1	1.6535	0.183688	
Planning Scenarios:Region	2214	737.9	1.4269	0.241058	
Population:Election	905	904.9	1.7499	0.189658	
Growth:Election	204	204.1	0.3946	0.531686	
Residuals	41371	517.1			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 9-5: Analysis of Variance of Third Model Reduction ((Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	9237	9236.7	17.8636	5.94E-05	***
Fund Per Capita	2005	2005.3	3.8781	0.052176	.
Planning Scenarios	191	191.2	0.3699	0.544703	
Region	6317	2105.6	4.0723	0.009391	**
Election	5214	5213.6	10.083	0.002085	**
Growth:Region	4895	1631.5	3.1554	0.028931	*
Fund Per Capita:Region	2754	918.1	1.7755	0.157973	
Planning Scenarios:Region	2792	930.8	1.8002	0.153295	
Growth:Election	263	263.4	0.5094	0.47735	
Residuals	43951	517.1			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 9-6: Analysis of Variance of Fourth Model Reduction (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	9237	9236.7	17.9661	5.63E-05	***
Fund Per Capita	2005	2005.3	3.9004	0.051483	.
Planning Scenarios	191	191.2	0.372	0.543535	
Region	6317	2105.6	4.0956	0.009093	**
Election	5214	5213.6	10.1408	0.00202	**
Growth:Region	4895	1631.5	3.1735	0.028231	*
Fund Per Capita:Region	2754	918.1	1.7857	0.155929	
Planning Scenarios:Region	2792	930.8	1.8105	0.151281	
Residuals	44214	514.1			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 9-7: Analysis of Variance of Fifth Model Reduction (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	9237	9236.7	17.6516	6.23E-05	***
Fund Per Capita	2005	2005.3	3.8321	0.053378	.
Region	6441	2147	4.1029	0.008888	**
Election	5244	5244	10.0214	0.002112	**
Growth:Region	4818	1606	3.069	0.031868	*
Fund Per Capita:Region	2779	926.5	1.7705	0.158465	
Residuals	47095	523.3			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 9-8: Analysis of Variance of Final Model Reduction (Change in Total VMT)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	9237	9236.7	17.2235	7.35E-05	***
Fund Per Capita	2005	2005.3	3.7392	0.056192	.
Region	6441	2147	4.0034	0.009951	**
Election	5244	5244	9.7783	0.002357	**
Growth:Region	4818	1606	2.9946	0.034771	*
Residuals	49875	536.3			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

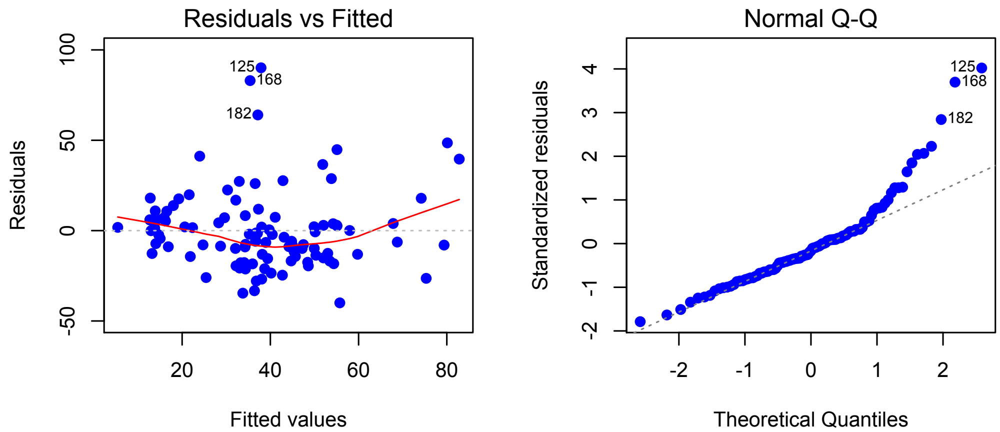


Figure 9-6: Diagnostic Plots for Final Model (Change in Total VMT)

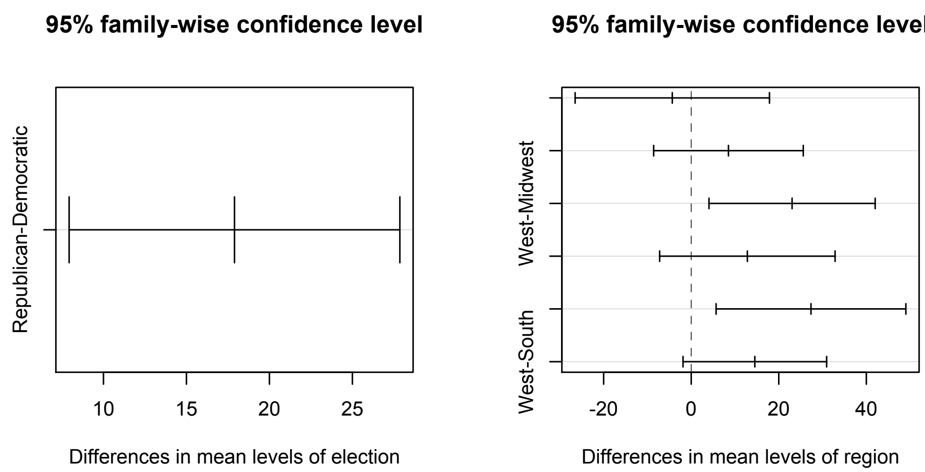


Figure 9-7: Tukey Multiple Comparisons of Means (Change in Total VMT)

Table 9-9: Tukey Multiple Comparisons of Means (95% Family-Wise Confidence Level) (Change in Total VMT)

	diff	lwr	upr	p adj
POLITICAL PARTY				
Republican-Democratic	17.89525	7.930258	27.86024	0.000567
LOCATION				
Northeast-Midwest	-4.31846	-26.5127	17.87578	0.956875
South-Midwest	8.506732	-8.5784	25.59187	0.564291
West-Midwest	23.03677	4.05958	42.01397	0.010694
South-Northeast	12.8252	-7.2089	32.85929	0.343342
West-Northeast	27.35524	5.68505	49.02543	0.007278
West-South	14.53004	-1.86857	30.92866	0.101406

9.3 VMT Per Capita

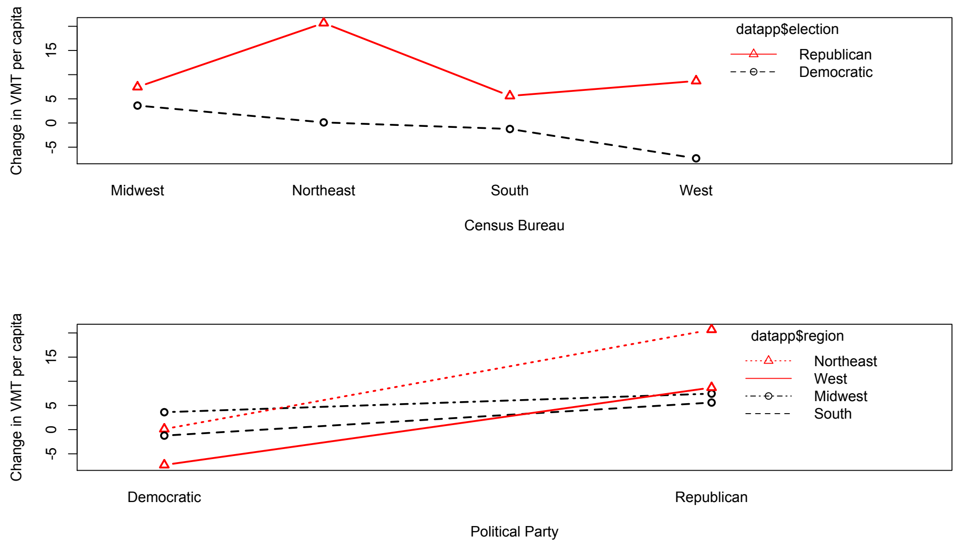


Figure 9-8: Interaction Plots (Change in VMT per Capita: Political Party and Change in VMT per Capita: Geographical Location)

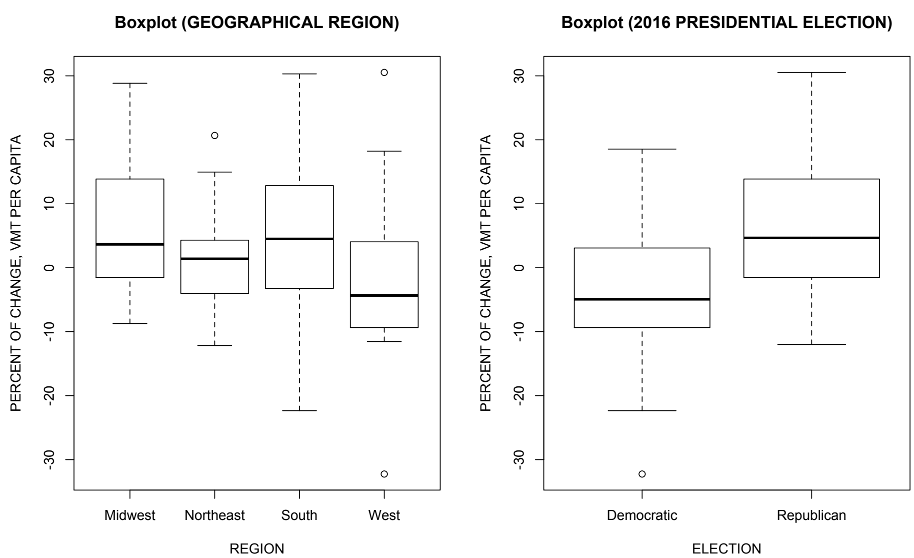


Figure 9-9: Boxplots for Categorical Variables and Percent of Change in VMT per Capita

Table 9-10: Analysis of Variance Table of Full Model (Change in VMT per Capita)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population	28.2	28.21	0.2711	0.604173	
Population Growth	700	699.98	6.7263	0.011472	*
Fund Per Capita	1189.2	1189.16	11.427	0.001165	**
Planning Scenarios	108.1	108.06	1.0383	0.311571	
Region	674.6	224.86	2.1607	0.099958	.
Election	1427.2	1427.21	13.7145	0.000411	***
Population Base:Region	285.9	95.29	0.9157	0.43768	
Growth:Region	581.1	193.69	1.8612	0.143696	
Fund Per Capita:Region	232.9	77.62	0.7459	0.528208	
Planning Scenarios:Region	193.3	64.43	0.6192	0.604827	
Population:Election	125.3	125.29	1.2039	0.276143	
Growth:Election	190.3	190.29	1.8285	0.180475	
Fund Per Capita:Election	64.9	64.91	0.6237	0.43222	
Planning.Scenarios:Election	115.8	115.84	1.1131	0.294879	
Residuals	7596.8	104.07			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 10.2 on 73 degrees of freedom
Multiple R-squared: 0.4378, Adjusted R-squared: 0.253
F-statistic: 2.369 on 24 and 73 DF, p-value: 0.002587

