Development of Alternative Measures of Transit Mode Share

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16. Abstract

Transit mode share is used as a critical barometer at various geographic levels. Its magnitudes and temporal trends play an important role in both policy debates at areawide levels (nationwide, states, regions, counties, cities) and in performance monitoring at sub-area levels (activity centers and corridors). The census journey-to-work data have typically been used for areawide measurement of transit's usual mode share, i.e., the share of workers who usually use transit for commuting. There has been much controversy and confusion in the literature about using census journey-to-work data for measuring transit mode share.

The objectives of this report are to examine the controversy and confusion in the literature and to develop alternative measures of transit mode share. This report covers the following aspects: 1) a framework for considering transit mode share and its measurement; 2) the relationship between transit's usual mode share and its actual mode share, i.e., the share of work trips that are made by transit as revealed by respondents to daily travel surveys; 3) the sensitivity of transit mode share to a variety of measurement concerns raised in the literature; 4) areawide measurement of transit mode share; 5) sub-area measurement of transit mode share; and 6) recommendations.

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EXECUTIVE SUMMARY

Problem Statement

Transit mode share is used as a critical policy barometer at various geographic levels. Its magnitudes and temporal trends play an important role in both policy debates at areawide levels (nationwide, states, regions, etc.) and in performance monitoring at sub-area levels (activity centers and corridors). The census journey-to-work data have typically been used for areawide measurement of transit's *usual mode share*, i.e., the share of workers who usually use transit for commuting. There has been much controversy and confusion in the literature about using census journey-to-work data for measuring transit mode share. Among the controversies is whether transit mode share should be measured only for locations where transit is available. The confusion relates to whether transit's usual mode share would understate transit's *actual mode share*, i.e., the share of work trips that are made by transit as revealed by respondents to daily travel surveys.

Objectives

The research goal was to examine the controversy and confusion in the literature and to develop alternative measures of transit mode share. To accomplish this goal, the research was designed to accomplish the following five objectives: 1) to develop a framework for considering the measurement of transit mode share; 2) to analyze the confusion on the relationship between transit's usual and actual mode shares; 3) to assess the sensitivity of transit mode share to a variety of controversies raised about using the census journey-to-work data to measuring transit mode share; 4) to examine areawide measurement of transit mode share; and 5) to examine sub-area measurement of transit mode share.

Findings and Conclusions

These objectives have been successfully achieved. The following summarizes the main findings and conclusions for each of these objectives.

Framework

- This framework specifies several key terminologies. *Transit mode share* refers generally to a measure of transit's share of travel among a set of modes in a particular market. An *alternative measure of transit mode share* refers to something that results from using a specific measure of travel, a specific set of modes, a specific travel market, and a specific method for data collection. A *measurement of transit mode share* refers to the act and process of carrying out a particular alternative measure of transit mode share.
- This framework specifies a general approach to developing alternative measures of transit mode that includes four sequential steps: 1) specifying the purpose of measurement; 2) specifying a set of criteria for evaluation; and 3) evaluating alternative measures using these criteria; and 4) selecting alternative measures based on this evaluation.

- The framework considers the purpose of measurement. Transit mode share is used primarily as a performance measure for both areawide and sub-area markets. Transit serves three primary policy objectives: congestion relief, travel options, and basic motorized mobility.
- This framework considers a set of evaluation criteria, including clarity, validity, modal consistency, statistical quality, cost of measurement, responsiveness, and timeliness.

Transit's Usual and Actual Mode Shares

Through both theoretical and empirical analyses using the 2001 National Household Travel Survey, it is clear that transit's usual mode share is greater than its actual mode share and the difference is significant, ranging from14.7 percent to 87.3 percent across 34 socio-demographic population segments in the nation. The reason is that more non-transit trips are made by workers who usually commute to work by transit than the number of transit trips made by workers who usually commute to work by non-transit. Despite this significant difference, transit's usual and actual mode shares are highly correlated. While it would not be an appropriate target for calibrating regional travel models, transit's usual mode share can still be used as a performance measure.

Sensitivity

The concerns raised in the literature over transit mode share are not unique to using journey-to-work data for measuring transit mode share. These concerns are not really about whether this practice is technically sound, but rather about this practice ignoring other alternative treatments for each of the four elements of measuring transit mode share. Any measurement of transit mode share can be subject to similar concerns. Rather than trying to avoid them, the focus should be on selecting alternative measures that are most appropriate for the particular situation at hand.

Areawide Measurement

There are two real alternative measures for areawide measurement of transit mode share. One is based on the number of person trips by all residents in areawide geography during a given period (a day, a week, etc.) for all purposes. The other is based on the number of workers who usually commute to their main job in a week. While the first option has several minor advantages, the second option has a significant advantage of minimal cost for implementation. The first option would require original data collection through statistical sampling every time measurement is required. With the relatively low magnitude of transit mode share experienced in Florida at areawide levels, the cost involved is too high for periodic measurement. The second option, on the other hand, can be implemented without any original data collection. It can be reliably measured annually for areawide geographies with a population of at least 65,000 using information contained in pre-tabulated tables from the Florida sample of the annual American Community Survey (ACS) starting 2006. The 2006 data are expected to be made public in August 2007.

Sub-Area Measurement

<u>Field Observations</u>. The Florida Department of Transportation (FDOT) should also consider using data from field observations to measure transit mode share for travel into activity centers and for travel passing cutlines across individual corridors. For an activity center, field observations would be made at the intersections of the center boundary and the radial facilities into the center during

the afternoon peak hours from 4 p.m. to 6 p.m. on a random sample of weekdays. Some estimate of how much transit mode share varies across weekdays would be required to determine the minimum number of weekdays for observation. For a corridor, field observations would be made at a random sample of corridor segments and weekdays. Similarly, some estimate of how much transit mode share varies across weekdays and corridor segments would be required to determine the number of days and segments for observation. Research is needed to assess the statistical variation of transit mode share across weekdays for given activity centers and across both weekdays and segments for corridors. Research also is needed to evaluate the improved accuracy in observed transit loading between in-vehicle load checks and roadside load checks.

Using Existing Processes. Studies under FDOT's MPO Transit Quality of Service Evaluation Program already identify activity centers and the longitudinal dimension of corridors in terms of activity centers at their two ends. Data on transit loading are already collected. These sub-areas consist of traffic analysis zones (TAZs). These studies are conducted in every metropolitan planning organization (MPO) region in Florida. These studies are conducted every time a local long range transportation plan is updated. It is recommended that FDOT slightly expand this program to include measuring transit mode share as well. Several changes to the current program would still be needed to implement this recommendation. To avoid major changes to the current program, this approach is designed for statewide sub-area measurement of transit mode share for the most recent update years. The standard process already in place for sub-area identification, data collection, and result submission greatly facilitates this statewide aggregation.

Small-Area Census Data. It is recommended that FDOT consider using small-area census data in the Census Transportation Planning Package (CTPP) for sub-area measurement of transit mode share for travel into activity centers and for travel within corridors that consist of TAZs. It is recommended that this approach be used for statewide sub-area measurement of transit mode share. The sub-areas for statewide sub-area measurement may be identified through one of two approaches. One would be those sub-areas from FDOT's Transit Quality of Service Evaluation Program. Alternatively, data at the TAZ level from the 2000 Census Transportation Planning Package (CTPP) can potentially be used to identify sub-areas throughout the state. In either case, a statewide sub-area measurement of transit mode share can be easily and reliably estimated. Research is needed, however, to develop a method for using CTPP 2000 in identifying activity centers and corridors, and to apply this method for measuring transit mode share.

Benefits

The results give FDOT several options to assess the effectiveness of transit policies in Florida. To assess the effectiveness of transit policies in Florida in providing travel options and basic motorized mobility, it is recommended that FDOT use post-2005 ACS for annual statewide measurement of transit mode share that is based on commuting under all conditions, with or without travel services available, and during all time periods. To assess the effectiveness of transit policies in Florida for congestion relief in individual sub-areas, it is recommended that FDOT use data from field surveys during the afternoon peak hours from 4 p.m. to 6 p.m. for periodic sub-area measurement of transit mode share. Further research is needed, however, to implement this option. In addition, two options are recommended to FDOT to assess the effectiveness of transit policies in Florida for congestion relief in sub-areas as a whole. Further research also is needed for both of these options.

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CHAPTER 1. INTRODUCTION

1.1. Importance

Mode share is a common subject in discussing investment priorities and the effectiveness of various modes among planning and engineering professionals and parties involved in the development and delivery of transportation services, as well as other interests such as environment groups. Pisarski (1996) emphasizes the importance as follows:

> Commuters' choice of mode of travel and the resultant split among the different modal sectors is a key issue in commuting analysis. The data on modal share are often viewed as the "Dow-Jones average" for commuting and are closely watched for changes or evidence of a new trend. This is largely because modal share is seen as having substantial bearing on energy consumption, environmental quality, facility operation, and investment needs. In no other area of commuting is public policy so focused on affecting commuter behavior; modal choice data are thus seen as a barometer of the effectiveness of that policy. That data are not always easy to decipher because of the inherent measurement complexity of the subject.

1.2. National Perspective

1.2.1. Census Journey-to-Work Data

One major source of modal share information is the journey-to-work data from the decennial census surveys since 1960. Workers who were 16 years or older were asked about the one mode they usually used to get to work during the week before the day on which they were surveyed. If more than one mode was involved in their commuting to work, they were asked to report the main mode, which is the one used for most of the distance. Data from this usual mode question can be used to determine transit's *usual mode share*, i.e., the share of workers who state that they usually use transit for commuting. When workers had more than one job, the journey-to-work data collected information for only the main job.

1.2.2. Debates

The census journey-to-work data have been at the center of policy debates on the role of public transit in the U.S. This is particularly true for the 2000 Census and related surveys. Opponents of federal involvement in supporting transit in low density areas have used the continued decline in transit mode share for commuting as a reason to argue for reducing federal transit funding (Cox and Utt 2002). In addition, this decline has been argued as evidence in a number of aspects: the failure of federal policy to shift travel from auto to transit (Love and Cox 1991; Winston 2000); transit not reducing congestion (Cox 2002); and implausibility of rosy scenarios of increasing future transit mode share (Cox and O'Toole 2004). Furthermore, others have argued in terms of the relatively small transit share as evidence that transit does not make much difference because even if transit mode share can be increased as a result of public policy, such increases would have minimum impacts on auto shares (Hensher 2003).

The transit industry, on the other hand, have used increases in transit ridership during the entire decade from 1990 to 2000 and particularly during the later half of the decade as a reason for increasing federal support to transit (STPP 2002). More important, the transit industry has argued that the census must be wrong and raised concerns about the design, conduct, etc. of the long form surveys. Some of these concerns are specific to 2000, including a change in the definition of a worker during the week before the survey day (APTA 2004). Most concerns, however, address the census journey-to-work data in general: 1) they exclude travel for non-commuting purposes; 2) they do not take into account travel to second jobs; 3) they collect only the main mode for multimodal commuting; and 4) they collect only the usual mode during an entire week (APTA 2004). The transit industry has further argued that it is misguided to measure transit mode share without taking into account if transit service is available or the level of transit service (Weyrich and Lind 1999; Millar and Guzzetti 2006).

1.2.3. Confusion

There is much confusion about how transit's usual mode share relates to its *actual mode share*, i.e., the share of work trips that are made by transit as revealed by respondents to daily travel surveys. Some appear to believe that the usual mode question in the census long form survey would lead to an understatement of transit's mode share (APTA 2004; STPP 2002). They reason that the usual mode question fails to count workers who use transit occasionally without realizing that the usual mode question also fails to count workers who use other modes occasionally. Pisarski (2003) takes into account both effects of the usual mode question. Pisarski (1996) believes that the use of transit by workers who usually use auto has a much greater effect on transit mode share than does the use of auto by workers who usually use transit, implying that transit's usual mode share would be lower than its actual mode share. But Pisarski (2003) believes that these two effects are likely to be a wash, implying that transit's usual and actual mode shares would be roughly the same. These beliefs, however, contradict what U.S. data have shown. Polzin and Chu (2005) measure transit's actual mode share with data from the National Household Travel Survey (NPTS) series for 1990, 1995, and 2001 and measure transit's usual mode share with a variety of sources, including the Decennial Census from 1970 to 2000, the American Community Survey from 2000 to 2002, the American Housing Survey for 1997, 1999, and 2001, and the NHTS series for 1990, 1995, and 2001. Their results show that transit's usual mode share is consistently greater than its actual mode share at the national level.

Data from the United Kingdom (UK) and the Netherlands add further confusion to the picture. According to Van Vuren and Bovy (1989), Terzis and Mogridge (1988) show with U.K. data that usual mode shares are higher than actual mode shares for car and train but lower for bus and others. Since car and train captured the largest shares (around 30%), it was concluded that usual mode shares are higher than actual mode shares for the major modes but lower for the minor modes. Using cross-sectional data and panel data from the Netherlands, however, van Vuren and Bovy (1989) show that usual mode shares are consistently higher than actual mode shares for bus and bicycle, but lower for car and walk. Van Vuren and Bovy further identify several potential factors that may influence the relative values of transit's usual and actual shares, and conclude that the relative values cannot be determined on a theoretical basis.

1.3. Florida Perspective

1.3.1. Ratio of Population and Ridership Growth Rates

The Government Accountability and Performance Act of 1994 requires the Florida Department of Transportation (FDOT) and other State agencies to implement performance-based program budgeting (PB^2). To meet this requirement, FDOT since fiscal year 1998 has been using the ratio of the statewide growth rate of transit ridership to the statewide growth rate of population as the key performance measure of its public transit program (OIG 1998).

One shortcoming of this ratio is that the spatial pattern of population growth rates does not match well with the spatial pattern of traffic congestion. The heaviest traffic congestion in Florida occurs largely in the largest urban counties, including Miami-Dade, Broward, Palm Beach, Hillsborough, Pinellas, Orange, and Duval. Based on an analysis of county-level population data from the Legislature's Office of Economic and Demographic Research (http://edr.state.fl.us/population.htm), percentage wise the six counties with the highest expected growth rates in population from 2000 to 2030 are all small counties, while the six counties with the largest population are all expected to grow much slower than the state as a whole (Miami-Dade, Broward, Pinellas, and Duval) or slightly faster than the state as a whole (Palm Beach and Hillsborough). Orange County is the only exception in that it is expected to grow significantly faster than the state as a whole.

1.3.2. Alternatives

Established by the Government Accountability and Performance Act of 1994, the Florida Legislature's Office of Program Policy Analysis and Government Accountability (OPPAGA 1999) assessed FDOT's public transit and other public transportation programs. OPPAGA concluded that the ratio of ridership to population growth rates is affected more by general economic conditions than by program performance and that the program's performance measures need modifications to better assess progress toward meeting the program's policy objectives.

OPPAGA (1999) proposed additional measures that assess the effectiveness of Florida's public transit policies to assist the Legislature in making policy and funding decisions. Specifically, OPPAGA recommended FDOT use transit mode share in terms of the percentage of commuters who use public transit as one such additional measure. However, in assessing the ability of state government to improve intra-city and inter-city mobility, the Committee on Transportation of the Florida Senate believed that transit mode share measured at the statewide level would be misleading and would not be an effective performance measure (Florida Senate 2001). This objection resulted from the concern that the measurement of transit mode share includes the entire state, even where there are no transit services. The Committee also determined that there was no statewide measurement of transit mode share available that includes only areas where service is provided.

1.4. Local Perspective

Local governments use transit mode share as a performance measure or to serve other purposes. According to Hendricks and Dyhouse (2002), for example, Hillsborough County is one of the few local governments in Florida that generates funds for public bus transit capital facilities through its roadway impact fee. Impact fees for transit can currently raise a small amount in places where fees are based upon current mode share. In this case, the land developer pays a fee that is reflective of the entire transportation impact from the development. The fee is then allocated across modes based upon current mode share. The existing transit mode share comes from estimates from U.S. Census data. However, local governments mostly use transit mode share as a performance measure in a variety of contexts. The following are just a few examples.

1.4.1. Comprehensive Plans

Local comprehensive plans often use transit mode share as a performance measure for local transit policies. Florida's City of Port Orange, for example, adopted a city-wide target of transit mode share in its 1998 Comprehensive Plan Update. Specifically, the City wanted to work with VOTRAN (i.e., the local transit agency) to achieve a 1.0% modal split for transit use by the year 2010, based upon a 0.51% transit mode share as reported in the 2000 Census.

1.4.2. Concurrency Requirements

It has also been proposed to use transit mode share as a performance measure for Washington State's concurrency requirements (Hallenbeck et al. 2006): "Development permits would only be denied if the transportation model predicted that trips generated by a project would cause an area's share of trips by a mode other than single occupant vehicles (SOV) to drop below an adopted standard. For example, a jurisdiction's concurrency standard might require that at least 10 percent of all p.m. peak period trips take place via a mode other than SOV. Development permits would then be issued on the basis of how the trips to be generated by that development might change the mode split estimated to occur within the concurrency study area. Using mode split standards as the concurrency measure is highly relevant, as it would be an excellent way to link concurrency practice to regional policy. It links development permits to the concept that as urban centers grow, mode choice must shift to higher percentages of shared ride travel."

