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16. Abstract

Traveler trip length has for years been used as a fundamental indicator of the best mix of transit modes and user perceptions of travel cost for transit versus auto. This study examines traveler trip lengths across transit modes, work trip duration frequency distributions and mode share distributions in 7 major cities, 8 Combined Statistical Areas and one Metropolitan Statistical Area and found the effect of increasing population and transit mode variety on work trip travel time and travel distance.

A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Based on NTD data, the average trip length for these four modes are: local bus (4.6 miles), light rail (3.9 miles), heavy rail (6.3 miles), and commuter rail (30.1).

Trip Time Frequency Distributions for home-based work trips in all major cities selected in this study followed the same pattern except in New York, NY. In virtually all cities from 1990 to 2005, frequencies decreased in all categories less than 30 minutes and increased in categories greater than 30 minutes. Meanwhile, Trip Time Frequency Distributions for home-based work trips in all selected MSAs also followed the same pattern. These results contradicted our assumption that cities or MSAs with different urban forms or transit history might have different Trip Length Frequency Distributions (TLFDs) and showed that at an aggregated level, there is no statistically significant difference among TLFDs for work trips in the selected areas.

Average work trip length for all the 50 MSAs in National Household Travel Survey data also showed that travel time and travel distance for home-based work trips in all selected MSAs are very similar. Also, from the linear regression functions with trip length as dependent variable, it can be seen that work trip time and distance tend to increase with increasing population, work trip time and distance tend to increase also as the number of transit modes increase.

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Examining the Role of Trip Length in Commuter Decisions to Use Public Transportation

by

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Research Report SWUTC/10/476660-00074-1

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June 2010

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DISCLAIMER

ABSTRACT

Traveler trip length has, for years, been used as a fundamental indicator of the best mix of transit modes and user perceptions of travel cost for transit versus auto. This study examines traveler trip lengths across transit modes, work trip duration frequency distributions, and mode share distributions in seven major cities, eight Combined Statistical Areas and one Metropolitan Statistical Area, and found the effect of increasing population and transit mode variety on work trip travel time and travel distance.

A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Based on NTD data, the average trip length for these four modes are: local bus (4.6 miles), light rail (3.9 miles), heavy rail (6.3 miles), and commuter rail (30.1).

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Average work trip length for all the 50 MSAs in National Household Travel Survey data also showed that travel time and travel distance for home-based work trips in all selected MSAs are very similar. Also, from the linear regression functions with trip length as dependent variable, it can be seen that work trip time and distance tend to increase with increasing population, work trip time, and distance tend to increase, also, as the number of transit modes increase.

EXECUTIVE SUMMARY

The nation's growth and need to meet mobility, environmental, and energy objectives place great demands on public transit systems. Transit providers are searching for ways to provide sufficient system capacity; however, they are experiencing increasing costs due to fuel price fluctuations and decreasing available funds. This situation means that public transportation providers must adapt their service concepts to maximize the goodness of fit between traveler demands and service types. Despite a significant amount of academic and practitioner-oriented research, the practice of choosing the right transit service to meet current demand and the right development to support transit ridership is still constrained by scarcity of information and data.

Traveler trip length has for years been used as a fundamental indicator of the best mix of transit modes, and user perceptions of travel cost for transit versus auto modes are clearly related to traveler trip length. A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Although most service providers would likely agree that traveler trip lengths increase from top to bottom of this list, few would agree regarding the thresholds separating the modes. This research was designed to examine trip length data for these, and sub-sets of these modes, to estimate thresholds among them. This will provide service providers with tools that will enable more direct choices among service types and more optimal design of transit services.

The National Transit Database (NTD) is the Federal Transit Administration's (FTA) national database of statistics for the transit industry. Reported by more than 600 transit agencies across the US, the database includes all modes of public transportation utilized on local and regional routes throughout the country, including private and public buses, heavy and light rail, ferryboats and vanpool service, as well as services for senior citizens and persons with disabilities, and taxi services operated under contract to a public transportation agency.

In this report, operational characteristics from NTD were selected to examine trip length characteristics for four transit modes – local bus, light rail, heavy rail and regional rail – to estimate trip length thresholds among these four transit modes. Also, a variable indicating the variety of available public transit modes for 50 MSAs is formulated based on information from NTD and is used for testing hypotheses regarding work trip length VS public transportation availability and type.