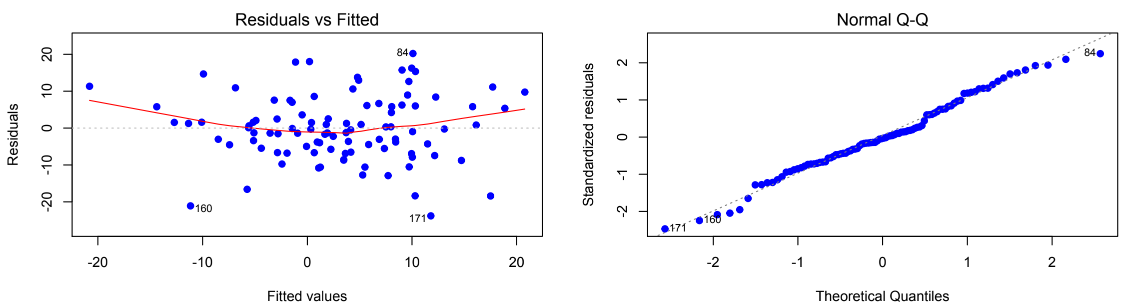


Figure 9-10: Diagnostic Plots for Full Model (Change in VMT per Capita)

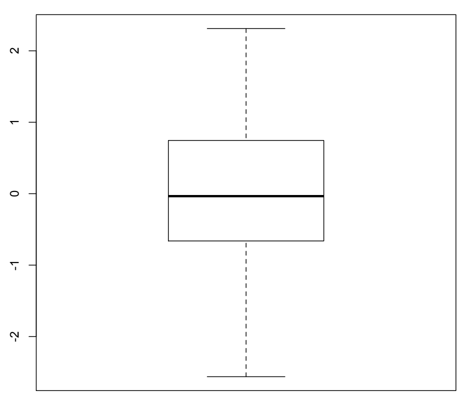


Figure 9-11: Boxplot of Rstudent to Check Outliers (Change in VMT per Capita)

Table 9-11: Analysis of Variance of Final Model Reduction (Change in VMT per Capita)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	704.4	704.4	6.7334	0.01103	*
Fund Per Capita	1145.9	1145.9	10.9538	0.00134	**
Region	701.9	233.97	2.2366	0.089306	.
Election	1441.6	1441.57	13.7802	0.000354	***
Residuals	9519.7	104.61			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 10.24 on 91 degrees of freedom
Multiple R-squared: 0.2933, Adjusted R-squared: 0.2467
F-statistic: 6.295 on 6 and 91 DF, p-value: 1.454e-05

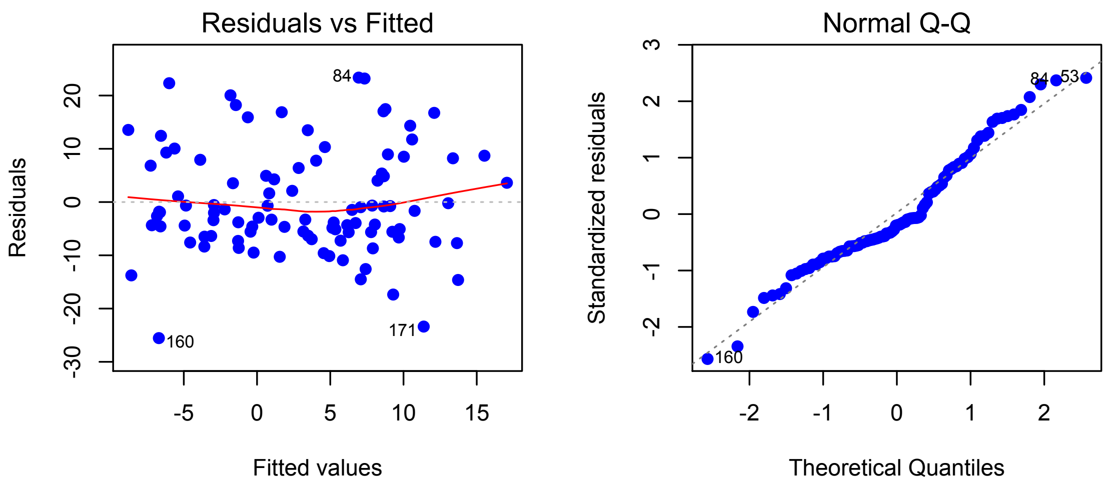
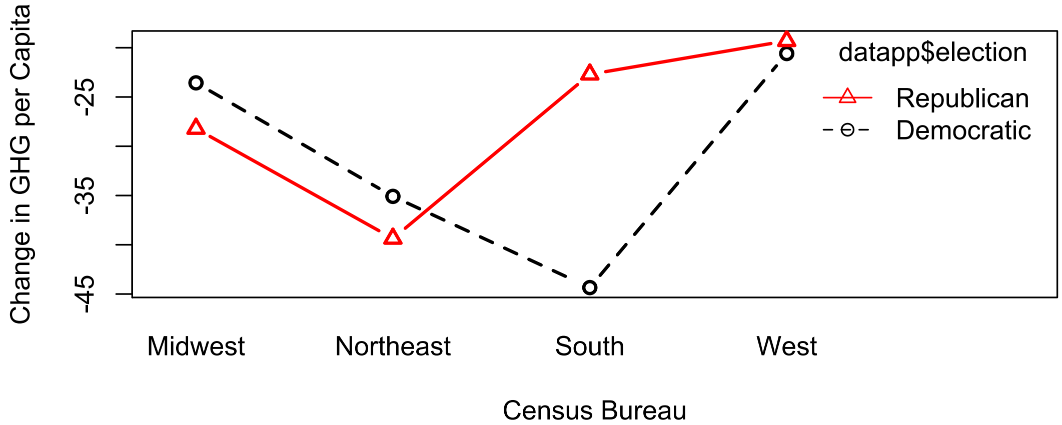


Figure 9-12: Diagnostic Plots for Final Model (Change in VMT per capita)

9.4 Greenhouse Gas Emission Per Capita



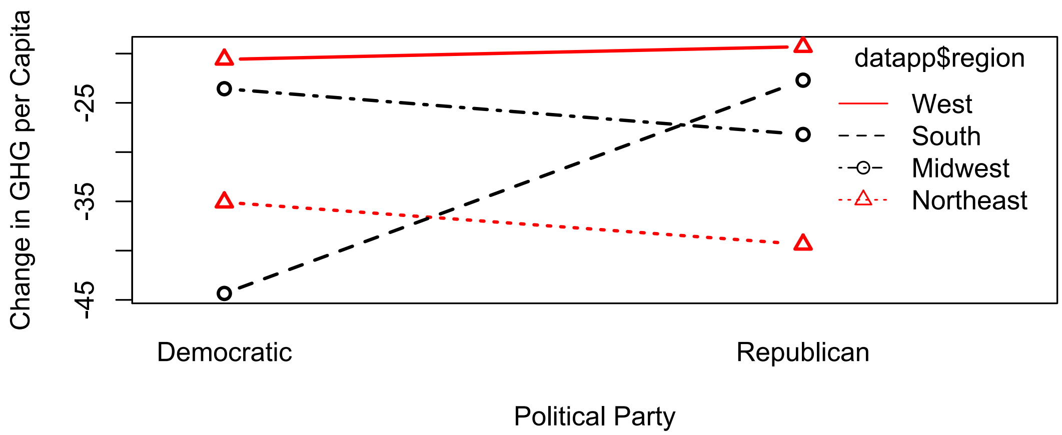


Figure 9-13: Interaction Plots (Change in GHG per Capita: Political Party and Change in GHG per Capita: Geographical Location)

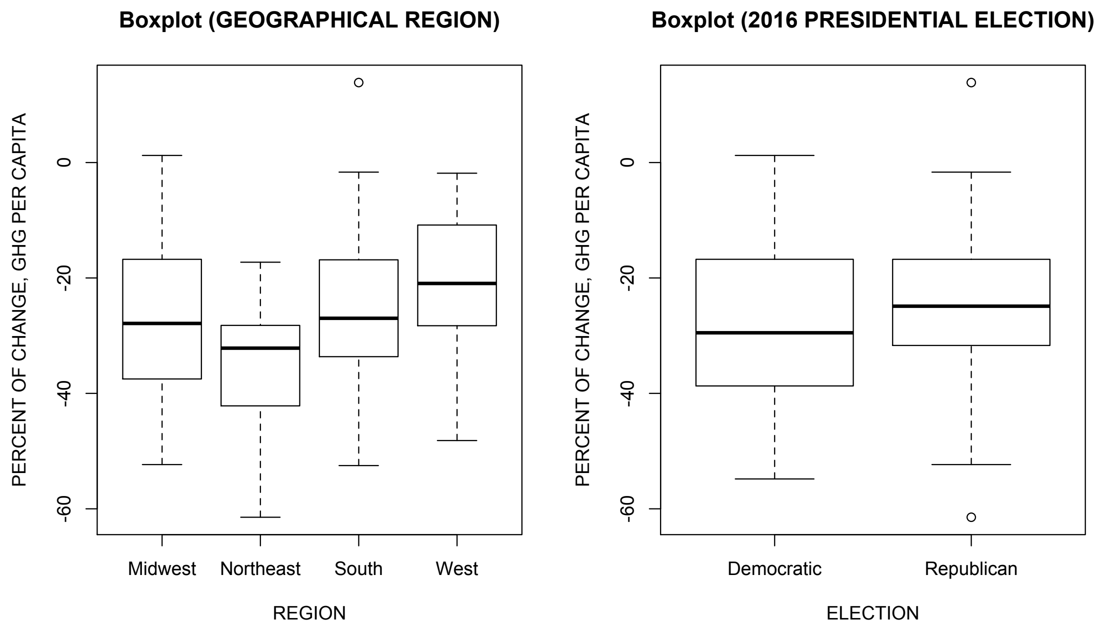


Figure 9-14: Boxplots for Categorical Variables and Percent of Change in GHG per Capita

Table 9-12: Analysis of Variance Table of Full Model (Change in GHG per Capita)

Variables	Sum Sq	Mean Sq	F value	Pr(>F)	
Population	132.9	132.88	0.644	0.425	
Population Growth	234.4	234.41	1.1361	0.2901	
Fund Per Capita	90	90.01	0.4363	0.5111	
Planning Scenarios	102.6	102.57	0.4971	0.4831	
Region	1598.5	532.82	2.5825	0.0602	.
Election	354	353.98	1.7157	0.1945	
Population:Region	122.9	40.96	0.1985	0.897	
Population Growth:Region	226.4	75.45	0.3657	0.778	
Fund Per Capita:Region	353.9	117.96	0.5717	0.6355	
Planning Scenarios:Region	903.2	301.06	1.4592	0.2332	
Population Base:Election	173.1	173.1	0.839	0.3628	
Population Growth:Election	330.1	330.1	1.5999	0.2101	
Fund Per Capita:Election	562.2	562.16	2.7247	0.1033	
Planning Scenarios:Election	6.2	6.24	0.0302	0.8625	
Residuals	14442.6	206.32			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