1.4.3. Site Impact Analysis

The site impact analysis procedures of FDOT require the consideration of development impacts on transit mode share (Hendricks and Dyhouse 2002). These procedures are specifically geared toward determining a new development's roadway traffic impacts upon the State Highway System and the Florida Interstate Highway System. In these procedures, public transit is viewed as a motor vehicle trip reduction measure. Local governments in Florida can justify the use of transit service as a mitigating factor only if it can be proven that transit service will have the effect of shifting mode split and reducing motor vehicle trips to and from the development site, thereby maintaining established highway LOS standards. However, it is challenging to express that impact in the form of transit mode share, especially in areas where transit service is nonexistent or infrequent.

1.5. Document Objectives

This report documents a research effort to examine the concerns raised in the national debates and the confusion on the relationship between transit's usual and actual mode shares and to develop alternative measures of transit mode share for the information needs of state and local governments in Florida and other states. To accomplish this goal, the research was designed to accomplish the following five objectives: 1) to develop a framework for considering the measurement of transit mode share; 2) to analyze the confusion on the relationship between transit's usual and actual mode shares; 3) to assess the sensitivity of transit mode share to a variety of concerns raised about using the census journey-to-work data to measuring transit mode share; 4) to examine measurement of transit mode share at areawide levels (states, metropolitan areas, counties, cities); and 5) to examine measurement of transit mode share at sub-area levels (activity centers and corridors).

1.6. Document Organization

The remainder of this document is organized into five chapters. Chapter 2 describes a framework for considering transit mode share and its measurement. Chapter 3 explores the relationship between transit's usual and actual mode shares. Chapter 4 assesses the sensitivity of transit mode share to the concerns raised in the literature about using census journey-to-work data for measuring transit mode share. Chapter 5 examines areawide measurement of transit mode share. Chapter 6 examines sub-area measurement of transit mode share. Chapter 7 makes recommendations. While chapters 5 and 6 are parallel to each other, chapters 2 through 4 help narrow down the options for consideration in Chapters 5 and 6.

CHAPTER 2. FRAMEWORK

2.1. Terminology

2.1.1. Transit Mode Share

Transit mode share refers generally to transit's share of travel among a set of modes in a travel market. Transit mode share is used interchangeably with transit mode split, transit modal split, or transit market share.

2.1.2. Alternative Measures

An *alternative measure of transit mode share* refers to something that results from using a specific measure of travel, a specific set of modes, a specific travel market, and a specific method of data collection. Each of these four elements of an alternative measure is described below.

- Travel may be alternatively measured as the number of person trips, the number of person miles, or even the number of travelers.
- Transit mode share may be measured among motorized modes only or among both motorized and non-motorized modes.
- Travel markets are defined by combinations of trip characteristics. Travel markets may be defined by trip purpose, particularly work versus non-work purposes. The most prominent among the many characteristics used in defining travel markets are temporal and spatial dimensions. Temporally, travel may be separated into peak hours, off-peak hours, daily, etc. Spatially, travel may be separated into areawide and sub-area markets. *Areawide* markets refer to nationwide, states, regions, counties, or cities, while *sub-areas* refer to activity centers or corridors.

    - For areawide markets, certain locations may be excluded, such as locations without transit service being available.
    - For sub-area markets, travel may also be measured differently by referring to different segments of a trip. An alternative measure of transit mode share may be concerned about the origin only, the destination only, or the origin and destination pair. An alternative measure may be concerned only about a particular middle point of the trip when it passes through a location.

- Different methods of data collection may be used for measuring transit mode share. Data on travel may be collected through traveler surveys, field observations, or model simulations. Furthermore, data from surveys may be collected specifically for measuring transit mode share or may have already been collected for other purposes.

2.1.3. Measurement

A *measurement of transit mode share* refers to the act and process of carrying out a particular alternative measure of transit mode share. Carrying out any one measurement will have to specify each of the four elements in an alternative measure described above. Consider measuring transit mode share with census journey-to-work data as an example. The following is fixed for all measurement using census data: travel is in terms of the number of persons, the travel market is for work purposes, and data are collected through household surveys. The following can vary, depending on the need for any measurement: temporal and spatial dimensions as well as the orientation relative to the commute from home to work (origin, destination, or origin and destination pair).

2.2. General Approach

The fact that any measurement of transit mode share requires a specific treatment for each element in an alternative measure means that concerns can always be raised about this measure because it ignores other treatments of these elements. In the case of using census journey-to-work data to measure transit mode share, the concerns raised in the literature are not really about whether this practice is technically sound, but rather about the fact that this practice ignores other treatments of the four elements in any measurement. The only approach to avoiding similar concerns would be to provide transit mode share using a variety of alternative measures. However, such an approach is not necessary in many cases. More important, such an approach is not practical because of the high cost involved.

A reasonable approach is to use a particular alternative measure of transit mode share that is most appropriate for the particular situation and resources available. This is the general approach taken for developing alternative measures of transit mode share for this research. Specifically, there are four sequential steps: 1) specifying the purpose of measurement; 2) specifying a set of criteria for evaluating alternative measures of transit mode share; 3) evaluating alternative measures using these criteria; and 4) selecting alternative measures based on this evaluation. The rest of this chapter focuses on the first two steps; Chapters 3 and 4 evaluate the sensitivity of alternative measures with respect to the variety of concerns raised in the literature; Chapters 5 and 6 evaluate alternative measures in terms of other evaluation criteria; and Chapter 7 selects alternative measures in the form of recommendations.

2.3. Purpose of Measurement

Transit mode share is used primarily as a performance measure for both areawide and sub-area markets. Transit mode share is typically used to assess the effectiveness of public policies toward transit at areawide levels, and to assess the effectiveness of local transit programs or projects at sub-area levels.

2.3.1. Policy Objectives

Transit serves three primary policy objectives: congestion relief, travel options, and basic motorized mobility. Many other policy objectives may have also been stated for transit, but they are largely derived from these three. It is important to point out that the objectives of providing travel options and basic mobility are not about just making transit available, but rather they are about transit services being provided at reasonable costs in terms of both time and monetary costs. Technically, transit is available at varying costs to everyone who can walk. Transit services provided without reasonable costs do not represent practical travel options or basic mobility.

2.3.2. Effects on Measurement

Transit's public policy objectives impact the measurement of its mode share in different ways. Three are discussed below.

Markets. Transit policy objectives impact what specific alternative measures of transit mode share may be appropriate for certain travel markets. Consider three of the concerns raised in the literature that relate to travel markets:

- whether off-peak travel is considered,
- whether the availability and level of transit service are considered, and
- whether measurement is areawide or for sub-areas.

Table 2-1 summarizes how the treatment of these concerns depends on transit's public policies.

Table 2-1. Transit's Policy Objectives and Measurement of Transit Mode Share

Concern	***Policy Objectives***		
	Congestion Relief	***Travel Options***	***Basic Mobility***
Period	Peak hours	All time	All time
Service Level	Service available	All travel	All travel
Geography	Sub-areas	Areawide	Areawide

For providing travel options and basic mobility, measurement of transit mode share should be general to the broad market. That is, transit mode share would be a more effective performance measure for providing travel options and basic mobility if it is measured areawide, under all conditions of travel with or without transit services, and with all time periods considered. The availability of travel options and basic mobility is important at any time of a day everywhere. In terms of transit services, it is under conditions without transit services that making transit available at reasonable costs is essential to providing travel options and basic mobility.

For congestion relief, on the other hand, measurement of transit mode share should be limited to a specific sub-market for each of these concerns. Whether the availability and level of service should be considered depends on the relevant transit policy objectives. For the objective of congestion relief, travel made under conditions without transit at reasonable costs would need to be excluded from the denominator in any measurement. In areas where transit service is not available, congestion is not likely to be a serious problem in practice. Furthermore, including travel without reasonable transit costs would delude the positive effects of improved transit services in existing transit markets on transit mode share. Defined with an inclusive denominator, transit mode share may appear to be declining over time but, in fact, it is stable or increasing in the established markets. The decline would result from the very low share in newly expanded service areas. In terms of the other two concerns, the level of congestion is the heaviest in certain sub-areas during daily peak hours.

Trip Elements. Transit policy objectives also impact whether a particular trip segment is an appropriate basis for measuring transit mode share in sub-area markets. Consider measuring transit mode share for all trips that end in a particular corridor. Such a measurement may be consistent with congestion relief for travel to the corridor but is inconsistent with congestion relief for travel within the corridor.

Policy Strategies. When an alternative measure of transit mode share is consistent with congestion relief in a sub-area, it may not be necessarily consistent with the primary strategies adopted in that sub-area for congestion relief. For example, an alternative measure that is based on travel within a corridor would not be consistent with strategies that are designed to influence travel to or from the corridor. Employer-based demand management strategies for employers located in a given corridor would be examples of strategies to influence travel to or from the corridor. On the other hand, an alternative measure based on travel within a given corridor would be consistent with strategies to improve transit services within this corridor.

A related consistency also should be maintained for either areawide levels or sub-areas. When the particular strategies for achieving any transit policy objective focus on commuting, an alternative measure of transit mode share based on commuting would be consistent. If the strategies are general to travel for all purposes, it would be consistent to use an alternative measure of transit mode share that is based on travel for all purposes. Furthermore, it would also be consistent to use an alternative measure that is based on commuting travel only if the strategies are general to all purposes. It would not be consistent, however, to use an alternative measure that is based on travel for all purposes if the strategies are specific to commuting.

2.4. General Criteria

Several criteria for evaluating alternative measures of transit mode share are general and largely independent of the data used. Two are considered here: clarity and validity.

2.4.1. Clarity

Performance measures should be readily understood by their intended audience. This is particularly true for measures intended to be reported to agency governing bodies and to the public. Acceptance of measures by stakeholders at all levels will be facilitated if the measures are easy to understand. Transit mode share is readily understood and would be considered to meet this clarity criterion.

2.4.2. Validity

A valid measure is one that measures what is intended. For transit mode share, it is important to maintain the consistency discussed earlier with public policy objectives in general and with congestion relief strategies for sub-area markets in particular. However, achieving any of these objectives through transit investments or public policies is not necessarily consistent with the ultimate objective of increasing net societal benefits. Furthermore, increasing transit mode share is not necessarily consistent with increasing net societal benefits either. In both cases, consistency requires that societal benefits of transit investments or public policies be greater than societal costs of making these investments or implementing these public policies.

2.5. Specific Criteria

Other criteria for evaluating alternative measures of transit mode share are specific to the data used. These are more relevant to developing alternative measures of transit mode share in the current research effort because examining data collection methods is part of this effort.

2.5.4. Responsiveness

Transit mode share would be considered as a responsive performance measure if it changes in a meaningful way in both magnitude and direction when changes occur in transit investments or public policy toward transit. Part of the responsiveness is independent of the data used. As discussed earlier about the appropriateness of alternative measures of transit mode share for certain travel markets, transit mode share would be far more responsive for congestion relief when it is measured at sub-area levels than at areawide levels. But part of the responsiveness depends on the data used. The more data collection focuses on travel that is the target of specific transit projects or public policies, the more responsive the resultant measure of transit mode share. In addition, an alternative measure of transit mode share would be more responsive if it is based on data collected from individuals than if it is based on aggregated data.

2.5.1. Modal Consistency

Modal consistency requires that travel is identically measured for each mode. As an example, consider measuring transit mode share at a cutline that cuts across all longitudinal facilities in a corridor with auto as the only competing mode. Consistency means that the number of travelers passing this cutline needs to be counted 100 percent or estimated through a sampling process for both modes during the afternoon peak hours. Inconsistency can occur in a number of different forms, and these forms of inconsistency should be avoided at any cost. The following are three examples:

1. Travelers by transit and auto are determined through different processes. Travelers by transit are directly observed, but auto travelers are estimated by multiplying the total number of passing autos directly observed with assumed average auto occupancy.

2. Different units of travel are used for different modes. Auto travelers are directly observed at the cutline, but the total number of transit boardings along the entire corridor is used to represent transit travelers.

3. Multiple transit modes used in a given linked transit trip are included as separate units of travel when transit mode share is measured with data from a local survey. While the unit of travel for non-transit modes is linked person trips, including multiple transit modes would mean that the unit of travel for transit is not linked trips.

2.5.2. Statistical Quality

The statistical quality of an alternative measure of transit mode share relates to its sampling errors and non-sampling errors (i.e., measurement errors). Sampling errors result when an alternative measure is based on a sample of travel rather than the entire population of travel. The only way to control sampling errors is to use data that are collected through statistical sampling. Cochran (1977) is a good source of techniques on statistical sampling. Measurement errors, on the other hand, include any other error that does not result from sampling but result from the entire measurement process including data collection, recording, processing, and reporting. Measurement errors are independent of whether sampling is used.

2.5.3. Cost

If cost were not an issue, measuring transit mode share would always be based on 100-percent counts rather than sampling. But, resources are always limited and as a result, sampling is frequently used. Furthermore, even sampling is not always feasible when transit mode share is relatively low in magnitude.

2.4.5. Timeliness

Timely reporting allows everyone to understand the benefits that resulted from actions to improved service, and also allows agencies to quickly identify and react to problem areas. Automating some aspects of data collection may help to develop more timely reports. Timeliness depends largely on cost considerations if measurement is based on original data collection. Timeliness is determined by the timing of data release and frequency of data collection if measurement is based on existing data.

2.4.6. Other Considerations

One other consideration is whether an alternative measure would allow measurement that is specific to a certain time of day, such as afternoon peak hours. Existing data, for example, may be collected by time of day but summarized for an entire day, preventing measurement for afternoon peak hours. Another consideration is the sensitivity of transit mode share to alternative measures in response to the concerns raised in the literature.

CHAPTER 3. TRANSIT'S USUAL AND ACTUAL MODE SHARES

3.1. Introduction

Through both theoretical and empirical analyses, this chapter clears the confusion in the literature about the relationship between transit's usual and actual mode shares. The next section develops a simple aggregate model of workers commuting to work by transit or by non-transit means. This model is used to establish a necessary and sufficient condition for transit's usual mode share being greater than its actual mode share. This theoretical analysis is followed by a data section describing the 2001 National Household Travel Survey (NHTS) and its variables used. The section on empirical analysis then uses NHTS to determine whether the necessary and sufficient condition is satisfied and to compare transit's usual and actual mode shares.

3.2. Theoretical Analysis

3.2.1. Setup

Consider a group of W workers who commute to work by transit or by non-transit means. Without losing generality, W is normalized to 1 to simplify the notations below. Let S_t^u be their share using transit as the usual mode during any week, and they will be referred to as the regular transit users. Similarly, let S_n^u be their share using non-transit as the usual mode during any week, and they will be referred to as the regular non-transit users. Assume that these two groups of commuters make the same number of daily one-way work trips on average. This number is smaller than 2 in general because of working at home, absenteeism, vacations, illness, so forth (Pisarski 1996). Without losing generality, this average daily number of commuting trips is normalized to 1.

On an average day, the regular transit users as a group make S_t^u work trips, but not all of these are trips by transit. Some of the regular transit users will use non-transit. Let D_t be the number of non-transit work trips by the regular transit users as a share of their total work trips. This share represents the occasional use of non-transit means on an average day by the regular transit users, and will be referred to as the disloyalty rate of the regular transit users. Thus, the regular transit users make $(1-D_t)\,S_t^u$ transit trips and $D_t\,S_t^u$ non-transit trips. Similarly, let D_n be the number of transit work trips by the regular non-transit users as a share of their total work trips on an average day. The regular non-transit users as a group make S_n^u work trips, with $D_n\,S_n^u$ transit trips and $(1-D_n)\,S_n^u$ non-transit trips. Similar to D_t, D_n represents the occasional use of transit on an average day by the regular non-transit users, and will be referred to as the disloyalty rate of the regular non-transit users. Table 3-1 summarizes these quantities.

Table 3-1. Model Summary

Weekly Usual Mode	*Number of Workers by Usual Mode*	*Daily Work Trips by Actual Mode*		
		Transit	*Non-Transit*	*Total*
Transit	$S_t^u W$	$(1-D_t) S_t^u$	$D_t S_t^u$	S_t^u
Non-Transit	$S_n^u W$	$D_n S_n^u$	$(1-D_n) S_n^u$	S_n^u
Total	W	$(1-D_t) S_t^u + D_n S_n^u$	$D_t S_t^u + (1-D_n) S_n^u$	1

3.2.2. Actual Mode Share

Under these conditions, the total number of work trips by all workers on any single day is 1, with $(1-D_t) S_t^u + D_n S_n^u$ being transit trips, and the rest being non-transit trips. Let S_t^a be transit's actual share of all work trips by all workers on an average day. Then we have the following relationship between transit's usual and actual mode shares (S_t^u and S_t^a):

$$S_t^a = \left(1 - D_t\right) S_t^u + D_n S_n^u. \quad (3\text{-}1)$$

The disloyalty rates by the regular transit users and non-transit users (D_t and D_n) provide the bridge between the two shares. For given values on transit's usual mode share and the disloyalty rates, equation (3-1) predicts transit's actual mode share. When transit's usual shares from Census journey-to-work data are used for calibrating regional travel demand models and data are available on usual mode shares and disloyalty rates, equation (3-1) may be used to convert usual shares to actual shares for calibrating regional travel demand models.