Based on analysis of three datasets – National Transit Dataset, Census Transportation Planning Products and National Household Travel Survey, the following conclusions were developed:

A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Based on NTD data, the average trip length for these four modes are: local bus (4.6 miles), light rail (3.9 miles), heavy rail (6.3 miles), and commuter rail (30.1). These results supported the common agreement that traveler trip lengths increase from local bus, light rail, rapid rail to commuter rail.

Trip Time Frequency Distributions for home-based work trips in all major cities selected in this study followed the same pattern except in New York, NY. In all the other major cities, work trips with durations in the 20-29 minutes and 30-34 minutes intervals represent the largest proportions of all work trips, while in New York (NY), work trips in the longer than 60 minutes category are approximately twice as frequent as any other city. Additionally, in virtually all cities from 1990 to 2005, frequencies decreased in all categories less than 30 minutes and increased in categories greater than 30 minutes. Meanwhile, Trip Time Frequency Distributions for home-based work trips in all selected MSAs also followed the same pattern. These results contradicted our assumption that cities or MSAs with different urban forms or transit history might have different Trip Length Frequency Distributions and showed that at an aggregated level, there is no statistically significant difference among TLFDs for work trips in the selected areas.

Average work trip length for all the 50 MSAs in National Household Travel Survey data also showed that travel time and travel distance for home-based work trips in all selected MSAs are very similar. For all 50 MSAs, average work trip distance ranged from 10.0 to 16.8 miles with an average of 13.0 miles, while travel time for work trips ranged from 18.8 to 32.2 minutes with an average of 23.3 minutes. Also, from the linear regression functions with trip length as dependent variable, it can be seen that work trip time and distance tend to increase with increasing population. Work trip time and distance tend to increase also as the number of transit modes increase.

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Chapter 1 Introduction

The nation's growth and need to meet mobility, environmental, and energy objectives place demands on public transit systems. Transit providers are searching for ways to provide sufficient system capacity; however, they are experiencing increasing costs due to fuel price fluctuations and decreasing available funds. This situation means that public transportation providers must adapt their service concepts to maximize the goodness of fit between traveler demands and service types. Despite a significant amount of academic and practitioner-oriented research, the practice of choosing the right transit service to meet current demand and the right development to support transit ridership is still constrained by scarcity of information and data.

Traveler trip length has for years been used as a fundamental indicator of the best mix of transit modes, and user perceptions of travel cost for transit versus auto modes are clearly related to traveler trip length. A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Although most service providers would likely agree that traveler trip lengths increase from top to bottom of this list, few would agree regarding the thresholds separating the modes. This research is designed to examine trip length data for these, and sub-sets of these modes, to estimate thresholds among them. This will provide service providers with tools that will enable more direct choices among service types and more optimal design of transit services.

Distributions of distances traveled by workers from residential locations to employment sites are fundamental metrics of urban form. Compact urban forms are considered synonymous with shorter work trip lengths while low density sprawling urban areas tend to suggest longer work trips. Similar to perceptions of urban form, availability of mature public transportation systems is perceived as having a relationship to work trip travel distances, and potentially, to facilitating urban form. This research is intended to quantify differences in work trip lengths across cities with different urban forms and a spectrum of available public transportation modes. That is, it will test hypotheses regarding work trip length versus urban form and work trip length versus public transportation availability and type.

Home-based work trips are more route-fixed, and usually carried out every day during approximately the same peak hours. So HBW trips can be targeted as the most important market share by public transportation providers because of their potentially large demand and aversion toward Peak Hour congestion. This study is focused on home-based work trips in the US and attempts to identify the hidden characteristics of home-based work trips and thus relationship to transit demand.

Chapter 2 Literature Review

Transit planners and decision makers have been trying for several decades to understand how urban form, land use and transit interact with each other. A large amount of research has been conducted on how densities, settlement patterns, land-use compositions, and urban designs of cities and neighborhoods influence transit usage on an aggregated level. For instance, whether a future light rail extension will be a cost-effective investment or whether headways should be increased on a conventional bus route critically depends on whether the built environment and the people living and working close by will support these changes with their patronage.

The key domestic study on the influence of urban form on transit demand (Pushkarev and Zupan) focused on the New York metropolitan area and identified significant relationships among the size and extensiveness of employment centers and transit patronage in corridors leading to the employment centers. Later, regional planning groups used simulation models to assess the impact of various growth scenarios on future travel behavior in their regions. Most find that concentrating jobs and housing where they can be served increases transit mode shares and reduces vehicle miles traveled.