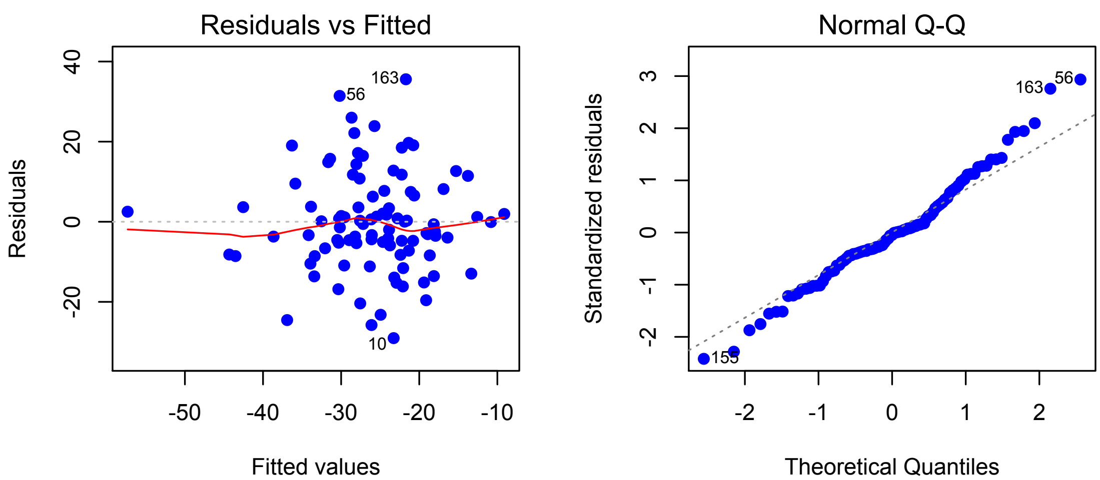


Figure 9-15: Diagnostic Plots for Full Model (Change in GHG per capita)

9.5 Total Greenhouse Gas Emission

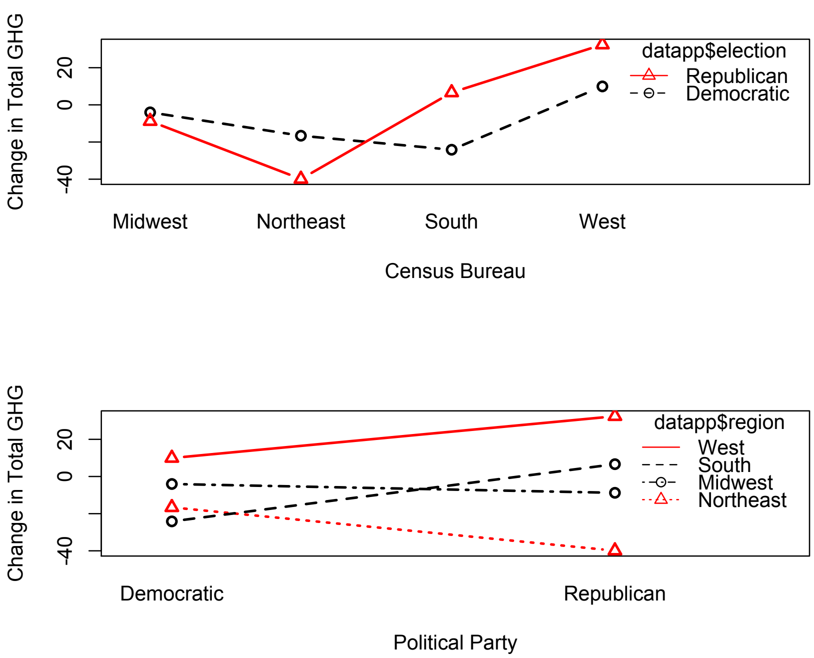


Figure 9-16: Interaction Plots (Change in Total GHG: Political Party and Change in Total GHG: Geographical Location)

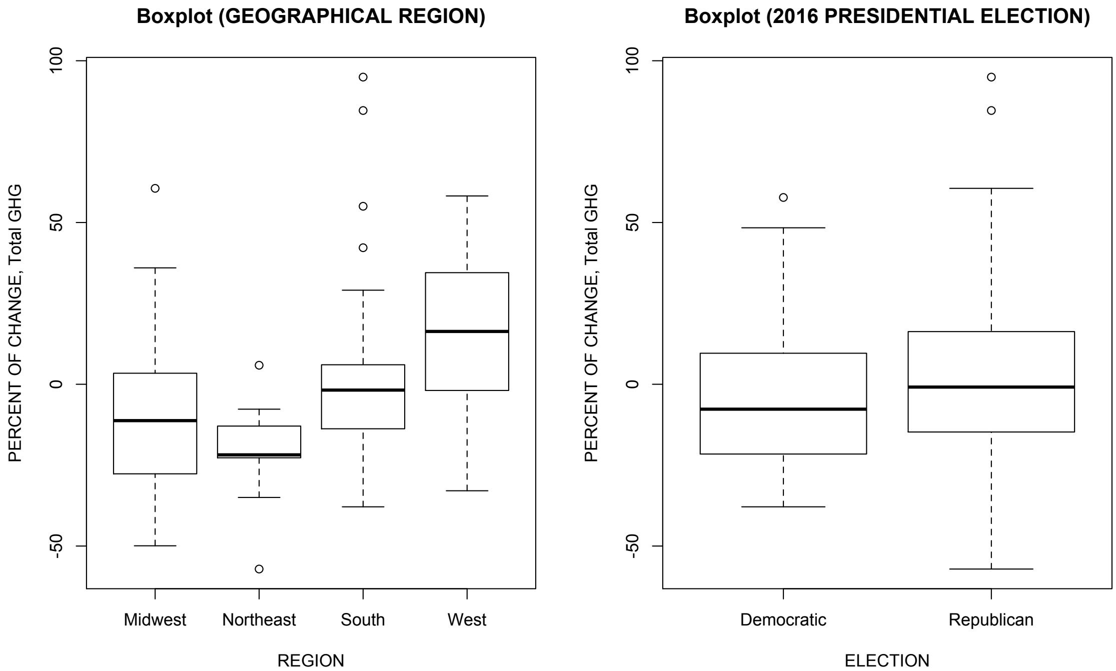


Figure 9-17: Boxplots for Categorical Variables and Percent of Change in Total GHG

Table 9-13: Analysis of Variance Table of Full Model (Change in Total GHG)

Variables	Sum Sq	Mean Sq	F value	Pr(>F)
Population	191	191	0.3197	0.57358
Population Growth	16373	16373	27.409	1.603e-06 ***
Fund Per Capita	169	169.3	0.2835	0.5961
Planning Scenarios	643	642.9	1.0762	0.30307
Region	7133	2377.8	3.9805	0.01113 *
Election	1627	1627.1	2.7238	0.10328
Population:Region	1190	396.5	0.6638	0.57707
Population Growth:Region	1938	645.9	1.0813	0.36265
Fund Per Capita:Region	662	220.8	0.3696	0.77519
Planning Scenarios:Region	154	51.3	0.0858	0.96759
Population Base:Election	725	725	1.2136	0.27434
Population Growth:Election	323	322.6	0.5401	0.46483
Fund Per Capita:Election	934	934.4	1.5643	0.21515
Planning Scenarios:Electio	8	8.1	0.0136	0.90764
Residuals	42413	597.4		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 24.44 on 71 degrees of freedom
Multiple R-squared: 0.4306, Adjusted R-squared: 0.2381
F-statistic: 2.237 on 24 and 71 DF, p-value: 0.00478

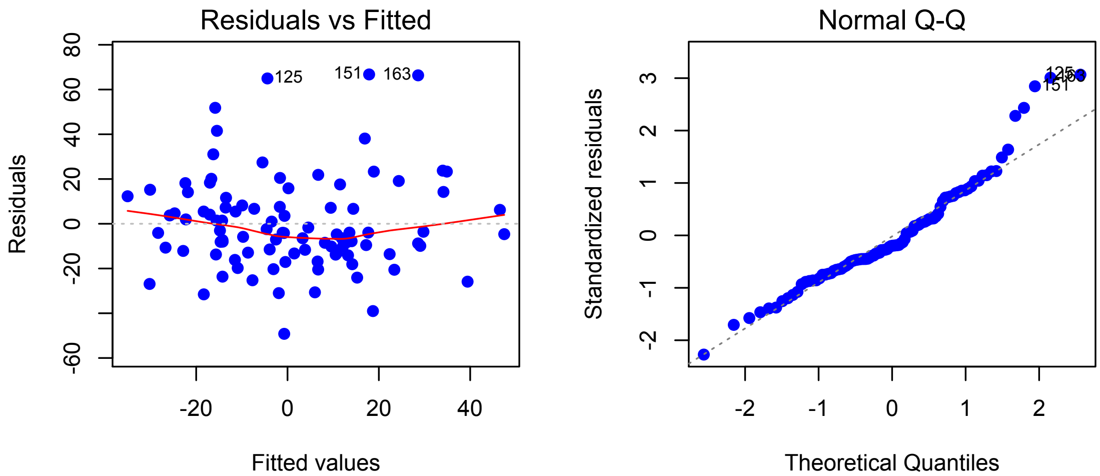


Figure 9-18: Diagnostic Plots for Full Model (Change in Total GHG)

Table 9-14: Analysis of Variance Table of Final Reduced Model (Change in Total GHG)

Variables	Sum Sq	Mean Sq	F value	Pr(>F)	
Population Growth	16544	16543.7	29.4057	5.09E-07	***
Region	6808	2269.3	4.0337	0.009741	**
Population Growth:Region	1622	540.6	0.9609	0.414909	
Residuals	49509	562.6			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

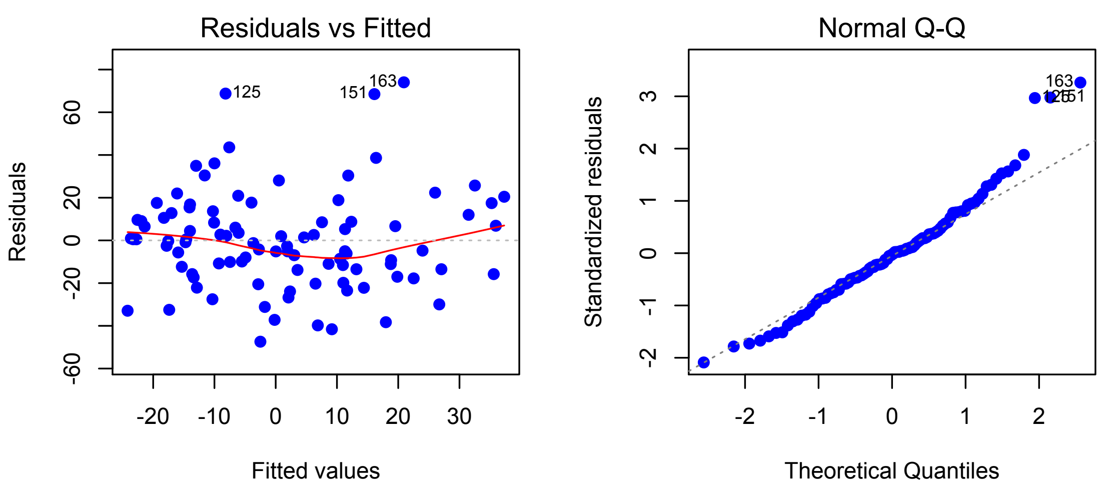


Figure 9-19: Diagnostic Plots for Final Model (Change in Total GHG)