3.2.3. Necessary and Sufficient Condition

Equation (3-1) can be used to establish a condition for determining whether transit's usual mode share is greater than its actual share. Specifically, using equation (3-1) with minor manipulation leads to $S_t^u - S_t^a = D_t S_t^u - D_n S_n^u$. This difference is positive, and hence transit's usual mode share is greater than its actual share, if and only if the following is true:

$$D_t S_t^u > D_n S_n^u. \quad (3\text{-}2)$$

Based on notations in Table 3-1, $D_t S_t^u$ is the number of non-transit work trips on an average day by the regular transit users as a share of the total number of work trips by all workers. It may be referred to as the overall disloyalty rate against transit. $D_n S_n^u$, on the other hand, is the number of transit work trips on an average day by the regular non-transit users as a share of the total number of work trips by all workers. This may be referred to as the overall disloyalty rate against non-transit. Thus, a necessary and sufficient condition for transit's usual mode share to be greater than its actual mode share is that the overall disloyalty rate against transit is greater than the overall disloyalty rate against non-transit.

The concept of mode loyalty is not new. This concept has been explicitly used by a number of authors in their analysis of transit mode share (Pisarski 2003; Polzin and Chu 2005; McGuckin and Srinivasan 2003; McGuckin and Srinivasan 2005). These authors, however, limit the use of mode loyalty to D_t and D_n, but overlook $D_t S_t^u$ and $D_n S_n^u$. While D_t and D_n bridge the relationship between transit's usual and actual mode shares, it is $D_t S_t^u$ and $D_n S_n^u$ that determine their relative values.

3.3. Data

3.3.1. Survey

NHTS collected data about persons and their one-way trips on designated travel days for a national random sample of 69,817 households. A one-way trip is defined as any time a subject went from one address to another for purposes other than changing the mode. The travel days were assigned to all days of the week and all seasons from March 2001 through June 2002. The travel day started at 4:00 a.m. of the day assigned and continued until 3:59 a.m. of the following day. Travel data were collected through telephone interviews to get information on pre-mailed travel diaries.

3.3.2. Database

The survey data have been compiled into a database. The database includes the purpose and modes of transportation among other things for each one-way trip. If more than one mode is used on a one-way trip, the mode that covered the most distance is designated as the main mode for that trip. Commuting to and from work is one of the many purposes.

The database includes several personal characteristics. For all respondents these include age, gender, whether the person was a driver, and whether the person had any medical conditions that made travel difficult. For workers (who worked for pay or profit during the week before the travel day), the survey collected journey-to-work data similar to those in the decennial census, including the usual commuting mode. In addition, the proximity of a worker's work place to transit facilities has been appended. The proximity for bus services is the shortest distance to the nearest bus line, and is the shortest distance to the nearest rail station for rail services.

The database also includes various household characteristics, including race, ethnicity, annual household income, vehicles available, and whether the residence is owned or rented. Similar to the proximity of a worker's work place to transit facilities, data have been appended to the database on the proximity of a household location to transit facilities. The database has also added the geographical characteristics of the area in which a household is located. These include the state, the statistical metropolitan area (MSA), whether the MSA has rail, the population size of the MSA, and whether the household is in a suburb or an urban area.

The database includes weights to expand the sample to national annual totals. Details about this survey and its databases can be found in the User's Guide (FHWA 2004).

3.3.4. Direct Measurement

For each segment defined by the various personal and household characteristics, NHTS can be used to determine the number of workers by their usual mode for commuting during the week before their travel day. In addition, the work trips made by these workers on their designated travel day can be tabulated by their usual mode and their actual mode used on the travel day. From these exercises, one can then get quantities on the number of workers and work trips by mode as illustrated in Table 3-2.

Table 3-2. Workers and Work Trips by Mode

Weekly Usual Mode	***Number of Workers by Usual Mode***	***Daily Work Trips by Actual Mode***		
		Transit	***Non-Transit***	***Total***
Transit	W_t	T_{tt}	T_{tn}	$T_t^u = T_{tt} + T_{tn}$
Non-Transit	W_n	T_{nt}	T_{nn}	$T_n^u = T_{nt} + T_{nn}$
Total	$W = W_t + W_n$	$T_t^a = T_{tt} + T_{nt}$	$T_n^a = T_{tn} + T_{nn}$	$T = T_t^a + T_n^a$

These quantities can then be used to directly measure the key parameters of the model as follows: $S_t^u = W_t/W$, $S_n^u = W_n/W$, $S_t^a = T_t^a/T$, $D_t = T_{tn}/T_t^u$, and $D_n = T_{nt}/T_n^u$. In addition, the overall mode disloyalty rates can be directly measured with the quantities in Table 3-2 as well. Specifically, the overall disloyalty rate against transit is T_{tn}/T and the overall disloyalty rate against non-transit is T_{nt}/T.

3.4. Empirical Analysis

This section uses NHTS to check if the necessary and sufficient condition for transit's usual mode share being greater than its actual share is met. In addition, this section uses NHTS to directly measure and compare transit's usual and actual mode shares. Finally, this section examines accuracy of using equation (3-1) to predict transit's actual mode share.

These analyses are done for the U.S. as a whole and for 34 transit segments defined by a total of 14 characteristics. Three of these are personal characteristics including a worker's gender, whether the worker is a driver, and whether the worker has a medical condition that negatively affects travel. Five are household characteristics including ethnicity, race, whether the residence is owned or rented, annual household income, and household vehicle availability. One characteristic measures the proximity of a worker's residence (O) and work place (D) to transit facilities in miles. Proximity is measured by the smaller of the distance to the nearest bus line and the distance to the nearest rail station. The last five relate to geographic features, including whether the worker lives in a suburb or an urban area, the size of a metropolitan area, whether rail is present, select individual metropolitan areas, and select individual states.

3.4.1. Necessary and Sufficient Condition

Table 3-3 shows the overall disloyalty rates that are directly measured from NHTS for the U.S. as a whole and all 34 transit segments. The overall disloyalty against transit is measured by T_{tn}/T

while the overall disloyalty against non-transit by T_{nt}/T. The overall disloyalty rates vary widely across the 34 transit segments, ranging from 0.23 percent (MSA Size-Other) to 11.18 percent (0-vehicle). The overall disloyalty rate against non-transit ranges from 0.04 percent (Texas) to 1.71 percent (0-vehicle).

More important, comparing columns (3) and (4) in Table 3-3 clearly shows that the overall disloyalty rate against transit is greater than the overall disloyalty rate against non-transit. For the country as a whole, for example, the overall disloyalty rate against transit is 1.52 percent versus 0.33 percent against non-transit. This suggests that the necessary and sufficient condition for transit's usual mode share to be greater than its actual share is met with NHTS. As a result, one would expect that transit's usual share be greater than its actual share.

Table 3-3. Overall Disloyalty Rates (Percent)

(1)	*(2)*	*(3)*	*(4)*
Characteristics	***Segments***	***Overall Disloyalty against Transit*** (T_{tn}/T)	***Overall Disloyalty against Non-Transit*** (T_{nt}/T)
Gender	Male	1.39	0.27
	Female	1.67	0.41
Driver Status	Driver	1.22	0.28
	Non-Driver	8.22	1.53
Medical Condition	With	3.06	1.03
	Without	1.38	0.29
Ethnicity	Hispanic	1.75	0.58
	Non-Hispanic	1.48	0.30
Race	White	1.04	0.19
	Black	3.94	0.78
Housing	Own	1.07	0.27
	Rent	2.70	0.49
Household Income	Under 15K	2.80	0.60
	15K+	1.30	0.27
Vehicle Availability	0	11.18	1.71
	1	3.08	0.76
	2+	0.77	0.17
Proximity to Bus Lines/Rail Stations (miles)	O<0.1 & D<0.05	4.68	0.71
	O<0.1 or D<0.05	2.16	0.51
	O≥0.1 & D≥0.05	0.32	0.11
Land Use	Suburban	1.43	0.32
	Urban	5.33	0.90
MSA Size	Other	0.23	0.12
	1-3 million	0.96	0.30
	3+ million	3.35	0.59
Rail	MSA with Rail	3.62	0.69
	Other	0.55	0.16
Metropolitan Area	New York	6.38	1.29
	Washington	3.96	0.51
State	Maryland	3.47	0.70
	New York	6.17	1.40
	Texas	0.53	0.04
	Wisconsin	0.24	0.11
U.S.		1.52	0.33

3.4.2. Mode Shares

Table 3-4 compares transit's usual and actual mode shares that are directly measured from NHTS. Specifically, column (3) shows transit's usual mode share; column (4) shows transit's actual mode share; and column (5) shows the percent deviation between the two shares.
Transit's usual mode share is measured by $S_t^u = W_t/W$, while transit's actual mode share is measured by $S_t^a = T_t^a/T$.

For the U.S. as a whole and each of the 34 transit segments, transit's usual mode share (column 3) is always larger than its actual mode share (column 4). For the U.S. as a whole, for example, transit's usual mode share is 5.05 percent, and its actual mode share is 3.75 percent. For workers living in households with no vehicles available, transit's usual mode share is 50.22 versus 43.80 for its actual mode share.

The degree of deviation between transit's usual and actual mode shares is significant. The deviation ranges from 14.7 percent to 87.3 percent. Specifically, transit's usual mode share is greater than its actual mode share by 87.3 percent among workers living in Texas, and by 14.7 percent among workers living in households with an annual household income below $15,000. Overall, the deviation between transit's usual mode share and its actual mode share is under 25 percent for 4 transit segments, ranges from 25 percent and 50 percent for 25 transit segments, and is over 50 percent for the other 5 segments. In terms of absolute values, the deviation is the largest at 6.42 percentage points for workers living in households without any vehicle available, and the smallest at 0.20 percentage points in areas outside the MSAs with at least 1 million population.

Table 3-4. Transit's Usual and Actual Mode Shares and Their Deviations (Percent)

(1)	*(2)*	*(3)*	*(4)*	*(5)*
Characteristics	***Segments***	***Transit's Usual Mode Share*** ($S_t^u = W_t/W$)	***Transit's Actual Mode Share*** ($S_t^a = T_t^a/T$)	***Deviation*** $\frac{\textbf{Column (3)-Column (4)}}{\textbf{Column (4)}}$
Gender	Male	4.37	3.16	38.3
	Female	5.84	4.50	29.8
Driver Status	Driver	3.52	2.61	34.9
	Non-Driver	33.69	28.02	20.2
Medical Condition	With	9.81	8.39	16.9
	Without	4.94	3.67	34.6
Ethnicity	Hispanic	9.30	7.20	29.2
	Non-Hispanic	4.50	3.27	37.6
Race	White	2.87	2.02	42.1
	Black	13.32	9.65	38.0
Housing	Own	2.91	1.92	51.6
	Rent	10.89	8.58	26.9
Household Income	Under 15K	9.00	7.35	22.4
	15K+	4.31	2.90	48.6
Vehicle Availability	0	50.22	43.80	14.7
	1	9.96	7.22	38.0
	2+	1.98	1.26	57.1
Proximity to Bus Lines/Rail Stations (miles)	O<0.1 & D<0.05	17.63	14.04	25.6
	O<0.1 or D<0.05	6.49	4.60	41.1
	O≥0.1 & D≥0.05	1.01	0.68	48.5
Land Use	Suburban	4.32	3.23	33.7
	Urban	19.53	15.04	29.9
MSA Size	Other	0.55	0.35	57.1
	1-3 million	2.83	2.10	34.8
	3+ million	11.47	8.76	30.9
Rail	MSA with Rail	13.55	10.45	29.7
	Other	1.59	1.12	42.0
Metropolitan Area	New York	26.55	20.57	29.1
	Washington	11.99	8.70	37.8
State	Maryland	11.29	7.87	43.5
	New York	26.37	20.45	28.9
	Texas	1.33	0.71	87.3
	Wisconsin	1.01	0.77	31.2
U.S.		5.05	3.75	34.7

3.4.3. Accuracy of Converted Actual Share

As suggested in the theoretical analysis, equation (3-1) may be used to convert transit's usual mode share to actual share. This section examines the accuracy of this conversion by comparing transit's actual mode share as converted from equation (3-1) with its actual mode share as directly measured from NHTS.

The converted value of transit's actual mode share is given by the right hand side of equation (3-1): $(1-D_t)\, S_t^u + D_n\, S_n^u$. This equation requires directly measured values for the disloyalty rate of regular transit users (D_t=T_{tn}/ T_t^u), for the disloyalty rate of regular non-transit users (D_n=T_{nt}/ T_n^u), transit's usual mode share (S_t^u = W_t/W), and for non-transit's usual mode share (S_n^u =1- S_t^u). The directly measured values for the disloyalty rates are shown in columns (3) and (4) of Table 3-5, while the values for transit's usual mode share are shown in column (3) of Table 3-4. The converted values are shown in column (5) of Table 3-5. In contrast, the directly measured value for transit's actual share is T_t^a/T, and the results are shown in column (4) of Table 3-4 and are repeated in column (6) of Table 3-5.

The accuracy of this conversion is measured by the percent deviation of transit's converted actual mode share from transit's actual mode share as directly measured from the 2001 NHTS. Specifically, this accuracy is measured by

$$100\left(\frac{\text{Converted - Directly Measured}}{\text{Directly Measured}}\right). \qquad (3\text{-}3)$$

One indication that the conversion is reasonable is the extremely high correlation of 0.9991 across the 34 transit market segments. But a high correlation does not necessarily mean small errors.

Shown in column (7) of Table 3-5, the percent deviation is small for most of the 34 transit segments. It ranges from 5 percent to 10 percent for 9 segments (all three levels of vehicle availability, Hispanic, Owning residence, outside MSAs with 1 or more million population, Maryland, Texas, and Wisconsin), ranges from over 10 percent to 15 percent for 2 segments (households with annual income ≥\$15,000 and proximity with O≥0.1 & D≥0.05), and is within 5 percent for the other 24 segments. For the country as a whole, transit's actual mode share is 3.75 percent as measured with NHTS and 3.84 percent as predicted, implying an error of 2.4 percent.

Conversion inaccuracies may have resulted from several sources. One source would be simplifying assumptions made in the model that do not represent reality. One example would be the assumption that the average daily number of work trips is the same across all workers. A second source would be sampling and non-sampling errors in the disloyalty rates and transit's usual mode share as measured from NHTS. But it is unclear what specific sources may have caused these deviations.

Table 3-5. Accuracy of Converted Actual Mode Share (Percent)

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
Characteristics	***Segments***	***Disloyalty of Regular Transit Users*** ($D_t = T_{tn} / T_t^u$)	***Disloyalty of Regular Non-Transit Users*** ($D_n = T_{nt} / T_n^u$)	***Transit's Actual Mode Share*** ***Converted*** $[(1-D_t) S_t^u + D_n S_n^u]$	***Directly Measured*** $[S_t^a = T_t^a / T]$	***Accuracy (5)-(6) / (6)***
Gender	Male	32.20	0.28	3.23	3.16	2.2
	Female	28.97	0.43	4.55	4.50	1.2
Driver Status	Driver	33.45	0.29	2.62	2.61	0.5
	Non-Driver	23.72	2.34	27.25	28.02	-2.7
Medical Condition	With	30.42	1.28	7.98	8.39	-4.9
	Without	30.53	0.33	3.75	3.67	2.1
Ethnicity	Hispanic	22.01	0.63	7.82	7.20	8.7
	Non-Hispanic	32.48	0.31	3.33	3.27	2.0
Race	White	35.26	0.19	2.04	2.02	1.1
	Black	30.23	0.89	10.06	9.65	4.3
Housing	Own	38.27	0.28	2.07	1.92	7.7
	Rent	25.22	0.55	8.63	8.58	0.6
Household Income	Under 15K	22.40	0.46	7.40	7.35	0.7
	15K+	29.28	0.29	3.33	2.90	14.7
Vehicle Ownership	0	20.84	3.70	41.60	43.8	-5.0
	1	31.41	0.85	7.60	7.22	5.2
	2+	40.59	0.18	1.35	1.26	7.4
Proximity to Bus Stops/Rail Stations (miles)	O<0.1 & D<0.05	26.14	0.89	13.75	14.04	-2.0
	O<0.1 or D<0.05	35.06	0.55	4.73	4.60	2.8
	O≥0.1 & D≥0.05	36.27	0.11	0.75	0.68	10.7
Land Use	Suburban	33.21	0.34	3.21	3.23	-0.6
	Urban	27.59	1.11	15.03	15.04	0.0
MSA Size	Other	54.14	0.12	0.37	0.35	6.2
	1-3 million	34.33	0.31	2.16	2.10	2.8
	3+ million	28.94	0.67	8.74	8.76	-0.2
Rail	MSA with Rail	28.36	0.85	10.44	10.45	-0.1
	Other	38.04	0.17	1.15	1.12	2.9
Metropolitan Area	New York	26.28	1.86	20.94	20.57	1.8
	Washington	32.68	0.62	8.62	8.70	-1.0
State	Maryland	32.85	0.82	8.31	7.87	5.6
	New York	25.90	2.03	21.03	20.45	2.9
	Texas	47.52	0.05	0.75	0.71	5.3
	Wisconsin	28.91	0.12	0.84	0.77	8.7
U.S.		30.53	0.35	3.84	3.75	2.4

CHAPTER 4. SENSITIVITY OF TRANSIT MODE SHARE

4.1. Concerns

This section assesses the sensitivity of transit mode share to treatments to the four elements of any alternative measure of transit mode share: 1) how travel is measured; 2) what modes are considered; 3) what travel market is considered; and 4) what method is used for data collection. The focus is on those treatments that have been raised as concerns in the literature about using census journey-to-work data for measuring transit mode share. These concerns may be classified into two categories. One category includes measurement concerns that relate to the first two elements of measuring transit mode share, and the other category includes market concerns that relate to the third element. The relationship between transit's usual and actual mode shares has already been covered in Chapter 3. The other measurement concerns are the following:

- Multiple Jobs: Whether commuting beyond the main job is considered.
- Multimode: Whether transit usage beyond the main mode is considered.
- Competing Modes: What competing modes are considered.
- Unit of Travel: Whether the unit of travel is person trips or person miles.