9.6 Trip Length

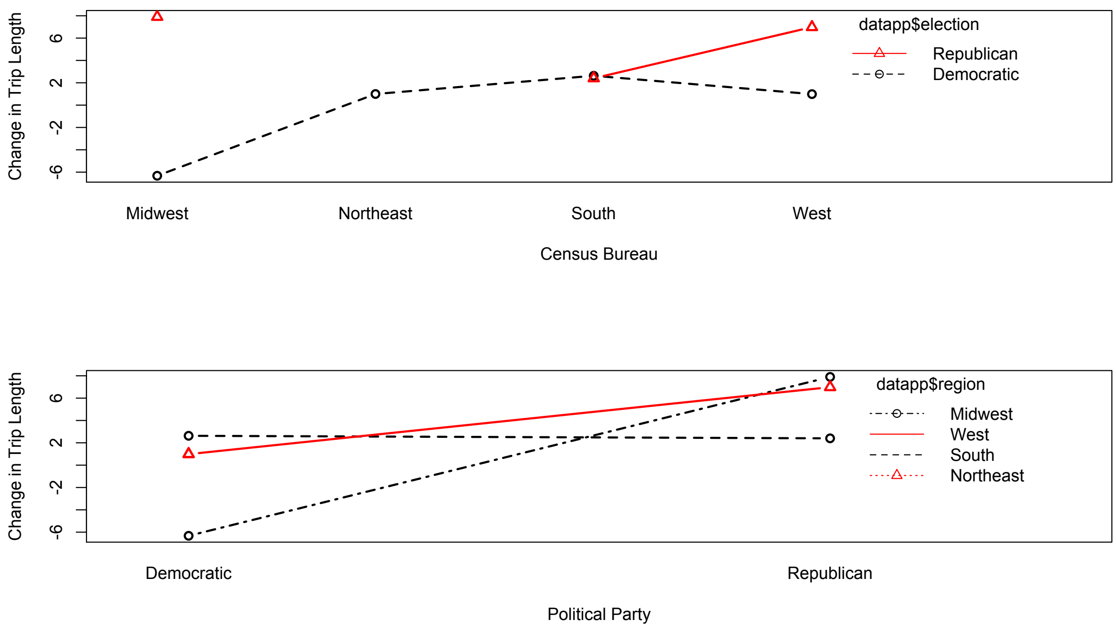


Figure 9-20: Interaction Plots (Change in Trip Length: Political Party and Change in Trip Length: Geographical Location)

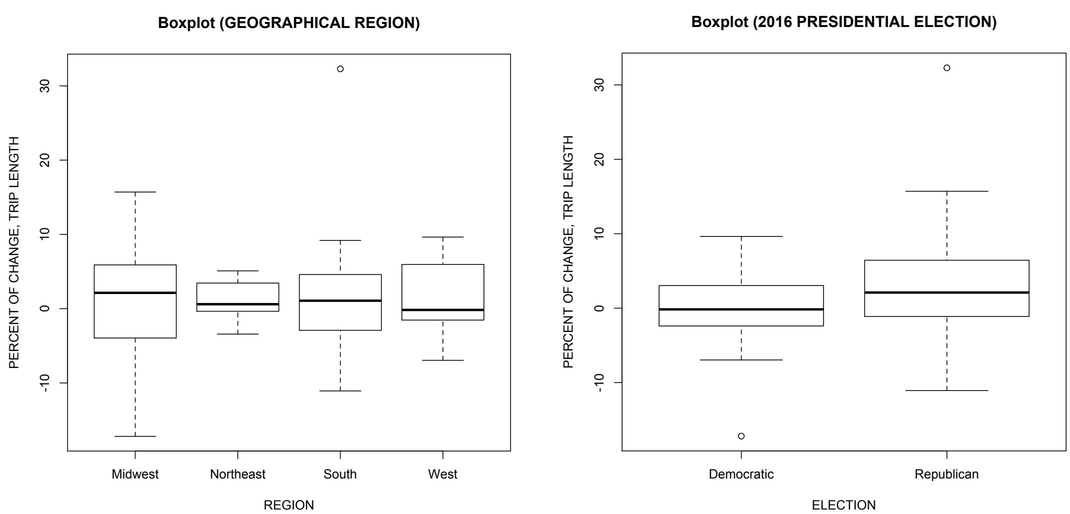


Figure 9-21: Boxplots for Categorical Variables and Percent of Change in Trip Length

Table 9-15: Analysis of Variance Table of Full Model (Change in Trip Length)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population	24.46	24.46	0.4664	0.50441	
Population Growth	433.39	433.39	8.2649	0.011	*
Fund Per Capita	44.17	44.17	0.8423	0.37236	
Planning Scenarios	8.57	8.57	0.1635	0.6913	
Region	43.98	14.66	0.2796	0.83933	
Election	299.05	299.05	5.703	0.02961	*
Population:Region	109.29	36.43	0.6947	0.56864	
Population Growth:Region	50.09	16.7	0.3184	0.81191	
Fund Per Capita:Region	39.43	13.14	0.2507	0.85969	
Planning Scenarios:Region	8.83	2.94	0.0561	0.9819	
Population:Election	0.06	0.06	0.0012	0.97275	
Population Growth:Election	377.97	377.97	7.208	0.01627	*
Residuals	839	52.44			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

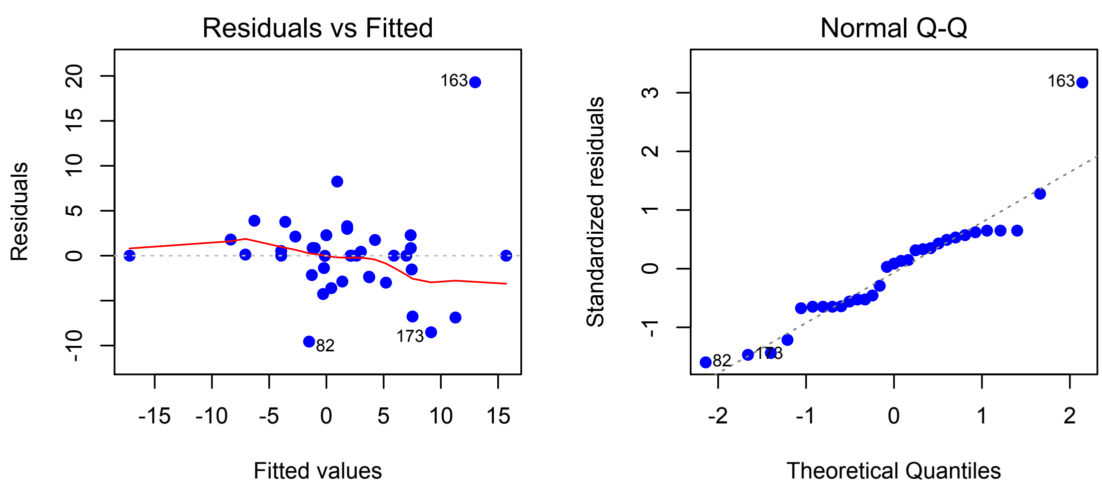


Figure 9-22: Diagnostic Plots for Full Model (Change in Trip Length)

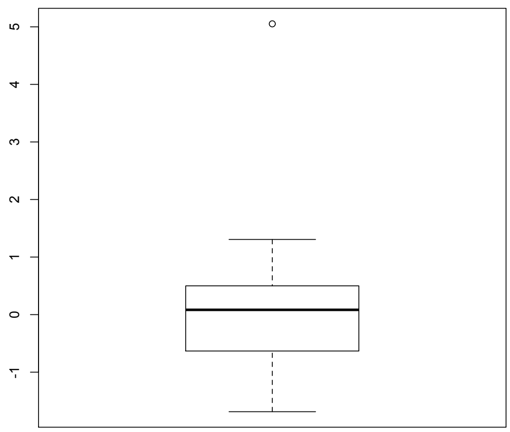


Figure 9-23: Boxplot of Rstudent to Check Outliers (Change in Trip Length)

Table 9-16: Analysis of Variance Table of Final Reduced Model (Change in Trip Length)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population Growth	172.94	172.938	9.3154	0.005653	**
Election	26.74	26.74	1.4403	0.2423	
Fund Per Capita	13.39	13.389	0.7212	0.404502	
Region	201.01	67.005	3.6093	0.02855	*
Population Growth:Election	5.61	5.613	0.3024	0.587704	
Election:Fund Per Capita	23.79	23.79	1.2815	0.269294	
Population Growth:Region	208.68	69.56	3.7469	0.025085	*
Fund Per Capita:Region	238.55	79.516	4.2832	0.015328	*
Residuals	426.99	18.565			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

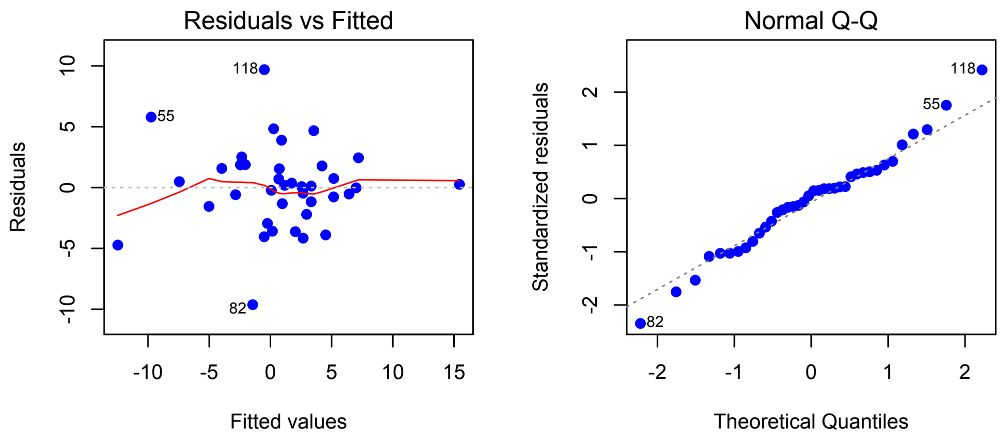


Figure 9-24: Diagnostic Plots for Final Reduced Model (Change in Trip Length)

9.7 VHD per Capita

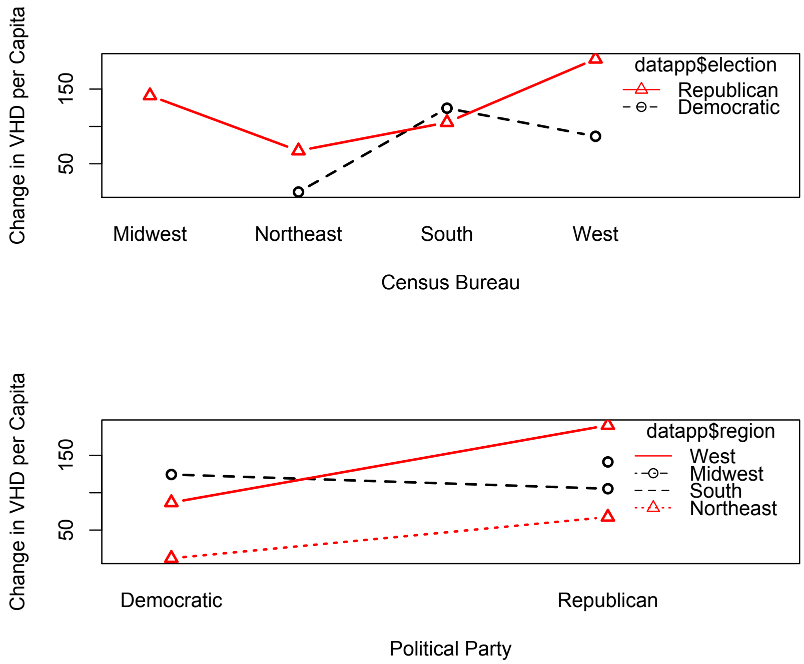


Figure 9-25: Interaction Plots (Change in VHD per Capita: Political Party and Change in VHD per Capita: Geographical Location)