The market concerns are the following:

- Trip Purpose: Whether travel beyond commuting is considered.
- Service: Whether the availability and level of transit service is considered.
- Peak Hours: Whether travel beyond the peak periods is considered.
- Geography: Whether measurement is areawide or for sub-areas.

4.2. Data

Assessing the sensitivity of these concerns on transit mode share is based on four main data sources: 2000 Census, NHTS, route-level service data, and the 2005 Florida Transit Information System (FTIS). Census data are already described to some extent in the introduction and Chapter 3 has already described NHTS. The following describes each of the other three sources.

4.2.1. Census Data

The census journey-to-work data were collected from a one-in-six sample of households. The survey day was April 1, 2000 for most respondents. Two formats of data are made available to the public. One format is the 5-percent public use micro samples (PUMS) at the household level, and the other is the full sample at the block-group level. Both are used for this sensitivity analysis.

4.2.2. Route-Level Service Data

Route-specific service data were collected on daily service spans and service frequency for all fixed routes in Florida. The research team reviewed the internet sites of individual transit agencies and communicated with transit agencies when data were unavailable from these internet sites. The data reflect conditions in 2006.

4.2.3. FTIS

Developed for FDOT, FTIS contains a variety of information about transit in Florida, including 2000 census population data at the block level, 2000 census journey-to-work data at the block-group level, and GIS data for the stops and routes of fixed-route transit services. One shortcoming of the GIS data is that the route data do not always match the stop data. In some cases, data are missing for both routes and stops. In many other cases, there were stop data but without route data or vise versa. The GIS data represent conditions in 2003, 2004, or 2005, depending on transit agencies and routes.

4.2.4. Usage

Table 4-1 summarizes the use of these data sources to address various concerns. For concerns other than transit service levels and availability, the assessment is based on a comparison of a base measurement and an alternative measurement. The use of data sources is shown separately for the base and alternative measurements. For the issue related to transit service levels and availability, the assessment is more involved and is discussed as part of discussing the approaches below.

Table 4-1. Data Sources

Concerns	***2000 Census***				***2001 NHTS***			
	5% PUMS		***Full Sample***		***Workers***		***Trips***	
	Base	***Alter.***	***Base***	***Alter.***	***Base***	***Alter.***	***Base***	***Alter.***
Multiple Jobs					X	X	X	X
Multimode							X	X
Competing Modes			X	X	X	X	X	X
Unit of travel							X	X
Trip Purpose							X	X
Peak Hours	X	X					X	X
Geography			X	X				
Service-Frequency			X	X				
Service-Daily Span			X	X				
Service–Proximity					X	X	X	X

Notes: The cells with “X” indicate that assessment is made.

4.3. Magnitude of Concerns

Before discussing the approaches and presenting the results, it is helpful to get an understanding of the numerical significance of each concern.

4.3.1. Unit of Travel

How the unit used to measure the amount of travel (person trips versus person miles) affects transit mode share depends on the relative trip length between transit and other modes. According to the NHTS online analysis tool at http://nhts.ornl.gov/2001/index.shtml, the average trip length for all trips purposes was about 7.0 miles for public transit, while it was about 9.8 miles for all modes combined. As a result, transit mode share is expected to be smaller when it is based on person miles traveled than when it is based on person trips.

4.3.2. Multimode

Using NHTS information on the access and egress modes of each linked trip, one can determine the numbers of linked and unlinked trips by mode. Table 4-2 shows the result. As one would expect, the use of transit for access or egress is proportionally far more significant (16.6%) than the use of other modes for access or egress (3.7%). Consequently, transit mode share is expected to be higher once modes used beyond the main mode of a linked trip are considered.

Table 4-2. Linked versus Unlinked Trips by Mode

	Transit	***Other Modes***
Main Mode (linked trips)	6,474,643,028	400,466,014,616
Access & Egress	1,289,438,977	15,452,493,352
Total (unlinked trips)	7,764,082,005	415,918,507,968
% Access & Egress	16.6	3.7

Notes: Estimated from NHTS

4.3.3. Other Concerns

The magnitude for each of the other concerns is stated as a share of a respective total in Table 4-3. The U.S. Bureau of Labor Statistics collects data on whether employed persons had two or more jobs during a reference week of the monthly Current Population Survey. In January 2006, it was estimated that over 7.5 million workers worked multiple jobs in the United States, representing 5.2 percent of all workers (http://www.bls.gov/cps/#multjob_m).

Table 4-3. Magnitude of Other Concerns

Concern	***Measure of Magnitude***	***Percent***
Multiple Jobs	Share of workers with more than 1 job in a week	5.2
Competing Modes	Share of person trips by modes other than transit and POVs	12.0
Trip Purpose	Share of work trips	14.9
Peak Hours	Share of person trips for all purposes during peak hours	27.4
Service Availability	Share of workers living near transit	73.0

Notes: The following indicates the source of data for each measurement:

- Multiple Jobs—national data, Current Population Survey
- Competing Modes—nationwide data, 2001 NHTS. POV=privately operated vehicles.
- Trip Purpose—nationwide, 2001 NHTS
- Peak Hours—nationwide, 2001 NHTS: 7:00 a.m. – 9:00 a.m. and 4:00 p.m. – 6 p.m.
- Service Availability—Florida, 2000 Census block-group data and FTIS data

Using the NHTS online analysis tool, it is estimated that modes other than transit and privately operated vehicles (POVs) account for about 12.0 percent of all person trips in the United States. Transit mode share based on just transit and privately operated vehicles would be higher than based on all modes. Using the same data source, it is estimated that work trips account for only 14.9 percent of all trips, and trips during the peak hours from 7:00 a.m. to 9:00 a.m. and from 4:00 p.m. to 6:00 p.m. account for 27.4 percent of all trips.

Using 2000 census data at the block-group level and FTIS data on routes and stops, it was determined that about 73 percent of workers lived in block groups near the routes and stops of fixed-route services in Florida. See the next section for more information on how the routes and stops are laid over the census geography in this analysis.

4.4. Approaches

Approaches to assessing the sensitivity of transit mode share differ between service-related and other concerns.

4.4.1. Service-Related

Two approaches are used to assess the sensitivity of transit mode share to transit service levels.

Proximity Analysis. The proximity analysis uses the information on the airline distance from residence and work place to bus routes and rail stations from NHTS. Transit mode share is separately computed by different ranges of these distances for the entire nation.

Route-Specific Analysis. The route-specific analysis lays all fixed-routes along with their daily service spans and daily frequency over the 2000 census block-group geography using a quarter-mile buffer for the entire state of Florida. Ideally, the researchers should have created quarter-mile buffers around all stops, and block groups that touch or overlap with these buffers would be considered as served by transit and hence included in this analysis. However, the mismatch in between stops and routes mentioned in the data section forced the researchers to consider alternative methods. These include buffering stops only, routes only, or both stops and routes. None of these are satisfactory because they either miss some block groups or double count some block groups that are served by transit. The following method was used instead. Block groups were selected first by whether they intersected with any routes. Additional block groups were selected when they overlapped with buffers around stops for which route GIS data are missing. This method excluded routes that existed in 2006 but did not in 2000.

4.4.2. Other Concerns

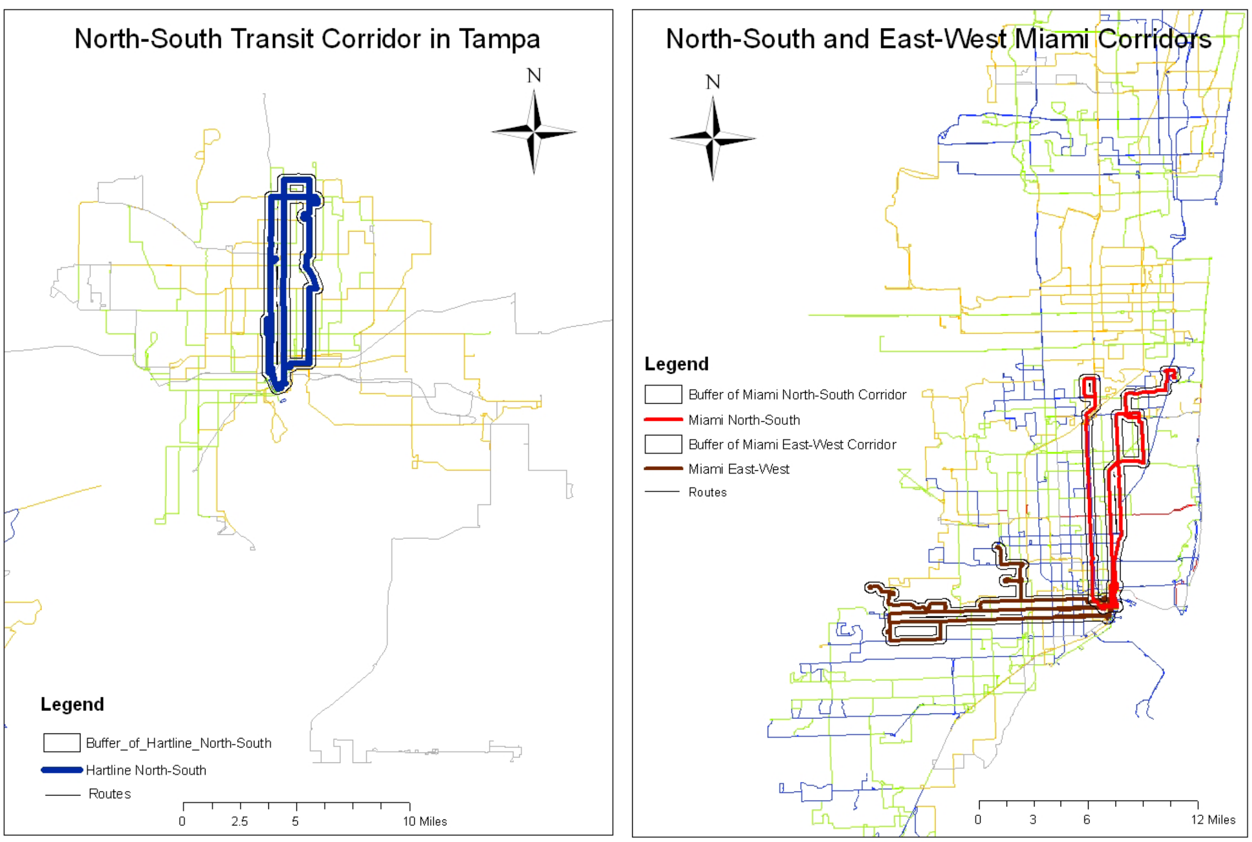
For other concerns, the assessment compares a base value to an alternative value. Table 4-4 describes the base and alternative for each concern.

Table 4-4. Base and Alternative for Other Concerns

Concern	*Base*	*Alternative*
Multiple Jobs	Workers with one job	All workers
Multimode	Main mode of a linked trip	Modes for unlinked trips
Competing Modes	Transit versus all other modes	Transit versus POV
Unit of Travel	Person trips	Person miles
Trip Purpose	All purposes	Work purpose
Peak Hours	Whole day	Peak hours (7:00-9:00 am & 4:00-6:00 pm)
Geography	Entire county	Select corridors

The geography issue is assessed by comparing transit mode share in individual counties versus three select corridors in Florida for illustration. The goal is to identify “transit corridors” that have relatively high frequencies and long daily service spans. One corridor is in Tampa, which is served by the Hillsborough Area Regional Transit (HART) and two corridors are in Miami, which are served mainly by the Miami-Dade Transit Agency (MDTA) (Figure 4-1).

Figure 4-1. Corridors



The Tampa corridor links the downtown area to the University of South Florida area, is 9.3 miles long and 1.7 miles wide, and was served by routes 1, 2, and 12. One Miami corridor connects the downtown area to the west, while the other corridor connects the downtown area to the north. The Miami east-west corridor is 11.7 miles long and 2 miles wide, and was served by routes 7, 8, and 11. The north-south corridor is 12.8 miles long and 2.18 miles wide, and was served by routes 9, 16, and 77. For a given corridor, a quarter-mile buffer was used to determine whether a block group is part of this corridor. The criterion for inclusion is whether the geography of a block group touches or overlaps the corridor buffer.

4.5. Results

4.5.1. Service Levels

Proximity Analysis. Tables 4-5, 4-6, and 4-7 show how transit's usual mode share varies by proximity to a worker's residence and to a worker's work place for the U.S. as a whole. The 2001 NHTS does not have a large enough sample for Florida to conduct a similar analysis for just Florida. Specifically, Table 4-5 shows the share of workers who usually commute to work by bus by where they live and where they work relative to bus lines. Table 4-6 shows the share of workers who usually commute to work by rail by where they live and where they work relative to rail stations. Table 4-7 shows the share of workers who usually commute to work by either bus or rail by where they live or where they work relative to bus lines or rail stations. The ranges are chosen to get a reasonably large number of sampled workers in each cell so that the estimated mode shares are statistically reliable.

Table 4-5. Bus Usual Mode Share by Proximity to Bus Line in U.S.

Miles between Bus Line and Residence	***Miles between Bus Line and Work Place***				
	(0, 1/80]	**(1/80, 1/50]**	**(1/50, 1/10]**	**(1/10, +]**	***Total***
(0, 1/50]	7.96%	13.74%	8.11%	3.31%	7.26%
(1/50, 1/20]	9.89%	11.76%	6.90%	3.96%	7.33%
(1/20, 1/4]	4.35%	4.84%	4.02%	2.32%	3.58%
(1/4, +]	2.01%	1.46%	2.30%	0.35%	0.81%
Total	4.29%	5.19%	4.18%	0.85%	2.34%

Table 4-6. Rail Usual Mode Share by Proximity to Rail Station in U.S.

Miles between Rail Station and Residence	***Miles between Rail Station and Work Place***				
	(0, 1/20]	**(1/20, 1/6]**	**(1/6, 1/3]**	**(1/3, +]**	***Total***
(0, 1/5]	60.68%	46.62%	41.41%	13.51%	37.05%
(1/5, 1/2]	50.64%	46.86%	23.54%	7.49%	20.06%
(1/2, 1]	50.75%	26.35%	19.80%	3.56%	8.75%
(1, +]	26.90%	15.77%	11.41%	0.23%	0.66%
Total	45.36%	30.30%	19.82%	0.56%	2.22%

Table 4-7. Transit's Usual Mode Share by Proximity to Rail Station or Bus Line in U.S.

Miles between Rail Station or Bus Line and Residence	*Miles between Rail Station or Bus Line and Work Place*				
	(0, 1/100]	**(1/100, 1/50]**	**(1/50, 1/20]**	**(1/20, +]**	***Total***
(0, 1/30]	14.36%	19.20%	17.16%	8.37%	13.24%
(1/30, 1/15]	14.20%	18.37%	16.36%	6.02%	11.65%
(1/15, 1/4]	8.83%	10.27%	14.99%	3.13%	7.18%
(1/4, +]	4.57%	3.04%	5.55%	0.55%	1.44%
Total	8.57%	9.66%	12.20%	1.67%	4.55%

Nationally, about the same share of workers usually commute to work by bus (2.34 percent, Table 4-5) and by rail (2.22 percent, Table 4-6), respectively. However, the variation in the mode share by proximity to transit differs significantly between bus and rail. Within close proximity to rail stations either from a worker's residence or from a worker's work place, a significant share of them usually commute to work by rail. Among workers who live within one-half of a mile and work within one-sixth of a mile, about 50 percent of them usually commute to work by rail. The share of workers who usually commute to work by bus is significantly smaller even when their residence and work place are within closer proximity to bus lines. Among workers who live within one-twentieth of a mile and work within one-fiftieth of a mile, fewer than 14 percent of them usually commute to work by bus.