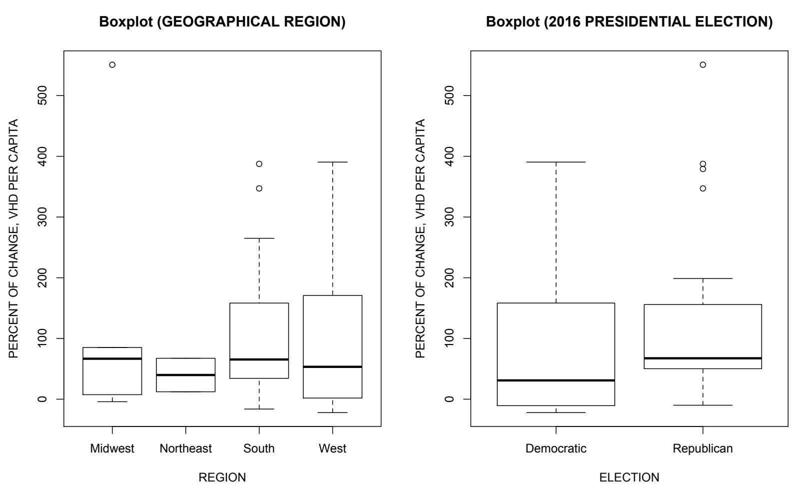


Figure 9-26: Boxplots for Categorical Variables and Percent of Change in VHD per Capita

Table 9-17: Analysis of Variance Table of Full Model (Change in VHD per Capita)

Independent Variables	Sum Square	Mean Square	F value	Pr(>F)	
Population	22040	22040	1.7896	0.19677	
Population Growth	13303	13303	1.0801	0.31171	
Fund Per Capita	290	290	0.0235	0.87972	
Planning Scenarios	34	34	0.0028	0.95839	
Region	26262	8754	0.7108	0.55749	
Election	3017	3017	0.245	0.62632	
Population:Region	117422	39141	3.1781	0.04772	*
Population Growth:Region	90216	45108	3.6626	0.04515	*
Fund Per Capita:Region	117948	58974	4.7884	0.0207	*
Planning Scenarios:Region	18353	9176	0.7451	0.48807	
Population:Election	23553	23553	1.9124	0.18273	
Population Growth:Election	30105	30105	2.4444	0.13445	
Fund Per Capita:Election	1	1	0.0001	0.99398	
Planning Scenarios:Election	23770	23770	1.9301	0.18082	
Residuals	234003	12316			

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

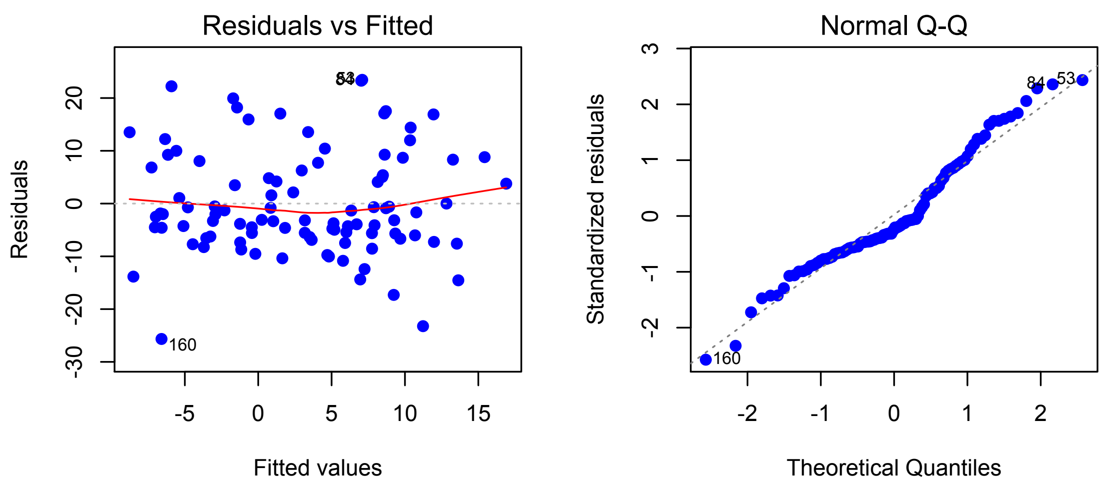
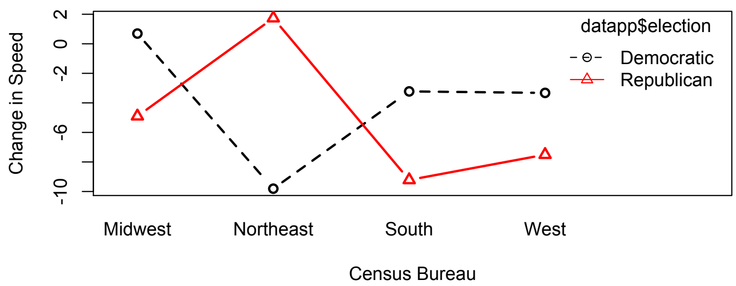


Figure 9-27: Diagnostic Plots for Full Model (Change in VHD per Capita)

9.8 Average Travel Speed



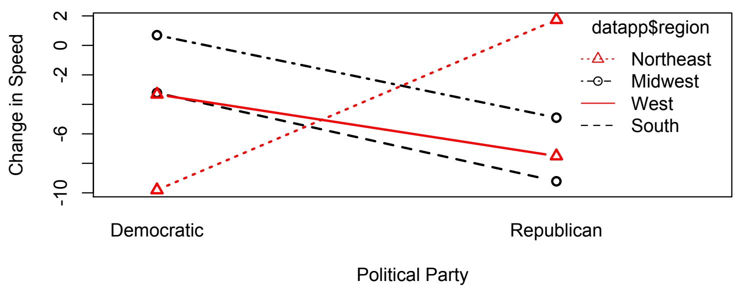


Figure 9-28: Interaction Plots (Change in Travel Speed: Political Party and Change in Travel Speed: Geographical Location)

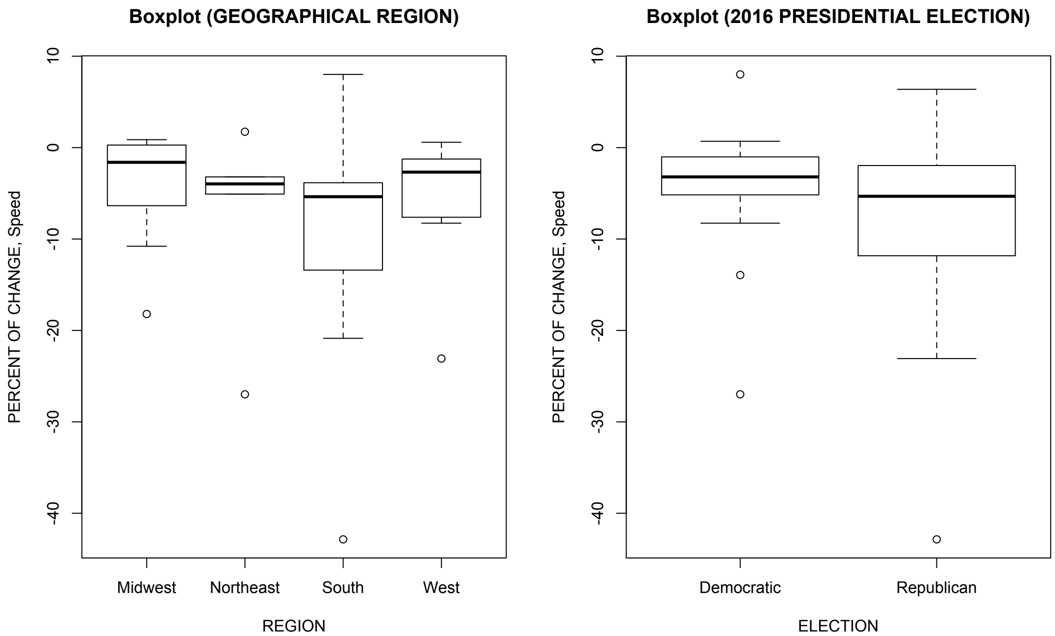


Figure 9-29: Boxplots for Categorical Variables and Percent of Change in Travel Speed

Table 9-18: Analysis of Variance Table of Full Model (Change in Travel Speed)

Variables	Sum Sq	Mean Sq	F value	Pr(>F)
Population	298.04	298.04	4.9546	0.03425 *
Population Growth	243.05	243.05	4.0404	0.05415 .
Fund Per Capita	356.59	356.59	5.928	0.02153 *
Planning Scenarios	4.67	4.67	0.0777	0.7825
Region	192.17	64.06	1.0649	0.37976
Election	107.71	107.71	1.7906	0.19162
Population:Region	88.48	29.49	0.4903	0.69184
Population Growth:Region	291.2	97.07	1.6136	0.20851
Fund Per Capita:Region	38.22	12.74	0.2118	0.88739
Planning Scenarios:Region	68.5	22.83	0.3796	0.76844
Population:Election	138.35	138.35	2.2999	0.1406
Population Growth:Election	59.29	59.29	0.9857	0.3293
Fund Per Capita:Election	315.77	315.77	5.2493	0.02969 *
Planning Scenarios:Election	10.21	10.21	0.1697	0.68352
Residuals	1684.32	60.15		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 7.756 on 28 degrees of freedom
Multiple R-squared: 0.5677, Adjusted R-squared: 0.1972
F-statistic: 1.532 on 24 and 28 DF, p-value: 0.1386