In addition to the difference between bus and rail, the sensitivity of transit mode share also differs between the residence end and the work end. Workers who usually commute to work appear to work at places much closer to transit service than their residences. While the exact reasons are unknown, there are at least two possible explanations. Transit agencies may typically focus far more on work places than on residences in designing their services, and workers may be more likely to access transit by auto or bike from the residence end than to the work end.

Route-Specific Analysis. Table 4-8 shows transit's usual mode share among census block groups located along all fixed-transit routes in Florida. Based on 2000 Census, transit mode share is 2.43 percent among workers living in these block groups. In comparison, transit mode share is 1.79 percent among all workers in Florida regardless where they live.

Table 4-8. Transit's Usual Mode Share by Daily Service Span and Daily Frequency in Florida

Daily Frequency	*Service Span (hrs)*					*Total*
	0.25-12	*12-14*	*14-16*	*16-18*	*>18*	
1-10	0.41%	0.76%	0.80%	0.21%	N/A	0.46%
11-15	0.77%	0.88%	0.58%	2.48%	8.54%	0.82%
16-25	0.92%	1.22%	1.29%	1.56%	2.31%	1.17%
26-40	0.93%	1.27%	1.97%	1.46%	3.30%	1.61%
>41	3.47%	1.66%	2.33%	2.82%	5.58%	3.57%
Total	0.82%	1.22%	1.96%	2.49%	5.47%	*2.43%*

In addition, Table 4-8 shows how transit mode share varies with daily service frequency, or daily service span, or combinations of daily service frequency and service span. Transit mode share ranges from 0.46 percent under a daily service frequency 1 to10 to 3.57 percent under a daily service frequency over 41. On the other hand, transit mode share ranges from 0.82 percent under a daily service span 0 to12 hours to 5.47 percent under a daily service span over 18 hours.

When measured with census block-group data, transit mode share is not as sensitive as one would expect from controlling for whether a worker lives near a transit line or for the level of transit service. One possible reason is that the measurement of transit mode share is based on proximity to commuting origins only rather than both origins and destinations. Another likely reason for low sensitivity is that the transit mode share data for individual block groups are area-based rather than address-based. When the data are area-based, the actual distance between an origin and a transit stop depends on the size of a block group and where a worker lives in the block group.

4.5.2. Other Concerns

Using the same format as Table 4-1 on data sources, Table 4-9 compares transit mode share between the base and alternative measures for each of the other concerns.

Table 4-9. Sensitivity of Transit Mode Share to Other Concerns

Concern	***2000 Census***				***2001 NHTS***			
	5% PUMS		***Full Sample***		***Workers***		***Trips***	
	Base	***Alter.***	***Base***	***Alter.***	***Base***	***Alter.***	***Base***	***Alter.***
Multiple Jobs					5.16%	4.99%	3.84%	3.72%
Multimode							1.59%	1.84%
Competing Modes			4.69%	4.91%	5.05%	5.27%	1.59%	1.81%
Unit of Travel							1.59%	1.15%
Trip Purpose							1.59%	3.74%
Peak Hours	4.70	4.80					1.59%	1.89%
Corridor–Tampa			1.40%	5.10%				
Corridor–Miami NS			5.39%	11.10%				
Corridor–Miami EW			5.39%	7.15%				

Notes: The empty cells indicate that no assessment was conducted.

Among the other concerns considered, transit mode share is most sensitive to corridor measurement versus county-wide measurement. Transit mode share also is sensitive to measurement for work only versus all purposes. These are followed by the unit of travel concern. Transit mode share is relatively insensitive to the remaining other concerns.

CHAPTER 5. AREAWIDE MEASUREMENT

5.1. Introduction

Chapters 2 through 4 have narrowed down the options for considering areawide measurement. Specifically, Chapter 2 has argued that areawide measures of transit mode share can serve as a performance measure for the objectives of providing travel options and basic motorized mobility. In addition, areawide measurement should be conducted under all conditions of travel with or without transit services, and with all time periods considered. Furthermore, modal consistency requires that determining the mode of a linked trip be based on the main mode of the trip in measuring transit mode share. Chapter 3 has shown that transit's usual mode share is consistently greater than its actual mode share, and that the deviation is numerically significant. Finally Chapter 4 has shown low sensitivity of transit mode share to whether a worker has more than one job or what competing modes are considered.

With these results, the following three measurement concerns leave additional options to consider for areawide measurement of transit mode share:

- Unit of travel: when transit mode share is based on the amount of travel, whether the measurement of transit mode share is based on person trips or person miles. The sensitivity analysis showed that transit mode share is quite sensitive to the unit of travel used.
- Usual versus actual mode: when transit mode share is based on work purposes, whether the measurement of transit mode share is based on the usual mode with which workers usually commute to work in a typical week or the work trips that these workers make on a typical day.
- Trip purpose: whether the measurement of transit mode share is for commuting only or for all purposes combined.

5.2. Options

Using person miles does not necessarily have any advantage over using person trips for measuring transit mode share. In fact, additional resources would be required to collect data on trip length in addition to trips and modes used. When stated by respondents, collecting data on trip lengths is likely to introduce additional errors in addition to those related to trips and modes. With the two remaining concerns, there are really two options to consider for areawide measurement of transit mode share.

5.2.1. Actual Share for all Purposes

One option is based on the total number of person trips via transit made by all residents during a given period (a day, a week, etc.) for all purposes. This option would require original data collection through sampling every time measurement is required. Based on this option and using the NHTS online tool, Florida's transit mode share is 1.06 percent in 2001.

5.2.2. Usual Share for Commuting

The second option is based on the total number of workers who usually commute to the main job by transit in a week. Starting in 2005, the U.S. Bureau of the Census has fully implemented the annual American Community Survey (ACS) that covers all counties in the U.S. The usual mode question that has been asked in the decennial census since 1960 also is asked in the ACS. In fact, the pre-tabulated tables S0801 and S0802 at the ACS website show a total of 7,700,885 workers 16 years or older who lived in Florida in 2005. Among them 138,505 usually commuted to work by transit during the reference week, and 292,634 worked at home. Among all workers 16 years or older in 2005 who lived in Florida but worked outside their homes, 1.87 percent of them usually commuted to work by transit during a typical week at a margin of error of ±0.1 percentage points with a confidence level of 90 percent.

One issue with the second option relates to the coverage of group quarters, such as institutions, college dormitories, and other group quarters. The 2005 ACS does not include workers who lived in these group quarters. As a result, commuting by transit or any other modes by college students who live in campus dormitories would not be reflected in the 1.87 percent transit mode share for Florida. However, these group quarters will be covered starting with the 2006 ACS. As a result, the 2006 ACS should be used to establish the base line for future comparison if this second option is preferred for areawide measurement.

5.3. Evaluation

These two options are comparable with respect to the evaluation criteria on modal consistency and statistical quality. The first option may have slight advantage in terms of responsiveness, timeliness, consistency with transit policy objectives, and consistency with the results from Chapter 3. However, the second option has major advantages over the first option in terms of measurement costs. Each of these is further discussed below.

5.3.1. Major Advantages of Usual Share

One major advantage of the second option relates to sample size requirements to achieve a given level of statistical quality in a measure of transit mode share. Besides the required statistical quality, the magnitude of transit mode share is a significant determinant of sample size requirements. The lower the magnitude is, the larger the sample size requirement is. Using NHTS, transit's actual mode share for all purposes is 1.59 percent versus 5.50 percent for its usual mode share for commuting. These two numbers are 1.06 percent versus 1.79 percent for Florida.

The other major advantage of the second option is in its minimal cost of implementation. At the relatively low mode shares typically experienced at the areawide levels in Florida, however, the cost involved for measuring transit's actual mode share would be too high for periodic determination of a performance measure. In general, sampling errors decrease but costs increase with sample size. Sample size requirements differ between making one measurement of transit mode share versus detecting changes in transit mode share over time.

Single Sample. For one isolated measurement, the commonly used formula for calculating the sample size for a simple random sample without replacement is as follows:

$$n = \left(\frac{z}{d}\right)^2 s\left(1 - s\right) \tag{5-1}$$

where,

- z is the z value (e.g., 1.645 for 90% confidence level and 1.96 for 95% confidence level);
- d is the margin of error (e.g., .07 = ±7%, .05 = ±5%, and .03 = ±3%); and
- s is the expected transit mode share (e.g., 0.05 = 5%).

At the 95-percent confidence level (z = 1.96), the second column of Table 5-1 shows the minimum sample requirement in terms of individual persons for varying combinations of the margin of error and base transit mode share. Base transit share ranges from 1 percent to 20 percent, while the margin of error ranges from 0.1 to 2 percentage points and corresponds to one-tenth of the base transit mode share. With the margin of error at one-tenth of the base mode share, the cost in terms of minimum sample size increases dramatically with the base mode share. For example, the minimum sample size for the base mode share of 1 percent is over 5 times as large as that for the base mode share of 5 percent and is almost 25 times as large as that for the base mode share of 20 percent. Even assuming a low cost of $50 per household survey conducted through in-person interviews, for example, the total cost would be at $1,901,600 for a base share of 1 percent and $76,850 for a base share of 20 percent.

Table 5-1. Sample Requirements by Base Transit Share and Margin of Error

Base Share (Margin of Error)	***Single Sample***	***Two Samples***
1% (0.1%)	38,032	79,825
5% (0.5%)	7,299	15,286
10% (1.0%)	3,457	7,218
20% (2.0%)	1,537	3,185

Notes: Confidence level = 95 percent.

Two Samples. For detecting changes in transit mode share from year 1 to year 2, the formula for calculating the sample size for simple random sampling with the same sample size in both years is given by

$$n = \left(\frac{z}{d}\right)^2 \left[s_1\left(1 - s_1\right) + s_2\left(1 - s_2\right)\right] \tag{5-2}$$

where s_1 and s_2 are the expected transit mode shares in year 1 and year 2, respectively. If transit mode share is expected to increase from year 1 to year 2, the minimum sample size for each of the two years is more than twice the sample size for a single year measurement. To illustrate, suppose that transit mode share is expected to increase from 5 percent in year 1 to 5.5 percent in year 2. At the same 95 percent confidence level and 0.5 percent margin of error, the minimum sample size required to detect this change is 15,286. Column 3 of Table 5-1 shows the sample size requirement for all four cases of base transit share and margin of error.

5.3.1. Minor Advantages of Actual Share

Responsiveness. These two options are comparable in terms of responsiveness. One may expect that transit mode share from the second option may be less responsive to changes in transit investments or public policies because it is based on small-area census data. For areawide measurement, however, the potential disadvantages of small-area census data largely disappear because any areawide geography (i.e., statewide, regions, counties, cities) fully covers small-area census geographies.

Timeliness. The annual sample for the fully implemented ACS covers all counties, and is large enough for a reliable annual measurement of transit mode share at the areawide level for areas with a population of at least 65,000. In fact, the Florida sample for the 2005 ACS included 99,565 household interviews. A second issue relates to the time lag between the end of a calendar year and the time that ACS's tabulated tables become available to the public. The annual ACS data from the previous year will be released in the summer of the following year (Bureau of the Census 2006). That is, the time lag is about 8 months. For measuring transit's actual mode share from originally collected data, on the other hand, the time lag probably is no more than 4 months. In comparison, the time lag is about 15 months for the data items required to determine the ratio of ridership and population growth rates (FDOT 2006).

Policy Objectives. For providing travel options and basic mobility, as argued in Chapter 2, areawide measurement should consider travel under all conditions, which means all times of a day, all locations with or without transit services, all trip purposes, etc. While the first option is consistent with this consideration, the second option is based on commuting travel only. If the policy strategies for providing travel options and basic mobility are general to all purposes, however, an alternative measure that is based on commuting travel only would still be consistent with these two options. It would not be consistent, however, to use an alternative measure that is based on travel for all purposes if the policy strategies are specific to commuting.

Sensitivity. Chapter 3 clearly shows that transit's usual mode overstates its actual mode share. As a result, transit's usual mode share would not be an appropriate performance measure if the focus is on the absolute value as it often is the case in national debates. However, it still is an appropriate performance measure if the focus is on temporal changes. Transit's usual and actual mode shares are highly correlated across the 34 transit segments analyzed with a correlation coefficient of 0.998 based on columns 3 and 4 in Table 3-4.

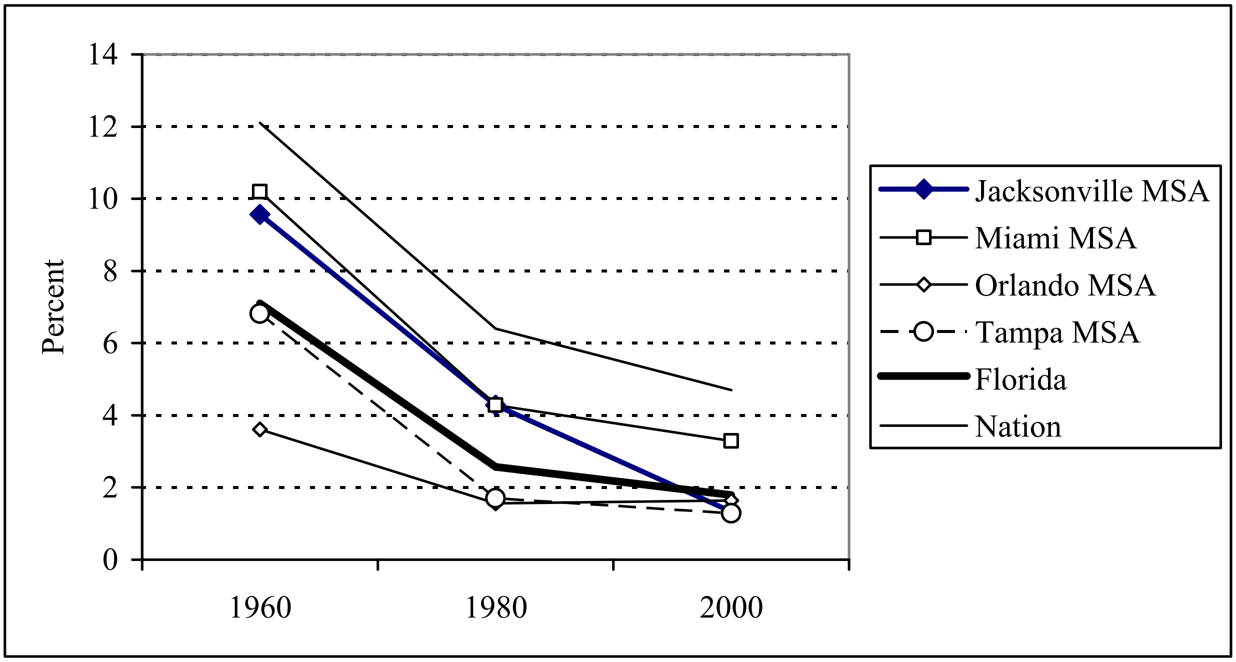
5.4. Trends in Transit Mode Share

It is important to understand how the selected measure of transit mode share has behaved in the past and is expected to behave in the future.

5.4.1. Past Trends

Using the journey-to-work data from the decennial census from 1960, 1980, and 2000, Figure 5-1 shows transit mode share for the nation as a whole, for Florida, and for the largest four metropolitan areas in Florida. Transit mode share has followed a general declining trend since 1960 at these different geographical levels.

Figure 5-1. Trends in Transit's Usual Mode Share



Note: Percent of workers who usually commute to work by transit. Measurement excludes taxicab and working at home. Data are from various census publications for the corresponding census years.

5.4.2. Future Trends

Transit mode share in a given passenger travel market is one feature of the market equilibrium. Besides the geography that defines each travel market, the determinants of this equilibrium include the socio-economic characteristics of the population, the amount and quality of transit services, and the land-use characteristics in the market through which the socio-economic and service attributes interact to reach the market equilibrium. Both FDOT (2002a) and Taylor and Fink (undated) review these determinants. Equally important in determining this equilibrium are public policies, including investment, pricing, environmental, energy, tax, and land-use policies. TCRP (1997) reviews these public policies and how they impact transit markets. These same determinants and factors also determine transit mode share.

While recent public policy efforts have overwhelmingly aimed at shifting travel from auto to transit over the last several decades, many have argued why transit share is going to stay low in an areawide scale. The literature has identified a number of reasons for this continuing trend.

- Unless a change in the generalized cost of auto travel is sufficient to lead to the disposal of an auto, the overall mode share is unlikely to be affected to a great extent (Hensher 2003). On the other hand, it is politically difficult to increase the cost of auto travel in the United States.
- Public policy in the United States instead has focused on reducing the cost of travel by transit. One problem with this approach is that it is ineffective in general in shifting travel from auto to transit because of several factors. One factor is lifestyle changes that require more complex travel and make transit far less attractive for such complex travel (Ferrell and Deakin 2001). Another factor is the existing low-density spatial structure (Bertaud 2002). Relative to service provision, these external factors have become the barriers to increasing transit ridership and mode share.

5.4.3. Hope

Transit mode share can be increased at the level of metropolitan areas. Tabulated 2000 census data from McGuckin and Srinivasan (2003) show that transit mode share increased from 1990 to 2000 in 15 of the 49 largest metropolitan areas, and increased from 1980 to 2000 in 5 of these areas (Table 5-2). Among the 15 metropolitan areas with increased transit mode share between 1990 and 2000 are Denver, Las Vegas, Oklahoma City, Orlando, Raleigh, Tampa, and West Palm Beach. The 5 metropolitan areas that experienced increased transit mode share between 1980 and 2000 are Houston, Las Vegas, Orlando, Phoenix, and San Diego.

Table 5-2. Transit' Usual Mode Share

Metropolitan Area	***Percent***			***Comparison***	
	1980	***1990***	***2000***	***2000 > 1990***	***2000 > 1980***
Boston-Worcester-Lawrence, MA-NH-ME-CT CMSA	9.4	8.3	9.0	X	
Denver-Boulder-Greeley, CO CMSA	5.8	4.0	4.3	X	
Houston-Galveston-Brazoria, TX CMSA	2.9	3.7	3.3		X
Las Vegas, NV-AZ MSA	2.0	1.8	4.1	X	X
Los Angeles-Riverside-Orange County, CA CMSA	5.1	4.5	4.7	X	
New York-Northern New Jersey-Long Island, NY-NJ-CT-PA CMSA	26.2	23.9	24.9	X	
Oklahoma City, OK MSA	1.1	0.5	0.6	X	
Orlando, FL MSA	1.6	1.3	1.7	X	X
Phoenix-Mesa, AZ MSA	1.9	2.0	2.0		X
Portland-Salem, OR-WA CMSA	7.2	4.7	5.7	X	
Raleigh-Durham-Chapel Hill, NC MSA	2.7	1.6	1.7	X	
Sacramento-Yolo, CA CMSA	3.4	2.4	2.7	X	
San Diego, CA MSA	3.3	3.2	3.4	X	X
San Francisco-Oakland-San Jose, CA CMSA	11.2	9.1	9.5	X	
Seattle-Tacoma-Bremerton, WA CMSA	7.5	5.6	6.8	X	
Tampa-St. Petersburg-Clearwater, FL MSA	1.7	1.3	1.4	X	
West Palm Beach-Boca Raton, FL MSA	1.9	1.1	1.4	X	

Note: Taxicab is included as transit, and working at home is included in the denominator.

Transit mode share can also increase over time at the statewide level. In fact, transit mode share increased between 1990 and 2000 in 12 states (Table 5-3). Many of these are states with relatively low population densities like Florida.

Table 5-3. States with Increased Transit Mode Share from 1990 to 2000

State	*Percent*	
	1990	*2000*
California	4.9	5.1
Colorado	2.9	3.2
Connecticut	3.9	4.0
Delaware	2.4	2.8
Louisiana	1.3	2.4
Massachusetts	8.3	8.7
Montana	0.6	0.7
Nevada	2.7	3.9
New Jersey	8.8	9.6
Oregon	3.4	4.2
South Dakota	0.3	0.5
Washington	4.5	4.9

Notes: 1990 data are from Travel to Work Characteristics for the 50 Largest Metropolitan Areas by Population in the United States: 1990 Census at http://www.census.gov/population/socdemo/journey/msa50.txt. 2000 data are in Reschovsky (2004).

Finally, there is some evidence that the trend of declining transit mode share that occurred over the four decades from 1960 to 2000 may have ended in Florida. As mentioned earlier, transit mode share in Florida was 1.79 percent in 2000 based on the 2000 Census, but was 1.87 in 2005 based on the 2005 ACS. Both numbers are measured by excluding taxicabs and working at home. It is important, however, to point out that the 2000 census number is far more reliable than the 2005 ACS number. Given that the margin of error for the 2005 ACS number is ±0.1, the 2000 census number does fall into the confidence interval of the 2005 ACS, but is toward the lower end of the interval. Given this assessment, it is unlikely that transit mode share in 2005 was lower than in 2000, and it is likely that transit mode share in 2005 was higher than in 2000.

CHAPTER 6. SUB-AREA MEASUREMENT

6.1. Introduction

The framework in Chapter 2 argued that transit mode share should be measured at the sub-area level for the objective of congestion relief. Furthermore, it would be a more effective performance measure if it is measured for sub-areas with transit service available during peak hours. While sub-areas may be of any form and shape, they can fall into two general categories: activity centers (downtowns, universities, etc.) and corridors. Activity centers can be separate or part of corridors.

Sub-area measurement should focus on the afternoon peak hours from 4:00 p.m. to 6:00 p.m. during which traffic congestion is typically the heaviest. While the length and timing of the afternoon peak hours vary across regions, using the same peak hours allows statewide sub-area measurement by combining the results from individual sub-areas. Focusing on these afternoon peak hours may make using existing tabulated data difficult, but will greatly reduce the cost of sampling-based field observations. These afternoon peak hours also are currently used by FDOT for level of service assessments for both highway and transit.

Before developing and evaluating alternative measures of transit mode share, the definition, classification, and identification of sub-areas, are discussed first. This discussion is done separately for activity centers and corridors.

6.2. Definition

6.2.1. Corridors

Merriam-Webster's Online Dictionary http://www.m-w.com/dictionary/corridor defines a corridor as "an area or stretch of land identified by a specific common characteristic or purpose." However, the definition of a corridor varies significantly in the transportation community. To define corridors for its Integrated Corridor Management Initiatives, USDOT (2006) compiles a list of 23 different definitions used by a variety of agencies at a variety of levels of government.

Different offices of the same agency may use different definitions. At the national level, for example, USDOT (2006) adopts a far more elaborate definition than the definitions that have been used by FHWA (2007) and BTS (2007). At the state level, for example, FDOT's Office of Policy Planning has developed a Transportation Glossary of the terms and acronyms used in transportation planning in Florida (http://www.dot.state.fl.us/planning/glossary/), and uses a definition that is quite different from what is used in *Project Traffic Forecasting Handbook* (FDOT 2002b) published by the transportation statistics section of the office.

The most widely used definition appears to be the following: "a broad geographical band that follows a general directional flow connecting major sources of trips that may contain a number of streets, highways and transit route alignments. The phrase "a general directional flow" does not refer to a one-way flow, but rather to a general cardinal direction such as East-West, North-South, etc.

At the national level, FHWA's online glossary (http://www.fhwa.dot.gov/planning/glossary), BTS's online glossary (http://www.bts.gov/dictionary/search.xml), GAO (2004), APA (2004), and TRB (2003) all use it. In Florida, the FY2007-2008 budget of Miami-Dade County (http://www.miamidade.gov/budget/budget_glossary.asp#T), FDOT's *Project Traffic Forecasting Handbook* (FDOT 2002), and CUTR (2005) all use it.

This definition appears to be attributable to the American Public Transportation Association (APTA), and has appeared in a number of APTA materials, including its *1994-1995 Transit Fact Book*, its *Handbook for Transit Board Members* (APTA undated), and its current online glossary (http://www.apta.com/research/info/online/glossary.cfm). It has some desirable characteristics. One characteristic is its flexibility in a number of ways. It is multi-modal. For measuring transit mode share, the presence of multiple modes is necessary. It is inclusive of trips that start in a given corridor, end in a given corridor, or start and end in a given corridor. It has no pre-defined size or scale. It is inclusive of both freight and people movement though this research focuses on people movement only. Another characteristic is its reflection of the perspective of operational improvements. One reason for the significant variation in defining a corridor is variations in the intended purpose of defining a corridor. As pointed out by USDOT (2006), the purpose may be land use management, access management, right-of-way identification, freight movement, recreational needs, trade facilitation, and operational improvements. Our purpose of defining a corridor relates to operational improvements.

6.2.2. Activity Centers

The definition of activity centers varies widely as well. Lin et al. (2006) use the following definition: "Activity centers are areas of strong development of a particular activity, such as residence, employment, or recreation." This definition is clearly too narrow and excludes activity centers with mixed land uses. Definitions adopted by local governments are comprehensive in general. The following are a few examples:

- The MPO in the Madison area of Wisconsin (2006) defines major activity centers as "major concentrations of existing and projected employment and commercial activity. These concentrations of relatively intensive or large-scale mixed land uses result in the generation of large numbers of trips, requiring significant investments in transportation and other public facilities and services. At the same time, these centers can be effectively served by pubic transit, particularly if they are developed or redeveloped with higher densities, mixed land uses, and pedestrian-friendly designs."

- The County of Alachua, Florida (Alachua County Commission 2004) defines activity centers as nodes of high intensity uses characterized by mixed-use, compact development (commercial, institutional, office, and medium to high density residential) in a pedestrian-oriented environment that supports a multi-modal transportation system.

- Chapter 28-24, *Developments of Presumed Regional Impact*, of the Florida Administrative Code, uses the following definition for regional activity centers:

> A "Regional Activity Center" means a compact, high intensity, high density multi-use area designated as appropriate for intensive growth by the local government of jurisdiction and may include: retail; office; cultural, recreational and entertainment facilities; hotels and motels; or appropriate industrial activities. The designated area shall be consistent with the local government comprehensive plan and future land use map intensities; shall routinely provide service to, or be regularly used by, a significant number of citizens of more than one county; contain adequate existing public facilities as defined in Rule 9J-5, F.A.C., or committed public facilities, as identified in the capital improvements element of the local government comprehensive plan; and shall be proximate and accessible to interstate or major arterial roadways.

The urban study literature typically uses a quantitative approach and defines activity centers as areas with higher than adjacent concentrations of employment at the level of traffic analysis zones (TAZs). The objective of these studies typically is to identify regional employment centers beside the traditional downtown. Giuliano and Small (1991) define a center as a contiguous set of zones, each with density above some cutoff *D* that together have at least *E* total employment and for which all the immediately adjacent zones outside the subcenter have density below *D*. With this definition, all high-density zones in the region are classified as part of some center unless they are both small (less than *E* employment) and isolated (not part of a cluster of high-density zones with *E* employment in total). The *peak* of the center is defined as the highest-density zone or group of contiguous zones within the subcenter that together have at least *E* employees. While this definition has been satisfactory to analyzing the employment patterns, residential location theory, and overall economic analysis in polycentric metropolitan areas, Casello and Smith (2006) find that it would miss important suburban activity centers in Philadelphia. Instead, they propose to incorporate the trip-attracting strength of activity centers in defining activity centers.

6.3. Classification

6.3.1. Corridors

Corridors can vary dramatically. It could be useful to get a better understanding of the travel market being served by a particular corridor by classifying them according to their functional purpose in the overall transportation system. FDOT has used different approaches to classifying corridors. Two approaches are described below.

<u>Approach One</u>. As part of its research for measuring multi-modal corridor level of service, FDOT (2001) adopts the following classification:

- <u>Class I Intercity Corridors</u>. These serve primarily city to city or metropolitan area to metropolitan area travel. They are generally 20 to 100 miles in length. The primary facility is often a freeway, but it can be a conventional state highway. The sole relevant mode is usually the automobile, although there may be some intercity bus service.

- Class II Urban Through/Around Corridors. These carry people completely through or around major metropolitan areas. They are generally 8 to 30 miles long. The primary facility is usually a freeway, but it can also be a conventional state highway or county/city arterial street. Examples are the I-4 freeway corridor and the Greenway in the Orlando urban area. The automobile is generally the most relevant mode in these corridors although there may be some urban bus service.

- Class III Urban Corridors. These carry people into and within urban/urbanized areas. They are generally 3 to 12 miles in length. They typically involve an Interstate freeway and arterials with bus, bicycle, and pedestrian shared use facilities. Auto, bus, and bicycle modes are relevant for these corridors. Examples include the I-275 freeway corridor in Tampa, and the I-110/Davis Highway corridor in Pensacola.

- Class IV Urban Corridors. These are comparatively short, between 2 and 8 miles in length. They generally do not contain a freeway and may be most appropriate in downtown settings. All modes (auto, transit, bicycle, pedestrian) are relevant. Examples include Monroe Street (between Magnolia and Bradford) in downtown Tallahassee, and Flagler Street (between Roosevelt and White) in Key West.

Approach Two. As part of describing the planning and screening process for its new Future Corridors Program, FDOT (2006) argues that a uniform approach to future corridor planning and development requires standard terminology that can communicate the status of each corridor as it moves from a concept to a specific project. Besides statewide corridors, it adopts the following classification:

- Regional Corridor. Corridor that connects communities within a single region; may be a segment of a broader statewide corridor. A region is an area of distinctive communities, cities, or counties where residents share a geographic identity; are socially, economically, and culturally interdependent; share a capacity for planning and function; and share a capacity to create competitive advantage.

- Corridor. More focused portion of a study area connecting more specific beginning and end points, potentially including multiple modes or facilities. A study area is a geographic area connecting regional origins and destinations with a potential statewide mobility or connectivity need.

6.3.2. Activity Centers

Activity centers have also been classified into categories. At least two different approaches have been used for classification. One approach is based on their regional significance. Broward County, Florida (2004), for example, separates regional activity centers from local activity centers. FDOT (2003) classifies multimodal transportation districts into three categories based on their regional significance as shown in Table 6-1.

Table 6-1. Classification of Multimodal Transportation Districts

Urban Center (Ex: Miami, Downtown Orlando)	*Regional Center* (Ex: Miami Beach)	*Traditional Town or Village* (Ex: DeLand)
Intense Development and Major Employment Supported By Residential and Retail	Significant Area of Development Smaller Than Urban Center	Communities Organized Around a Focal Point With Sense of Community Identify
General • Population >50,000 • Jobs > 50,000 • Jobs: Dwelling Units, 1:1 • Area: 10 square miles • Compact Core of Community & Commercial Services • Pedestrian Orientation • High Density • Mix of Land Uses	**General** • Population: 25,000 - 50,000 • Jobs > 5,000 • Jobs: Dwelling Units: 1:1 • Area: 5 square miles • Compact Core of Community and Commercial Services • Pedestrian Orientation • Mid to High Density • Mix of Land Uses	**General** • Population < 25,000 • Jobs < 5,000 • Area: 2 square miles • Compact Core of Community Services • Pedestrian Orientation • Mid Density • Mix of Land Uses
Transportation • Multiple Modes of Transit • Walking is Significant • Parking Provided, but Limited • Significant Amenities • Dense Network of Narrow Local Streets Plus Arterial Roadways	**Transportation** • Multiple Transit Services Available • Walking is Significant • Parking Provided, but Limited • Significant Amenities	**Transportation** • May Have Bus • Walking is Significant • Parking is Provided • Significant Amenities

Note: Adopted from Table 1, FDOT (2003).

Frequently, however, activity centers are classified by their functional purposes. The Comprehensive Plan of the County of Alachua, Florida (Alachua County Commission 2004) characterizes Activity Centers into two types based on the primary land use. A retail-oriented Activity Center has commercial activities as its primary use and an employment-oriented Activity Center has institutional, industrial, or office as the primary use. Activity Centers are designated at high, medium and low levels and correspond to the market size, area, and intensity. FDOT's Transit Quality of Service Evaluation Program (Hillsborough MPO 2005) also uses this functional approach.

6.4. Identification

The primary purpose of this chapter is to develop alternative measures of transit mode share for individual sub-areas that have already been identified. However, FDOT would need an approach to identifying sub-areas if it wants a systematic measurement of transit mode share for sub-areas around the state. Such a systematic measurement would allow FDOT to get estimates of transit mode share for all of these sub-areas combined. The selection of an identification approach depends largely on the desired scale and scope of sub-area measurement of transit mode share and the related costs. There are two general approaches to identifying sub-areas for a systematic measurement of transit mode share throughout Florida.

One approach would be to proactively use existing data to identify sub-areas of concentrated transit usage throughout Florida. One such existing data source is the small-area census data at the TAZ level contained in the Census Transportation Planning Package (CTPP) 2000. CTPP is a set of special tabulations from answers to the census long form surveys mailed to one in six households, and is widely used for transportation planning. Tabulations are separated by place of residence, by place of work, and for flows between home and work. Because of the large sample size, the data are reliable and accurate. The results can help FDOT improve its current transit quality of service evaluation program, and serve as a baseline of transit mode share for the identified sub-areas for monitoring the effectiveness of future improvements in these areas on transit mode share. The identified sub-areas can serve as candidates for field measurement of transit mode share that are more responsive to improvements in these sub-areas. More are discussed in a later section on field measurement of transit mode share.

The other approach would simply use sub-areas that have already been identified through existing processes at the various levels of government on land use planning, transportation management, and funding programs. These processes in Florida are briefly described separately for corridors and activity centers.