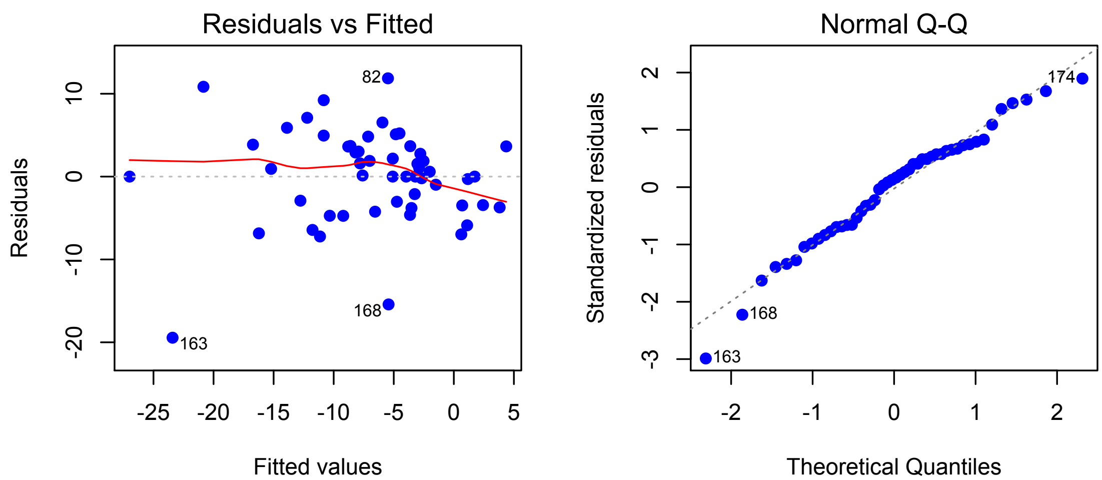


Figure 9-30: Diagnostic Plots for Full Model (Change in Travel Speed)

9.9 Number of Goals

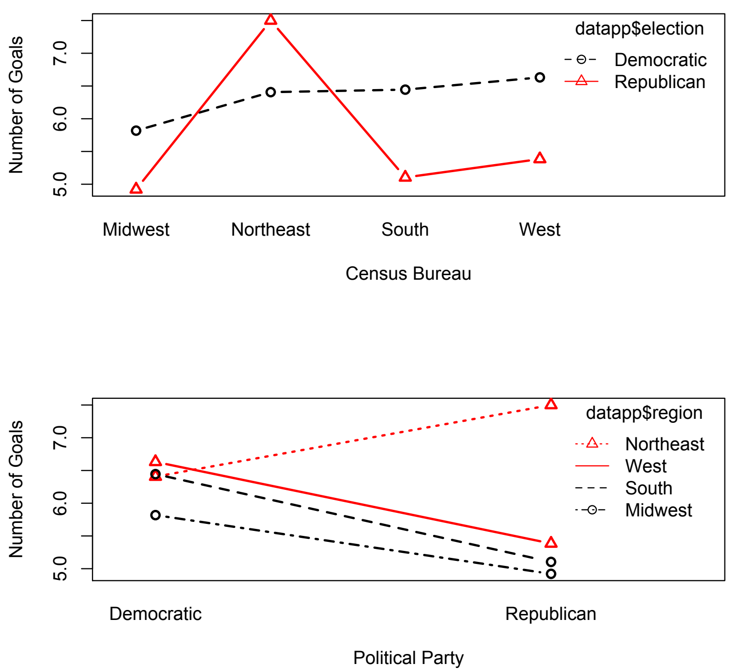


Figure 9-31: Interaction Plots (Number of Goals: Political Party and Number of Goals: Geographical Location)

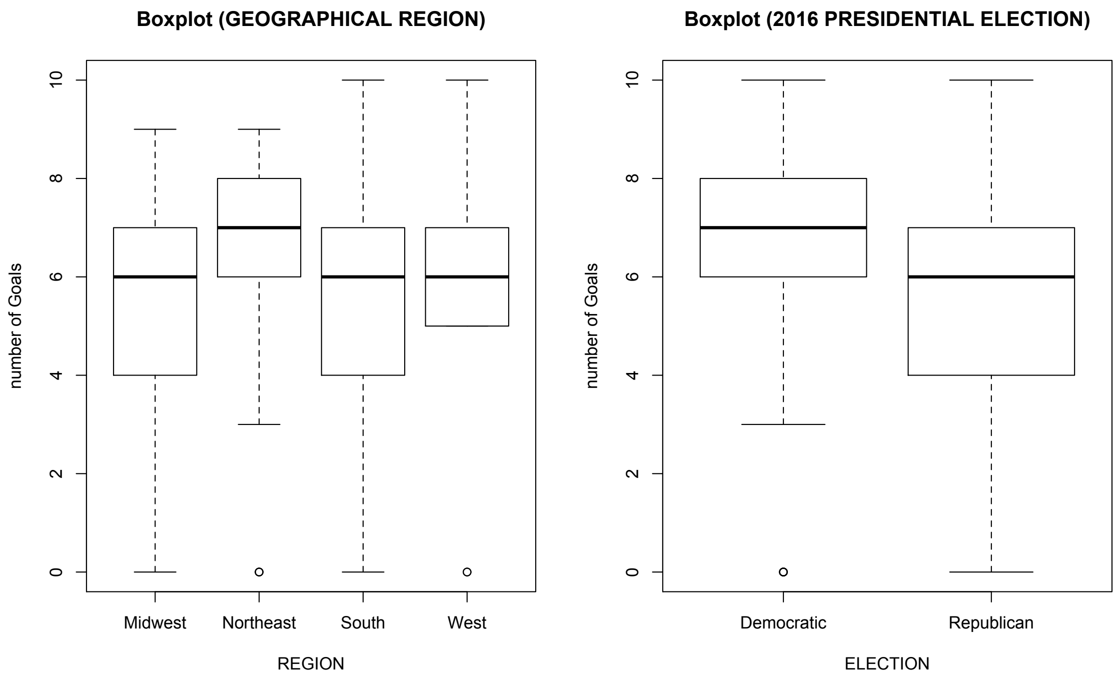


Figure 9-32: Boxplots for Categorical Variables and Number of Goals

9.10 Number of Performance Measures

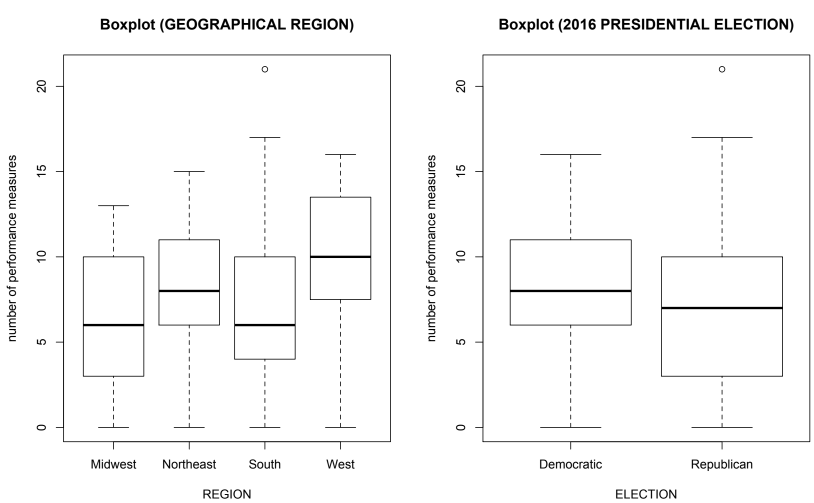


Figure 9-33: Boxplots for Categorical Variables and Number of Performance Measures

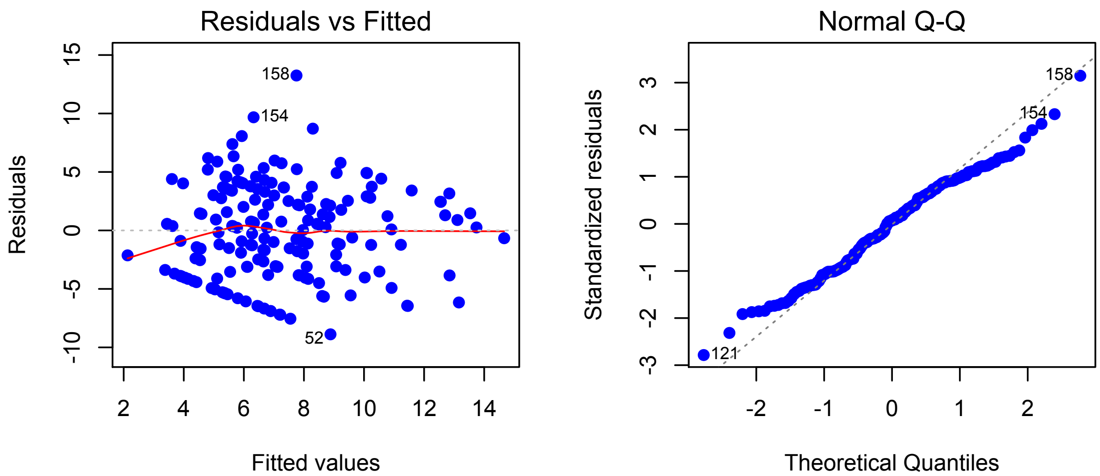


Figure 9-34: Diagnostic Plots for Full Model (Number of Performance Measures)

REFERENCES

- Algers, Staffan, Jonas Eliasson, and Lars-Göran Mattsson. 2005. “Is It Time to Use Activity-Based Urban Transport Models? A Discussion of Planning Needs and Modelling Possibilities.” *The Annals of Regional Science* 39 (4): 767–89. https://doi.org/10.1007/s00168-005-0016-8.

- Allison, Juliann, and Jonathan Davidson. 2008. “Collaborative Regional Planning in California: Potential Models for Sustainable Governance.” *Pol Icy Matter’s* 2 (2): 1–16.

- Amekudzi, Adjo, and Michael Meyer. 2006. “Considering the Environment in Transportation Planning: Review of Emerging Paradigms and Practice in the United States.” *Journal of Urban Planning and Development* 132 (1): 42–52. https://doi.org/10.1061/(ASCE)0733-9488(2006)132:1(42).

- Amekudzi, Adjo, Mshadoni Smith, Stefanie Brodie, Jamie Fischer, and Catherine Ross. 2012. “Impact of Environmental Justice on Transportation: Applying Environmental Justice Maturation Model to Benchmark Progress.” *Transportation Research Record: Journal of the Transportation Research Board* 2320 (December): 1–9. https://doi.org/10.3141/2320-01.

- Amirgholy, Mahyar, Mehrdad Shahabi, and H. Oliver Gao. 2017. “Optimal Design of Sustainable Transit Systems in Congested Urban Networks: A Macroscopic Approach.” *Transportation Research Part E: Logistics and Transportation Review* 103 (July): 261–85. https://doi.org/10.1016/j.tre.2017.03.006.

- Baer, William C. 1997. “General Plan Evaluation Criteria: An Approach to Making Better Plans.” *Journal of the American Planning Association* 63 (3): 329–44. https://doi.org/10.1080/01944369708975926.

- Bartholomew, Keith. 2006. “Land Use-Transportation Scenario Planning: Promise and Reality.” *Transportation* 34 (4): 397–412. https://doi.org/10.1007/s11116-006-9108-2.

- Bartholomew, Keith, and Reid Ewing. 2008. “Land Use–Transportation Scenarios and Future Vehicle Travel and Land Consumption: A Meta-Analysis.” *Journal of the American Planning Association* 75 (1): 13–27. https://doi.org/10.1080/01944360802508726.

- Batac, Tiffany, Guido Schattanek, and Michael D. Meyer. 2012. “NCHRP 08-36, Task 107 Synthesis of State DOT and MPO Planning and Analysis Strategies to Reduce Greenhouse Gas Emissions.” http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(107)_FR.pdf.