6.4.1. Corridors

<u>MPO Transit Quality of Service Evaluation Program</u>. Starting in 2001, FDOT has required that all MPOs in areas with fixed-route transit services evaluate the transit services within their regions with respect to six quality-of-service measures each time their Long Range Transportation Plan is updated. Among these measures is passenger loading. The measurement of passenger loading begins with the selection of major activity centers in each MPO region. Areas with a population of at least 200,000 select at least 10 activity centers, while smaller areas select at least 6. Each activity center consists of single or multiple TAZs. Using estimated total travel demand between any two activity centers from the regional travel demand model, the measurement is to be carried out for the 15 directional pairs of activity centers with the highest total travel demand. Data are to be collected on a typical weekday afternoon peak period. A typical weekday is defined as Tuesday, Wednesday, or Thursday, and the afternoon peak period is defined from 4:00 p.m. to 6:00 p.m., which was chosen to mirror the afternoon peak period used in FDOT procedures for level of service analyses on the highway side. For each directional pair of activity centers, data are to be collected from at least 20 bus trips. Furthermore, passenger loading is to be counted at the maximum load point determined by the MPO or the transit agencies. If transfers are required to travel, data are to be collected for only the first segment of the center to center trip.

<u>Transit Corridor Program</u>. The following description is adopted from FDOT (2005). The Transit Corridor Program is authorized in Chapter 341, Florida Statutes and specific program guidelines are provided in FDOT Procedure Topic Number 725-030-003. The Transit Corridor Program provides funding to Community Transportation Coordinators or transit agencies to support new services within specific corridors when the services are designed and expected to help reduce or alleviate congestion or other mobility issues within the corridor. Transit Corridor funds are discretionary and are distributed based on documented need. Transit Corridor Program funds may be used for capital or operating expenses. Eligible projects must be identified in a

Transit Development Plan, a Congestion Management System Plan, or other formal study undertaken by a public agency. The FDOT Central Office annually reviews all existing (i.e., currently approved and operating as of the annual review) Transit Corridor projects and allocates to the respective FDOT district office sufficient funds to cover these ongoing projects. First priority for funding under this program is for existing projects to meet their adopted goals and objectives. Any remaining funds are allocated to each of the FDOT districts by formula, based on each district's percentage of the total state urbanized population. Projects are funded at one-half the non-federal share. Projects designed to alleviate congestion in a region may receive state funding at up to 100 percent of the project cost.

Congestion Management Systems. Chapter 339.177, Florida Statutes, requires a traffic congestion management system. In Florida, this system is called the Florida Mobility Management Process (MMP). MMP is a systematic process that provides information on transportation system performance and on alternative strategies for alleviating congestion and enhancing the mobility of persons and goods. All of Florida's twenty-five Metropolitan Planning Organizations (MPOs) currently operate MMPs. Typically a Florida MPO's MMP:

- identifies the location of congestion by measuring the system's performance,
- identifies the causes of congestion,
- reflects the collaboration a multi-disciplinary local steering committee with FDOT representation,
- recommends strategies to alleviate congestion which can be implemented quickly, inexpensively and can avoid the addition of general purpose lanes of roadway,
- is corridor-based, and
- provides a link between the short-range transportation improvement program (TIP) and the long-range planning process (LRTP).

Long Range Transportation Plans. These plans typically identify a set of corridors for which both short term and longer strategies are specified to solve congestion and other transportation problems there.

6.4.2. Activity Centers

Local Comprehensive Plans. Local land use plans frequently designate regional activity centers using the definition mentioned earlier from Florida's Administrative Code. The Tampa Comprehensive Plan (Hillsborough MPO 2005) groups activity centers into five types: High Intensity Activity Center (e.g., Downtown Tampa); Mixed Use Regional Activity Centers (e.g., Westshore Business District, University North); Regional Attractors (e.g. University of South Florida, Tampa International Airport, MacDill Air Force Base); Community Activity Centers (e.g. Hyde Park Village); Neighborhood Activity Centers. The densities and intensities for these activity centers play an important part in determining the transportation improvements required to serve them.

MPO Transit Quality of Service Evaluation Program. The Agency Guide to FDOT's Transit Quality of Service Evaluation Program specifies a number of criteria for MPOs to identify activity centers. For MPOs in areas with a population of at least 200,000, for example, the following guidelines are specified to select activity centers (Hillsborough MPO 2005):

- select at least ten activity centers;
- at least one location in the Central Business District (CBD);
- major intermodal terminal, such as passenger airports and AMTRAK stations;
- at least one regional shopping center (if present);
- at least one university or community college (if present);
- at least one major park-and-ride facility (if present);
- a large office development outside the CBD; and
- a geographically diverse set of suburbs, neighborhoods, and/or tourist attractions.

The 10 activity centers identified by Hillsborough MPO (2005) are listed in Table 6-2.

Table 6-2. Activity Centers for Transit Quality of Service Evaluation

ID	Activity Center Name	Activity Center Type	Travel Demand Analysis Area TAZ(s)	Trip End TAZ
A	Downtown Tampa	Non-residential	362-401, 406, 425, 436	380
B	Westshore Business District /Tampa International Airport	Non-residential	254-6, 266, 277-80, 289-95, 297-9, 411-3	298
C	University of South Florida/Busch Gardens	Non-residential	82-3, 121-7, 182, 185-7, 195-6	122
D	Port of Tampa/Port Sutton	Non-residential	356-9, 656, 663, 667	357
E	MacDill Air Force Base	Non-residential	465, 469	469
F	New Tampa	Residential	62-79, 470-3	68
G	Brandon	Residential	603, 605-7, 609, 611, 616-22, 624-9	616
H	Town & Country	Residential	131-3, 143-5, 157-62, 172-5	133
I	Temple Terrace	Residential	238, 241-50	241
J	East Tampa	Residential	321-4, 332-9, 403-5, 407-8	337

Note: adopted from Table 1, Hillsborough MPO (2005).

6.4. Options

One useful way to identify options for sub-area measurement would be through two aspects of any measure of transit mode share (Table 6-3). One relates to the segments of a trip, i.e. whether the measurement is for trip ends (origin or destination), for origin and destination pairs (O-D), or for one middle point of a trip (i.e., cutline). The other aspect relates to the source of data. The primary data sources for sub-area measurement are local surveys, small-area census data, and field observations.

Table 6-3. Options for Sub-Area Measurement

Data	***Relation to Trip Segments***			
	Origin	***Destination***	***O-D***	***Cutline***
Local Surveys		Activity Centers	Corridors	
Small-Area Data		Activity Centers	Corridors	
Field Observations		Activity Centers		Corridors

Note: empty cells indicate that that measurement is inappropriate.

For ease of reference, the rest of this chapter will refer to these options in a particular way. They may be referred to as a sub-group regardless of the source of data as follows:

- Trip-end measurement refers to alternative measures that are based on trip ends.
- Origin measurement refers to alternative measures that are based on travel that starts in a sub-area.
- Destination measurement refers to alternative measures that are based on travel that ends in a sub-area.
- Origin-destination measurement refers to alternative measures that are based on travel that starts and ends in a corridor.
- Cutline measurement refers to alternative measures that are based on travel that passes a cutline in a corridor.

A particular option may also be referred to by specifying both data source and relation to trip segments. The option of destination measurement with local surveys, for example, may use local surveys of employers to determine the modal usage of their employees for commuting to their work places.

Not all options are appropriate for particular sub-area types (Table 6-3). Origin-destination measurement is only appropriate for corridors with local surveys or small-area census data. In addition, field observations may be used for destination measurement in activity centers or for cutline measurement in corridors. Finally, trip-end measurement technically can be carried out for both corridors and activity centers with local surveys or small-area census data. However, origin measurement or destination measurement is not entirely consistent with congestion relief within a corridor because the level of traffic congestion is driven primarily by travel along the corridor rather than to or from the corridor.

While origin measurement is technically possible for activity centers, trip-end measurement of transit mode share should focus on destination measurement. Recent research indicates that trip destinations are far more important in determining mode usage than they have been believed and are more important than trip origins (Barnes 2005; Barnes and Davis 2001; Chatman 2003). While either residential areas or non-residential areas can serve as destinations, residential areas are often considered as trip origins and non-residential areas as trip destinations. As a result, trip-end measurement of transit mode share should focus on non-residential activity centers.

Before going into the various options in detail, it is important to point out some of their features. Measurement based on field observations typically includes all through-traffic but excludes some internal travel for corridors and all internal travel for activity centers. The degree to which some interval travel is excluded for corridors depends on corridor characteristics (e.g., width and length) and measurement strategies (e.g., number of cutlines). On the other hand, all through-traffic is excluded when measurement is based on small-area census data and is typically excluded when measurement is based on local surveys.

6.5. Local Surveys

Local surveys refer to surveys of residents, employees, customers, etc. for their modal usage for trips ending at an activity center (destination measurement) or for trips that start and end in a corridor (origin-destination measurement).

6.5.1. Destination Measurement

The purpose of destination measurement with local surveys is to determine the transit share of all trips that start somewhere outside of an activity center but end in it. One source would be commuting mode surveys of employees who work or employers that are located in a given activity center. Employer-based trip-reduction programs in various metropolitan areas often require employers of certain size to survey their employees and report the results to program administrators. One problem of these surveys is that they ignore small employers. To measure transit mode share, such local surveys would need to include all employers or a random sample of all employers.

6.5.2. Origin-Destination Measurement

The purpose of origin-destination measurement with local surveys is to determine the transit share of all trips that start and end in the same corridor. Origin-destination data from regional household surveys, for example, can provide data for origin-destination measurement. But existing household surveys rarely have a large enough sample for measuring transit mode share in individual corridors.

6.5.3. Evaluation

Advantages. Modal consistency can be ensured with local surveys if data are collected through the same instrument for all modes. Problems can arise, for example, when household origin-destination surveys are supplemented with origin-destination data from transit on-board surveys. In addition, the time period can be controlled with local surveys. Finally, the sampling errors of measurement based on local surveys also can be controlled.

Disadvantages. As already discussed in Chapter 5, the cost of implementation measurement with local surveys can be high. The cost of measuring transit mode share with local surveys is made worse by low response rates. Of the about 15,000 employees at 7 large employment centers in southeast Florida, only 9 percent responded (Corradino 2000). Besides cost, such low response rates can also introduce serious biases into the results, particularly if transit commuters are far less or more likely to respond.

6.6. Small-Area Census Data

Small-area data from the Bureau of the Census contain information on the number of workers by the mode they usually use for commuting to work. These small-area census data can be used for destination measurement for activity centers and for origin-destination measurement for corridors.

6.6.1. Destination Measurement

Destination measurement can be carried out with Part 2 of CTPP data for non-residential activity centers consisting of TAZs. Data on the number of workers by mode and by time arriving at work, for example, are contained in Table 2-021 for CTPP 2000. The usual modes these workers use for commuting from home can be combined across all TAZs in an activity center, and the combined data can then be used for a destination measurement of transit mode share.

6.6.2. Origin-Destination Measurement

Origin-destination measurement can be carried out with CTPP data for corridors consisting of TAZs. Part 3 of CTPP contains commuter flow data by mode between any TAZ pair. These data, for example, are contained in Table 3-006 for CTPP 2000. The commuter flows for each mode can be combined across all TAZ pairs within a corridor, and the combined data can then be used for an origin-destination measurement of transit mode share.

6.6.3. Evaluation

Advantages. The cost of implementation is low. In addition, the actual measurement for individual sub-areas located throughout the state can be consistently carried out by a single research team once sub-areas are defined in terms of specific TAZs.

Disadvantages. One problem with using CTPP data is that the departure from home or arrival time at work is not part of the standard tabulations in Part 3 of CTPP. As a result, origin-destination measurement of transit mode share cannot be specific to the afternoon peak hours from 4 pm to 6 pm. However, arrival time at work is included in Part 2 of CTPP, and destination measurement can be specific to the afternoon peak hours.

CTPP data cover commuting but not other purposes. Destination measurement with CTPP data for a university campus, for example, would include transit usage by all employees of the university, but would exclude transit usage by non-employee students. When transit mode share is the measurement objective, however, this exclusion of students does not necessarily make CTPP data useless in the case of university campuses. If transit is heavily used (i.e., high transit mode share) when both students and employees are considered, it is likely that transit is heavily used when only employees are considered.

An emerging issue is that this approach would rely on data collected through the American Community Survey (ACS) in the future. ACS will be collected through much smaller samples on an annual basis than the decennial census, and the use of ACS data for sub-areas will require combining ACS data from different years. At the same time, however, the continuous measurement approach of ACS data throughout a year is subject to far less temporal randomness than the data from the traditional decennial census, which is based on conditions during the same single week for the vast majority of respondents.

Potentially the most significant disadvantage of using small-area census data is the lack of control over the sample size involved for individual sub-areas. The Bureau of the Census has been sampling about 1 out of every 6 workers through the long-form surveys as part of the decennial census. For a given sub-area, it cannot be increased if the sample size from this sampling rate is smaller than the minimum sample size required for a particular confidence level and margin of error. However, this lack of control over sample size would not be an issue if the ultimate assessment of transit mode share and its temporal change is done at the state level or sub-state levels such as FDOT districts by combining the small-area census data from individual sub-areas throughout the state or within each FDOT district.

6.7. Field Observations

Field observations are designed to determine the number of persons passing a given location via various modes during the afternoon peak hours from 4 p.m. to 6 p.m. in the field. For a given sub-area, field observations are typically conducted at multiple locations. For a corridor, these multiple locations may be located along a single or multiple cutlines, which are imaginary lines extending across all longitudinal facilities in the corridor. Cutline measurement can be carried out for corridors with these field data. For an activity center, on the other hand, these multiple locations are typically located along a single cordon line, which is an imaginary line that completely encompasses an activity center and is typically given by the boundary of the activity center. Destination measurement can be carried out for activity centers with these field data along cordon lines.

The following discussion focuses on two key aspects of conducting field observations: the selection of observation methods and the selection of observation locations and days. Observation methods influence measurement errors, while observation locations and days affect sampling errors. Alternatives are described and evaluated for their advantages and disadvantages. To make this discussion concrete, it focuses on vehicle occupancy for privately operated vehicles (POVs) and passenger loading for transit.

6.7.1. Observation Methods

Automated—POV Occupancy. A number of automated methods are under development for measuring POV occupancy from the roadside. However, they are not technically feasible in the near future. Focusing on automated roadside methods, for example, TTI (2006) finds that the potential for roadside occupancy detection by automated methods is great, but no system has entered commercial production. One serious problem with these automated methods is their inability to overcome the invisibility of hidden occupants. Another serious problem is that none of the automated methods under development can penetrate metallic window tint.

Automated—Transit Loading. Automated methods to measure passenger loading for transit typically involve processing archived data that keep track of passenger activities at individual stops. Automatic passenger counters (APCs), for example, can keep track of both the number of passengers who get on and the number of passengers who get off at each stop. When swiping is required upon both boarding and alighting for all passengers, smart cards can keep track of passenger activities individually. Another potential automated method would be to use archived video from existing surveillance cameras in buses.

Little is known about measurement errors from using smart cards, but measurement errors from using APCs have been documented. Using data from buses with both APCs and video surveillance cameras in Portland, Oregon, Kimpel et al. (2002) find that APCs systematically over-count passenger loads with an average measurement error of about 9 percent. No similar data on the measurement errors of using APCs are available from other transit systems.

More generally, however, using these automated methods on a wide scale is practically infeasible in the near future because few agencies in Florida have the needed equipment beyond testing stages.

Manual—POV Occupancy. Based on the extensive reviews by Heidtman and Tornow (1997) and Gan et al. (2005), there are mainly two manual methods for measuring POV occupancy at specific locations. Roadside windshield detection involves stationing observers along the roadside to perform physical counts of vehicle occupants in different lanes. Video surveillance, on the other hand, uses video cameras mounted on overpasses or along the roadside to capture passing vehicles in the field and uses human viewers to view the captured videos to extract occupancy data off-field.

Both manual methods appear to undercount POV occupancy. In terms of estimating transit mode share, missing certain vehicles from counting does not necessarily lead to measurement errors as long as the missing process is random or the counted vehicles are still representative of all vehicles. What can lead to serious measurement errors in transit mode share is missing certain occupants in vehicles that are being counted. Some occupants are not being counted largely because an observer's inability to see some occupants. It is difficult to see small persons in the back seat of any vehicle. It is difficult to see any occupants when there is window glare or sun light in the observer's eyes. It is impossible to see occupants in the back seats of vehicles with tinted windows.

Available evidence appears to suggest that video surveillance is more accurate than roadside windshield detection. Video viewers can take their time to determine the number of occupants for individual vehicles, while field observers do not have that luxury. However, overall costs can be considerably higher with video surveillance. As a result of this cost difference, roadside windshield detection is far more widely used than video surveillance.

The various reviews of observation methods do not mention any study that attempts to quantify the measurement error for either of these two manual methods. The absence of such studies is not surprising because no method currently exists that can give the absolute true measure of vehicle occupancy. Such a true value is necessary for evaluating the accuracy of any other observation method.

Practices have been suggested to improve the accuracy of roadside windshield detection. It is more important for observers to record occupancy data for vehicles that they clearly see rather than recording a value for every vehicle. To reduce observer fatigue, breaks should be scheduled into field observations, such as taking a 10-minute break after collecting data for 20 minutes. In both of these cases, however, some vehicles are skipped. As a result, simply adding all occupants from counted vehicles would significantly undercount the total number of vehicle occupants. Instead, the total number of vehicle occupants should be estimated by using the occupant data from the counted vehicles to derive average vehicle occupancy and then multiplying it with the total number of vehicles passing an observation site. Loops not observers should be used to count the total number of passing vehicles.

<u>Manual—Transit Loading</u>. For transit, on the other hand, load checking is the only manual method. Load checks are one form of point checks that are widely used by transit agencies on a routine basis for a variety of planning purposes. Load checks can be conducted either from the roadside or from inside vehicles while stationary at a stop.

While no documented evidence appears available on the relative accuracy of roadside versus in-vehicle load checks, logic would suggest that in-vehicle load checks are more accurate. Because of the concern that going inside transit vehicles would interfere with operations, however, load checks are almost always conducted from outside a vehicle by transit agencies that responded to a survey for a Transit Cooperative Research Program project (Furth 2000). The problem is that making accurate load measurements from outside a vehicle can be difficult with load checks, especially if a bus has tinted windows. Observing the number of passengers in a wrapped bus is simply impossible from the roadside.

Limited evaluations appear to show that roadside load checks systematically over-count passenger loading. Furth (2000) reviews two agency studies that found that measurement errors displayed a systematic error as well as random errors. Both studies found diminished accuracy when loads were greater. The first study determined that when a load was above 35 passengers, the systematic over-count was 9 percent and the random error was 10 percent. That is, most observations would range from 40 to 48 when the real load is 40 passengers. The other study found that there was a systematic over-count of 9 passengers, with a further random variation of, on average, 10 passengers when loads were over 40 passengers, i.e., most observations would range from 39 to 59.

<u>Magnified Errors</u>. The opposite directions in measurement errors between the manual methods for POV occupancy versus the manual methods for transit loading would mean not only that the resulting transit mode share would be over-stated, but also that the degree of measurement errors would be far greater than that in either POV occupancy or transit loading. To illustrate, Table 6-4 shows the percent errors in transit mode share for the case with 1,000 transit passengers and 50,000 POV occupants from a field observation by different combinations of errors in POV occupancy and transit loading.

Table 6-4. Illustrative Measurement Errors in Transit Mode Share

Errors in Transit Loading	*Errors in POV Occupancy*				
	-10%	*-5%*	*0%*	*5%*	*10%*
-10%	0.0	-5.2	-9.8	-14.0	-17.9
-5%	5.4	0.0	-4.9	-9.4	-13.4
0%	10.9	5.2	0.0	-4.7	-8.9
5%	16.3	10.3	4.9	0.0	-4.5
10%	21.7	15.4	9.8	4.7	0.0

Notes: Based on the case with 1,000 transit passengers and 50,000 vehicle occupants from field observations.

Several observations are clear from this table. If the same degree of measurement errors is present in both vehicle occupancy and transit loading (the cells along the diagonal line), there is no measurement error in transit mode share. If transit loading is undercounted (negative in 1st column of Table 6-4) and errors in POV occupancy are smaller in magnitude, transit mode share would be understated (negative in Table 6-4). If transit loading is over-counted and errors in vehicle occupancy are smaller in magnitude, transit mode share would be overstated. If errors are in the same direction for both POV occupancy and transit loading, errors in transit mode share would not be greater than either component error. If errors are in the opposite direction, on the other hand, errors in transit mode share would be greater than the sum of both component errors. In the case with positive10-percent errors in transit loading and negative 10-percent errors in vehicle occupancy, for example, transit mode share would be overstated by 21.7 percent.

6.7.2. Measurement Plan

Once an observation method is chosen for each mode, a measurement plan is needed to specify observation locations and days as well as other details such as the selection, training, and assignment of observers. Rather than covering every aspect of a measurement plan, the following discussion focuses on the selection of observation locations and days because they drive the precision of measured transit mode share and the cost of measurement.

In developing a measurement plan, it is important to understand the most desirable outcome. Consider annual measurement for an activity center. The most desirable outcome is to get a random sample of all person trips by transit or POVs that start or end in this activity center from 4:00 p.m. to 6:00 p.m. on all weekdays in a year. For a corridor, the most desirable outcome is to get a random sample of all person trips by transit or POVs along part or the full length of this corridor from 4:00 p.m. to 6:00 p.m. on all weekdays in a year. Getting a random sample is critical. It is well established that both vehicle occupancy and transit loading vary significantly across locations and days.

There are two general approaches to selecting observation locations and days. One is based on sampling, but the other is more subjective. Each is described below.

Subjective. This approach would select observation locations and days without systematically considering the spatial and temporal variations in vehicle occupancy, transit loading, and transit mode share.

For corridors, one cutline would be selected. This cutline should be selected so that the transit mode share is as close to the result from the most desirable outcome as possible. Load checks by transit agencies typically are conducted at or near maximum-load locations for measuring vehicle crowding. For measuring transit mode share, however, locations with maximum transit loading may not be locations for maximum vehicle occupancies. Focusing on locations with maximum transit loading can seriously overstate transit mode share. This cutline would intersect with each of the longitudinal facilities in the corridor. For activity centers, on the other hand, one cordon line would be determined first on the basis of the boundary of an activity center. This cordon line will intersect all radial facilities that serve transit or POVs to this activity center.

For either corridors or activity centers, all of the intersecting points would serve as the general locations for observation regardless of whether transit is available on these facilities. Excluding facilities without transit service would overstate transit mode share. The exact observation locations may deviate from the general locations, and should be near transit stops so that roadside observations are easier due to slowing buses, and field observers would have the opportunity to get on the buses when bus windows are covered by ads. In addition, each exact location should be used to observe both transit loading and vehicle occupancy.

Field observations would be made on a typical day during the pre-specified afternoon peak hours from 4:00 p.m. to 6:00 p.m. On a weekly basis, any of the three middle days would be considered as a typical day.

Sampling-Based. This approach would select observation locations and days by considering the spatial and temporal variations in vehicle occupancy, transit loading, and transit mode share. For activity centers, the sampling process will only involve days because observation locations would be largely fixed by the boundary. Some estimate of how much transit mode share varies across weekdays would be required to determine the minimum number of weekdays for observation. Once the sample size is determined, these weekdays would be randomly sampled throughout the year. For corridors, however, the sampling process would involve not only weekdays but also the individual segments of a corridor. Similarly, some estimate of how much transit mode share varies across weekdays and corridor segments would be required to determine the number of days and segments for observation. For either sub-area type, the minimum sample size (weekdays for activity centers but weekday-segment combinations for corridors) is given by the following standard formula:

$$n = \left(\frac{z\sigma}{d} \right)^2 \qquad (6\text{-}1)$$

where,

- z is the z value (e.g.,1.96 for 95-percent confidence level);
- d is the margin of error (e.g., 0.05 = ±5 percent); and
- σ is the standard deviation of transit mode share (e.g., 0.05 = 5 percent). This standard deviation is measured across weekdays for activity centers but across both weekdays and segments for corridors.

Evaluation. Observing vehicle occupancy and transit loading will need to rely on manual methods. For vehicle occupancy, video surveillance appears to be more accurate but costs more than roadside windshield detection. For transit loading, in-vehicle load checks are expected to be more accurate than roadside load checks.

Locations and days for field observations for any sub-area should be selected randomly by taking into account how much transit mode share varies across locations and days. Currently no information is found available on the statistical variation.

Selecting locations and days for field observations is frequently subjective in practice without taking into account the spatial and temporal variation. This subjective approach will cost far less than the sampling-based approach, but one would be far less certain in whether any changes in transit mode share are real or just part of the spatial and temporal variation.

CHAPTER 7. RECOMMENDATIONS

7.1. Introduction

Transit mode share is used as a critical policy barometer at various geographic levels. Its magnitudes and temporal trends play an important role in both policy debates at areawide levels (nationwide, states, regions, etc.) and in performance monitoring at sub-area levels (activity centers and corridors). The census journey-to-work data have typically been used for areawide measurement of transit's usual mode share, i.e., the share of workers who usually use transit for commuting. There have been many concerns in the literature about using census journey-to-work data for measuring transit mode share.

This report has documented a research effort to develop alternative measures of transit mode share that address these concerns. An alternative measure of transit mode share refers to something that results from using 1) a specific measure of travel, 2) a specific set of modes, 3) a specific travel market, and 4) a specific method of data collection. For this research, a framework is developed for considering transit mode share and its measurement. This framework is then used to assess the sensitivity of transit mode share to the concerns raised in the literature. The framework and the results from the sensitivity assessment are finally used to develop alternative measures of transit mode share.

Transit serves three primary public policy objectives: congestion relief, travel options, and basic motorized mobility. Transit mode share should be measured at sub-area levels for the objective of congestion relief, but at areawide levels for the objectives of providing travel options and basic motorized mobility. Measurement of transit mode share is complementary between areawide levels and sub-areas. The recommendations below are presented separately for areawide measurement and sub-area measurement.

7.2. Areawide Measurement

There are two real alternative measures for areawide measurement of transit mode share. One is based on the number of person trips by all residents in areawide geography during a given period (a day, a week, etc.) for all purposes. The other option is based on the number of workers who usually commute to their main job in a week. While the first option has several minor advantages, the second option has a significant advantage of minimal cost for implementation. The first option would require original data collection through statistical sampling every time measurement is required. With the relatively low magnitude of transit mode share experienced in Florida at areawide levels, the cost involved is too high for periodic measurement. The second option, on the other hand, can be implemented without any original data collection. It can be reliably measured annually for areawide geographies with a population of at least 65,000 using information contained in pre-tabulated tables from the Florida sample of the annual American Community Survey (ACS) starting 2006. The 2006 data are expected to be made public in August 2007.

It is recommended that FDOT and local governments consider using post-2005 ACS for annual areawide measurement of transit mode share for any areawide geography with a population of at least 65,000. Among the 67 counties in Florida, 37 had a population of at least 65,000 in 2000. In terms of the four elements of alternative measures of transit mode share, the recommended alternative measure of transit mode share has the following specifications:

- Travel Market: Commuting from home to work at any time of day;
- Measure of Travel: Number of persons 16 years or older who worked for pay or profit during the week proceeding their survey dates in any areawide geography with a population of at least 65,000 in the year of measurement;
- Modes: All modes used for commuting from home to work but excluding working at home with taxicab excluded from transit. If more than one mode is used, only the main mode is considered; and
- Method for Data Collection: Tabulated data by the Bureau of the Census from ACS collected through statistical sampling.

7.2. Sub-Area Measurement

Three alternative options for sub-area measurement of transit mode share are recommended. These are referred to as alternative options rather than alternative measures because they are not ready to be implemented at this point. The first option is based on original data collection through field observations, and further research also is recommended for implementation. The second option is based on an existing FDOT program, and changes to this program are required to implement this option. The last option also is based on ACS, and further research is recommended before it is implemented. While the first option is designed for sub-area measurement of transit mode share in individual sub-areas, the other two options are designed for statewide sub-area measurement of transit mode share.

7.2.1. Field Observations

Method. FDOT should also consider using data from field observations to measure transit mode share for travel into activity centers and for travel passing cutlines across individual corridors. For an activity center, field observations would be made at the intersections of the center boundary and the radial facilities into the center during the afternoon peak hours from 4 pm to 6 pm on a random sample of weekdays. Some estimate of how much transit mode share varies across weekdays would be required to determine the minimum number of weekdays for observation. For a corridor, field observations would be made at a random sample of corridor segments and weekdays. Similarly, some estimate of how much transit mode share varies across weekdays and corridor segments would be required to determine the number of days and segments for observation.

Further Research. Research is needed to assess the statistical variation of transit mode share across weekdays for given activity centers and across both weekdays and segments for corridors. The results will determine the minimum amount of observations required for achieving particular levels of confidence and margin of errors in transit mode share measured for individual sub-areas.

Research also is needed to evaluate the improved accuracy in observed transit loading between in-vehicle load checks and roadside load checks. In addition, this evaluation will also examine the factors that influence the level of accuracy improvements from in-vehicle load checks. Intuitively one would expect that in-vehicle observations are more accurate, but no quantitative information is currently available on the relative accuracy between these two observation methods for transit loading. If the improvement from in-vehicle observation is marginal, roadside observations may be preferred because in-vehicle observations interfere with normal transit operations.

7.2.2. Existing Processes

Studies under FDOT's MPO Transit Quality of Service Evaluation Program already identify activity centers and the longitudinal dimension of corridors in terms of activity centers at their two ends. Data on transit loading are already collected. These sub-areas consist of traffic analysis zones (TAZs). These studies are conducted in every MPO region in Florida. These studies are conducted every time a local long range transportation plan is updated.

It is recommended that FDOT slightly expand this program to include measuring transit mode share as well. While it is not a modal performance measure for transit, transit mode share is a multimodal performance measure and it is an outcome that can be greatly influenced by transit quality of service in individual sub-areas. In addition, reaching particular levels of transit mode share is frequently a planning objective for both transit agencies and MPOs.

To avoid major changes to the current program, this approach is designed for statewide sub-area measurement of transit mode share for the most recent update years. The standard process already in place for sub-area identification, data collection, and result submission greatly facilitates this statewide aggregation. One potential problem for statewide aggregation is that long range transportation plan updates are not entirely synchronized across the MPO regions. But this should not be a major barrier because the difference is small. Specifically, the largest 9 MPO regions will adopt their next updates in 2009, and another 9 regions in 2010, and the remaining 7 regions in 2011. If synchronization is necessary, these three groups may be aggregated separately to get sub-area measurement of transit mode share for each group.

Several changes to the current program would still be needed to implement this recommendation.

- Add transit mode share as the seventh performance measure for the top activity center in terms of employment and for the top two pairs of activity centers in terms of origin-destination travel demand. For activity centers, measuring transit loading and vehicle occupancy would be all new efforts. For the two pairs of activity centers, however, transit loading is already required, but measuring vehicle occupancy would be new efforts.
- Currently the ranking of activity center pairs is based on the travel demand flow between the two extreme end TAZs. It would be more desirable to measure travel demand flow between all TAZ pairs for a given pair of activity centers.
- Currently transit loading is measured at the maximum load point as determined by the MPO or transit agency. As practiced, maximum load points are often at transfer centers that are off-road. When a maximum load point is not at roadside (e.g., an off-road

transfer center), the observation point needs to be moved to the closest roadside location so that transit loading and vehicle occupancy can be observed at the same location.

7.2.3. Small-Area Census Data

It is recommended that FDOT consider using small-area census data in the Census Transportation Planning Package (CTPP) for sub-area measurement of transit mode share for travel into activity centers and for travel within corridors that consist of TAZs. The cost is low, but adequate sample size is likely to be an issue for individual sub-areas. This is particularly true for future years because CTPP data will have to come from the annual ACS, which uses an annual sample that is significantly smaller than what has been used by the decennial census. Because of this sample size issue for individual sub-areas, it is recommended that this approach be used for statewide sub-area measurement of transit mode share. The sub-areas for statewide sub-area measurement may be identified through one of two approaches.

- One approach would be those sub-areas from FDOT's Transit Quality of Service Evaluation Program. A statewide sub-area measurement of transit mode share can be easily and reliably estimated.
- An alternative approach would be to use data at the TAZ level from the 2000 Census Transportation Planning Package (CTPP) to identify sub-areas throughout the state. Research is needed to develop a method for using CTPP 2000 in identifying activity centers and corridors, and to apply this method for measuring transit mode share. In assessing the sensitivity of transit mode share to geographic areas, Chapter 4 identified a few corridors in Tampa and Miami based on the presence of transit services and the quality of these services. While possible, it was a labor-intensive process. Rather than using the presence and quality of transit services, the identification criteria with using CTPP 2000 would be the concentration of transit usage by commuters. The objective would be to identify clusters of TAZs as workplaces or as origin-destination pairs that show transit mode shares that are much higher than surrounding TAZs. The results can provide FDOT with information on activity centers and corridors throughout Florida that have relatively high transit mode share. The results can serve as a baseline of transit mode share for the identified sub-areas for monitoring the effectiveness of future improvements in these areas on transit mode share. The identified sub-areas can serve as candidates for sub-area measure of transit mode share with field observations. The method developed can be used for periodic future measurement of transit mode share using data from ACS.

7.3. Summary

To assess the effectiveness of transit policies in Florida in providing travel options and basic motorized mobility, it is recommended that FDOT use post-2005 ACS for annual statewide measurement of transit mode share that is based on commuting under all conditions, with or without travel services available, and during all time periods.

To assess the effectiveness of transit policies in Florida in congestion relief, it is recommended that FDOT use data from field surveys during the afternoon peak hours from 4 p.m. to 6 p.m. for periodic sub-area measurement of transit mode share for individual sub-areas. Further research is needed, however, to implement this option.

FDOT has two options to assess the effectiveness of transit policies in Florida in congestion relief with statewide sub-area measurement of transit mode share. One would be to expand its MPO Transit Quality of Service Evaluation Program to include transit mode share, and changes to the current program will be required to implement this option. The other option would be to use census small-area data to identify sub-areas throughout the state and aggregate information from the individual sub-areas for statewide sub-area measurement of transit mode share. Further research is needed to develop the method to use census small-area data to identify sub-areas through the state.

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