- Berke, Philip, and David Godschalk. 2009. “Searching for the Good Plan: A Meta-Analysis of Plan Quality Studies.” *CPL Bibliography* 23 (3): 227–240.
- Berke, Philip R., and Maria Manta Conroy. 2000. “Are We Planning for Sustainable Development?” *Journal of the American Planning Association* 66 (1): 21–33. https://doi.org/10.1080/01944360008976081.
- Bocarejo, Juan Pablo, and Daniel Ricardo Oviedo. 2012. “Transport Accessibility and Social Inequities: A Tool for Identification of Mobility Needs and Evaluation of Transport Investments.” *Journal of Transport Geography*, Special Section on Theoretical Perspectives on Climate Change Mitigation in Transport, 24 (September): 142–54. https://doi.org/10.1016/j.jtrangeo.2011.12.004.
- Boisjoly, Geneviève, and Ahmed M. El-Geneidy. 2017. “How to Get There? A Critical Assessment of Accessibility Objectives and Indicators in Metropolitan Transportation Plans.” Transport Policy 55 (Supplement C): 38–50. https://doi.org/10.1016/j.tranpol.2016.12.011.
- Bond, Alexander, Jeff Kramer, and Karen Seggerman, 2010. “Staffing and administrative capacity of Metropolitan Planning Organizations”. Federal Highway Administration.
- Brömmelstroet, Marco te, and Luca Bertolini. 2011. “The Role of Transport-Related Models in Urban Planning Practice.” *Transport Reviews* 31 (2): 139–43. https://doi.org/10.1080/01441647.2010.541295.
- Cambridge Systematics Inc. 2002. “Technical Methods to Support Analysis of Environmental Justice Issues, Project 8-36 (11).” Cambridge, Massachusetts: Prepared by Cambridge Systematics Inc for the National Cooperative Highway Research Program. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(11)_FR.pdf.
- Castiglione, Joe, Mark Bradley, John Gliebe, Strategic Highway Research Program Capacity Focus Area, Transportation Research Board, and National Academies of Sciences, Engineering, and Medicine. 2014. *Activity-Based Travel Demand Models: A Primer*. Washington, D.C.: Transportation Research Board. https://doi.org/10.17226/22357.
- Conroy, Maria Manta, and Philip R Berke. 2004. “What Makes a Good Sustainable Development Plan? An Analysis of Factors That Influence Principles of Sustainable Development, What Makes a Good Sustainable Development Plan? An Analysis of Factors That Influence Principles of Sustainable Development.” *Environment and Planning A: Economy and Space* 36 (8): 1381–96. https://doi.org/10.1068/a367.
- Dalton, Linda C., and Raymond J. Burby. 1994. “Mandates, Plans, and Planners: Building Local Commitment to Development Management.” *Journal of the American Planning Association* 60 (4): 444–61. https://doi.org/10.1080/01944369408975604.

- Davidson, William, Robert Donnelly, Peter Vovsha, Joel Freedman, Steve Ruegg, Jim Hicks, Joe Castiglione, and Rosella Picado. 2007. "Synthesis of First Practices and Operational Research Approaches in Activity-Based Travel Demand Modeling." *Transportation Research Part A: Policy and Practice*, Bridging Research and Practice: A Synthesis of Best Practices in Travel Demand Modeling, 41 (5): 464–88. https://doi.org/10.1016/j.tra.2006.09.003.

- Deyle, Robert E., and Ryan E. Wiedenman. 2014. "Collaborative Planning by Metropolitan Planning Organizations: A Test of Causal Theory." *Journal of Planning Education and Research* 34 (3): 257–75. https://doi.org/10.1177/0739456X14527621.

- Duthie, Jen, Ken Cervenka, and S. Waller. 2007. "Environmental Justice Analysis: Challenges for Metropolitan Transportation Planning." *Transportation Research Record: Journal of the Transportation Research Board* 2013 (December): 8–12. https://doi.org/10.3141/2013-02.

- Federal Highway Administration, and Federal Transit Administration. 2004. *The Metropolitan Transportation Planning Process: Key Issues*. FHWA-HEP-07-039. Washington, DC. www.planning.dot.gov.

- FHWA. 2017. "Performance-Based Planning and Programming: A Report to Congress." Federal Highway Administration. https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/regulations-and-guidance/transportation-planning/69421/performance-based-planning-report-congress-12018.pdf.

- Gerber, Elisabeth R., and Clark C. Gibson. 2009. "Balancing Regionalism and Localism: How Institutions and Incentives Shape American Transportation Policy." *American Journal of Political Science* 53 (3): 633–48. https://doi.org/10.1111/j.1540-5907.2009.00391.x.

- Gian-Claudia Sciara, and Susan Handy. 2017. "Regional Transportation Planning." In *The Geography of Urban Transportation*, Fourth. Guilford Publications. https://books.google.com/books?id=WE3IDAAAQBAJ&lr=&source=gbs_navlinks_s.

- Goetz, Andrew R., Paul Stephen Dempsey, and Carl Larson. 2002. "Metropolitan Planning Organizations: Findings and Recommendations for Improving Transportation Planning." *Publius: The Journal of Federalism* 32 (1): 87–105.

- Grant, Michael, William Seth Hartley, Ron Milam, Jerry Walters, Laurence O'Rourke, Jennifer Brickett, and Sonya Suter. 2013. "Handbook for Estimating Transportation Greenhouse Gases for Integration into the Planning Process." https://trid.trb.org/view.aspx?id=1280724.

- Grossman, Alice. 2018. “Adoption of Performance Measures in Regional Transportation Planning: Current Practice and Lessons for Future Applications”. School of Civil and Environmental Engineering. Georgia Institute of Technology.

- Guyadeen, Dave, and Mark Seasons. 2018. “Evaluation Theory and Practice: Comparing Program Evaluation and Evaluation in Planning.” *Journal of Planning Education and Research* 38 (1): 98–110. https://doi.org/10.1177/0739456X16675930.

- Handy, Susan. 2008. “Regional Transportation Planning in the US: An Examination of Changes in Technical Aspects of the Planning Process in Response to Changing Goals.” *Transport Policy*, New Developments in Urban Transportation Planning, 15 (2): 113–26. https://doi.org/10.1016/j.tranpol.2007.10.006.

- Hartell, Ann. 2017. “Performance Measures and the Uncertainties of Planning: Current Practice at Transportation Planning Organizations.” Paper. Institute for Multi-Level Governance and Development, WU/Vienna University of Economics and Business. http://www-sre.wu.ac.at/sre-disc/sre-disc-2017_03.pdf.

- Hatzopoulou, M., and E. J. Miller. 2009. “Transport Policy Evaluation in Metropolitan Areas: The Role of Modelling in Decision-Making.” *Transportation Research Part A: Policy and Practice* 43 (4): 323–38. https://doi.org/10.1016/j.tra.2008.11.001.

- Holmes, E.H., and J.T. Lynch. 1957. “Highway Planning :Past, Present, and Future.” *Highway Division, Proceedings of the ASCE* 83: 1–13.

- Iacono, Michael, David Levinson, and Ahmed El-Geneidy. 2008. “Models of Transportation and Land Use Change: A Guide to the Territory.” *CPL Bibliography* 22 (4): 323–40. https://doi.org/10.1177/0885412207314010.

- Jeon, Christy Mihyeon, Adjo A. Amekudzi, and Randall L. Guensler. 2013. “Sustainability Assessment at the Transportation Planning Level: Performance Measures and Indexes.” *Transport Policy* 25 (January): 10–21. https://doi.org/10.1016/j.tranpol.2012.10.004.

- Johnston, Robert A. 2004. “The Urban Transportation Planning Process.” In *The Geography of Urban Transportation*, third, 115–40. New York, NY: Guilford Press. https://trid.trb.org/view/756062.

- Jun, Hee-Jung. 2017. “The Link Between Local Comprehensive Plans and Housing Affordability: A Comparative Study of the Atlanta and Detroit Metropolitan Areas.” *Journal of the American Planning Association* 83 (3): 249–61. https://doi.org/10.1080/01944363.2017.1321496.

- Karner, Alex, and Deb Niemeier. 2013. “Civil Rights Guidance and Equity Analysis Methods for Regional Transportation Plans: A Critical Review of Literature and

Practice." *Journal of Transport Geography* 33 (December): 126–34. https://doi.org/10.1016/j.jtrangeo.2013.09.017.

- Knieling, Joerg, and Frank Othengrafen. 2015. "Planning culture—a concept to explain the evolution of planning policies and processes in Europe?." European Planning Studies 23.11: 2133-2147.

- Kramer, Jeff, Alexandria Carroll, and Behzad Karimi. 2017. "MPO Staffing and Organizational Structures." FHWA-HEP-18-058. Tampa, FL: Prepared by the Center for Urban Transportation Research University of South Florida for Federal Highway Administration. https://www.fhwa.dot.gov/planning/processes/metropolitan/related_topics/mpo_staffing/index.cfm.

- Larry Goode, Joseph S. Milazzo, Justin B. McCurry, Krista Tanaka, Brad Forbis, Stacie Hill, Jacob Garrison, and Nicholas Delgiudice. 2001. "Analysis of the Governance of Metropolitan Planning Organizations (MPOs) in the United States for Potential Application to North Carolina." FHWA/NC/2002-019. Raleigh, NC: North Carolina Department of Transportation. http://digital.ncdcr.gov/cdm/ref/collection/p249901coll22/id/727325.

- Laurian, Lucie, Jan Crawford, Maxine Day, Peter Kouwenhoven, Greg Mason, Neil Ericksen, and Lee Beattie. 2010. "Evaluating the Outcomes of Plans: Theory, Practice, and Methodology." *Environment and Planning B: Planning and Design* 37 (4): 740–757.

- Lee, Richard J., and Ipek N. Sener. 2016. "Transportation Planning and Quality of Life: Where Do They Intersect?" *Transport Policy* 48 (May): 146–55. https://doi.org/10.1016/j.tranpol.2016.03.004.

- Leonard, Kenneth J., John H. Suhrbier, Eric Lindquist, Michael J. Savonis, Joanne R. Potter, and Wesley R. Dean. 2008. "How Can Transportation Professionals Incorporate Climate Change in Transportation Decisions?" In *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I.* Washington, DC, USA: the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Department of Transportation. http://www.iooc.us/wp-content/uploads/2010/09/Impacts-of-Climate-Change-and-Variability-on-Transportation-Systems-and-Infrastructure-Gulf-Coast-Study-Phase-I.pdf.

- Lewis, Paul G. 1998. "Regionalism and Representation: Measuring and Assessing Representation in Metropolitan Planning Organizations." *Urban Affairs Review* 33 (6): 839–53. https://doi.org/10.1177/107808749803300606.

- Lindquist, Eric. 2007. “Climate Change and Adaptive Strategies in Sub-National Transportation Planning Agencies in the United States.” In . Vrije Universiteit, Amsterdam. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.550.6071&rep=rep1&type=pdf.

- Litman, Todd, and David Burwell. 2006. “Issues in Sustainable Transportation.” *International Journal of Global Environmental Issues* 6 (4): 331–47. https://doi.org/10.1504/IJGENVI.2006.010889.

- Luna, Marcos. 2015. “Equity in Transportation Planning: An Analysis of the Boston Region Metropolitan Planning Organization.” *The Professional Geographer* 67 (2): 282–94. https://doi.org/10.1080/00330124.2014.935160.

- Lyons, William, Haley Peckett, Lindsey Morse, Monisha Khurana, and Logan Nash. 2012. “Metropolitan Area Transportation Planning for Healthy Communities,” December. /view.aspx?id=1308608.

- Maantay, J. 2001. “Zoning, Equity, and Public Health.” *American Journal of Public Health* 91 (7): 1033–41.

- Manaugh, Kevin, Madhav G. Badami, and Ahmed M. El-Geneidy. 2015. “Integrating Social Equity into Urban Transportation Planning: A Critical Evaluation of Equity Objectives and Measures in Transportation Plans in North America.” *Transport Policy* 37 (January): 167–76. https://doi.org/10.1016/j.tranpol.2014.09.013.

- Margerum, Richard, Keith Bartholomew, Rebecca Lewis, Robert Parker, and Stephen Dobrinich. 2017. “Metropolitan Centers: Evaluating Local Implementation of Regional Plans and Policies.” *TREC Final Reports*, March. https://doi.org/10.15760/trec.164.

- Merriam-Webster. n.d. “Definition of EFFECTIVENESS.” Accessed August 15, 2018. https://www.merriam-webster.com/dictionary/effectiveness.

- Miller, John. 2011. “Characteristics of Effective Collaboration in Response to Diversified Transportation Planning Authority.” Research article. Advances in Decision Sciences. 2011. https://doi.org/10.1155/2011/725080.

- Nadafianshahamabadi, R., Tayarani, M., & Rowangould, G. M. .2017. “Differences in expertise and values: Comparing community and expert assessments of a transportation project”. *Sustainable cities and society* (28): 67-75. https://doi.org/10.1016/j.scs.2016.08.027

- “National Highway System - FHWA HEPGIS Maps.” n.d. Accessed November 28, 2016. http://hepgis.fhwa.dot.gov/fhwagis/#.

- Nelson, Arthur, Thomas Sanchez, James Wolf, and Mary Farquhar. 2004. "Metropolitan Planning Organization Voting Structure and Transit Investment Bias: Preliminary Analysis with Social Equity Implications." *Transportation Research Record: Journal of the Transportation Research Board* 1895 (January): 1–7. https://doi.org/10.3141/1895-01.

- Office of Management and Budget. 1993. "Government Performance Results Act of 1993." The White House. 1993. https://obamawhitehouse.archives.gov/node/19677.

- Ortuar, Juan de Dios, and Luis G. Willumsen. 2011. *Modelling Transport*. John Wiley & Sons.

- Oswald Beiler, Michelle, Leylin Marroquin, and Sue McNeil. 2016. "State-of-the-Practice Assessment of Climate Change Adaptation Practices across Metropolitan Planning Organizations Pre- and Post-Hurricane Sandy." *Transportation Research Part A: Policy and Practice* 88 (Supplement C): 163–74. https://doi.org/10.1016/j.tra.2016.04.003.

- Pan, Shuai, Yunsoon Choi, Anirban Roy, and Wonbae Jeon. 2017. "Allocating Emissions to 4 Km and 1 Km Horizontal Spatial Resolutions and Its Impact on Simulated NOx and O3 in Houston, TX." *Atmospheric Environment* 164: 398–415. https://doi.org/10.1016/j.atmosenv.2017.06.026.

- Plumeau, Peter, and Stephen Lawe. 2009. "Meeting the Challenge of Institutional Fragmentation in Addressing Climate Change in Transportation Planning and Investment." *Transportation Research Record: Journal of the Transportation Research Board* 2139 (December): 81–87. https://doi.org/10.3141/2139-10.

- Poorfakhraei, Amir, Mohammad Tayarani, and Gregory Rowangould. 2017. "Evaluating Health Outcomes from Vehicle Emissions Exposure in the Long Range Regional Transportation Planning Process." *Journal of Transport & Health* 6 (September): 501–15. https://doi.org/10.1016/j.jth.2017.05.177.

- Preston, John, and Fiona Rajé. 2007. "Accessibility, Mobility and Transport-Related Social Exclusion." *Journal of Transport Geography* 15 (3): 151–60. https://doi.org/10.1016/j.jtrangeo.2006.05.002.

- Proffitt, David G., Keith Bartholomew, Reid Ewing, and Harvey J. Miller. 2017. "Accessibility Planning in American Metropolitan Areas: Are We There Yet?:" *Urban Studies*, June. https://doi.org/10.1177/0042098017710122.

- Puentes, R., and L. Bailey. 2003. "Improving Metropolitan Decision Making in Transportation: Greater Funding and Devolution for Greater Accountability," October. http://trid.trb.org/view.aspx?id=678104.

- Ram B. Kulkarni, Deb Miller, Rosemary M. Ingram, Chi-Wah Wong, and Julie Lorenz. 2004. "Need-Based Project Prioritization: Alternative to Cost-Benefit Analysis." *Journal of Transportation Engineering* 130 (2). https://doi.org/10.1061/(ASCE)0733-947X(2004)130:2(150).

- Rowangould, Gregory, and Mohammad Tayarani. 2016. "Effect of Bicycle Facilities on Travel Mode Choice Decisions." *Journal of Urban Planning and Development* 142 (4): 04016019. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000341.

- Sanchez, Thomas W., and James F. Wolf. 2007. "Environmental Justice and Transportation Equity: A Review of MPOs." In *Growing Smarter: Achieving Livable Communities, Environmental Justice, and Regional Equity*, edited by Robert Doyle Bullard. Cambridge, MA: MIT Press.

- Savonis, Michael, Virginia R. Burkett, and Joanne R. Potter. 2008. "Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I."

- Schmidt, Nicholas, and Michael Meyer. 2009. "Incorporating Climate Change Considerations into Transportation Planning." *Transportation Research Record: Journal of the Transportation Research Board* 2119 (November): 66–73. https://doi.org/10.3141/2119-09.

- Sciara, Gian-Claudia. 2017. "Metropolitan Transportation Planning: Lessons From the Past, Institutions for the Future." *Journal of the American Planning Association* 83 (3): 262–76. https://doi.org/10.1080/01944363.2017.1322526.

- Seggerman, Karen, and Jeff Kramer. 2013. "Review of MPO Long Range Transportation Plans and Estimate of Statewide 2035 Metropolitan Area Financial Shortfal." FDOT BDK84 Task Work Order #932-04. Center for Urban Transportation Research. http://www.mpoac.org/documents/LRTP_Review2013.pdf.

- Singleton, Patrick A., and Kelly J. Clifton. 2017. "Considering Health in US Metropolitan Long-Range Transportation Plans: A Review of Guidance Statements and Performance Measures." *Transport Policy*. https://doi.org/10.1016/j.tranpol.2017.02.003.

- Susan Handy. 2002. "Accessibility-vs. Mobility-Enhancing Strategies for Addressing Automobile Dependence in the US." In . https://escholarship.org/uc/item/5kn4s4pb.

- Tayarani, Mohammad, Amir Poorfakhraei, Razieh Nadafianshahamabadi, and Gregory Rowangould. 2018. "Can Regional Transportation and Land-Use Planning Achieve Deep Reductions in GHG Emissions from Vehicles?" *Transportation Research Part D: Transport and Environment* 63 (August): 222–35. https://doi.org/10.1016/j.trd.2018.05.010.

- Tayarani, Mohammad, Amir Poorfakhraei, Razieh Nadafianshahamabadi, and Gregory M. Rowangould. 2016. “Evaluating Unintended Outcomes of Regional Smart-Growth Strategies: Environmental Justice and Public Health Concerns.” *Transportation Research Part D: Transport and Environment* 49 (December): 280–90. https://doi.org/10.1016/j.trd.2016.10.011.

- Transportation for America. 2017. “Transportation Performance Measures (2017 Survey).” https://t4america.org/wp-content/uploads/2017/02/MPO-Performance-Measures-Survey.pdf.

- Transportation Research Board. 2011. “How We Travel: A Sustainable National Program for Travel Data.” TRB Special Report 304. Washington, DC. http://www.trb.org/Publications/Blurbs/164998.aspx.

- U.S. Department of Transportation. 2012. “Moving Ahead for Progress in the 21st Century Act (MAP-21).” Text. Department of Transportation. August 14, 2012. https://www.transportation.gov/map21.

- U.S. Environmental Protection Agency. 2016. “Using MOVES for Estimating State and Local Inventories of On road Greenhouse Gas Emissions and Energy Consumption.” https://www.epa.gov/sites/production/files/2016-06/documents/420b16059.pdf.

- U.S. GAO. 2001. “GAO-02-12- Environmental Protection: Federal Incentives Could Help Promote Land Use That Protects Air and Water Quality.” GA 1.13:GAO-02-12. U.S. Government Printing Office. https://www.gpo.gov/fdsys/pkg/GAOREPORTS-GAO-02-12/content-detail.html.

- ———. 2009. “Metropolitan Planning Organizations: Options Exist to Enhance Transportation Planning Capacity and Federal Oversight.” GAO-09-868. United States Government Accountability Office. https://www.gao.gov/products/GAO-09-868.

- USDOT. 2015. “National Transportation Statistics.” BUREAU OF TRANSPORTATION STATISTICS. 2015. https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html.

- Vanasse Hangen Brustlin. 2007. “Determination of the State of the Practice in Metropolitan Area Travel Forecasting. Findings of the Surveys of Metropolitan Planning Organizations.” Vanasse Hangen Brustlin. http://onlinepubs.trb.org/onlinepubs/reports/VHB-2007-Final.pdf.

- Washington, Simon P., Ida van Schalkwyk, Sudeshna Mitra, Michael D. Meyer, Eric Dumbaugh, and Matthew Zoll. 2006. “Incorporating Safety into Long-Range Transportation Planning.” *NCHRP Report*, no. 546. https://trid.trb.org/view.aspx?id=781129.

- Weiner, Edward. 2013. *Urban Transportation Planning in the United States: History, Policy, and Practice*. Fourth. New York, NY: Springer.

- Willson, Richard. 2001. "Assessing Communicative Rationality as a Transportation Planning Paradigm." *Transportation* 28 (1): 1–31. https://doi.org/10.1023/A:1005247430522.

- Wolf, James F., and Mary Beth Farquhar. 2005. "Assessing Progress: The State of Metropolitan Planning Organizations under ISTEA and TEA-21." *International Journal of Public Administration* 28 (13–14): 1057–79. https://doi.org/10.1080/01900690500290629.

- Wolf, James F., and Margaret Fenwick. 2003. "How Metropolitan Planning Organizations Incorporate Land-Use Issues in Regional Transportation Planning." *State and Local Government Review* 35 (2): 123–31. https://doi.org/10.1177/0160323X0303500205.

- Zegras, Christopher, Joseph Sussman, and Christopher Conklin. 2004. "Scenario Planning for Strategic Regional Transportation Planning." *Journal of Urban Planning and Development* 130 (1): 2–13. https://doi.org/10.1061/(ASCE)0733-9488(2004)130:1(2).