On an intermediate scale, dense office and residential activity centers generate larger numbers of transit trips for work and non-work purposes than do less dense, auto-oriented suburban activity centers. Less dense, less diverse suburban activity centers generate far higher numbers of vehicle trips and lower levels of auto occupancy, particularly when combined with abundant, free parking. Residential density and design influence travel behavior directly, but in a less powerful way than the socioeconomic characteristics of residents. Different types of households live in dense and spacious areas within metropolitan regions. In American cities, affluent residents seek space at the metropolitan fringe, while in European cities, affluent residents often seek amenities and more central locations.

King (2008) estimated the average trip length for several transit modes based on the trip type they serve in Atlanta, GA and the results showed that the local bus has the shortest average trip length (4.03 miles). LRT and HRT trip lengths were assumed to be the same length (7.08) and commuter rail has the longest trip length which is 26.8 miles per trip. A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Although most service providers would likely agree that traveler trip lengths increase in the listed order, few would agree regarding the thresholds separating the modes.

Remarkably, little is known concerning trip length variation for a single metropolitan area at two or more points in time, or for two or more areas at one point in time. Two exceptions are an early report by the Southeastern Wisconsin Regional Planning Commission [SEWRPC (1975), Chapter IX] which compared automobile driver trip length by trip purpose, and Bellomo, Dial and Voorhees (1970) which examined several urban areas at two points in time.

The SEWRPC study indicated little change in the trip length frequency distribution between 1963 and 1974. Mean travel time of work trips was unchanged at 17.9 min, although mean travel distance did increase by 0.4 to 5.4 miles.

Chapter 3 - Data Sources

3.1 National Transit Database (NTD)

The National Transit Database (NTD) is the Federal Transit Administration's (FTA) national database of statistics for the transit industry. Reported by more than 600 transit agencies across the US, the database includes all modes of public transportation utilized on local and regional routes throughout the country, including private and public buses, heavy and light rail, ferryboats and vanpool service, as well as services for senior citizens and persons with disabilities, and taxi services operated under contract to a public transportation agency.

The types of data reported include:

- Operational Characteristics - Vehicle revenue hours and miles, unlinked passenger trips and passenger miles, etc.
- Service Characteristics - Service reliability and safety, etc.
- Capital Revenues and Assets - Sources and uses of capital, fleet size and age, and fixed guide ways, etc.
- Financial Operating Statistics - Revenues, Federal, state and local funding, costs, etc.

In this report, operational characteristics from NTD were selected to examine trip length characteristics for four transit modes – local bus, light rail, heavy rail and regional rail – to estimate trip length thresholds among these four transit modes. Also, a variable indicating the variety of available public transit modes for 50 MSAs is formulated based on information from NTD and is used for testing hypotheses regarding work trip length VS public transportation availability and type.

3.2 Census Transportation Planning Products (CTPP)

CTPP is a set of special tabulations from decennial census demographic surveys designed for transportation planners. The CTPP and its predecessor, UTPP, have used data from the decennial census long form from 1970 to 2000. As the Census Bureau has replaced the decennial census long form with the American Community Survey (ACS), the CTPP 2005 (the latest data products) is based on the ACS. Because of the large sample size, the data are relatively reliable and accurate. Selection of study areas is based on the criteria and at least one large city is included in each of the chosen areas [seven major cities, eight Combined Statistical Areas (CSA) and one Metropolitan Statistical Area (MSA)). For revealing hidden factors which significantly affect people's decisions to choose transit as their travel mode, Trip Length Frequency Distributions and Mode Share Distributions of home-based work trips were compared over time and across selected areas by using journey-to-work flow data from CTPP 1900, CTPP 2000 and CTPP 2005.

Table 3.1 Study Areas

Study Areas		
Major cities	**Combined Statistical Areas**	**Metropolitan Statistical Areas**
Chicago, Illinois	Atlanta-Sandy Springs-Gainesville, GA-AL	Miami-Fort Lauderdale-Miami Beach, Fl
Dallas, Texas	Birmingham-Hoover-Cullman, AL	
Detroit, Michigan	Boston-Worcester-Manchester, MA-NH	
Houston, Texas	Detroit-Warren-Flint, MI	
Los Angeles, California	Los Angeles-Long Beach-Riverside, CA	
New York, New York	San Jose-San Francisco-Oakland, CA	
Philadelphia, Pennsylvania	Seattle-Tacoma-Olympia, WA	
	Washington-Baltimore-Northern Virginia, DC-MD	

3.3 National Household Travel Survey (NHTS)

The National Household Travel Survey (NHTS) is a source of national statistics and trend data on the travel of the American public by all modes of transportation. The 2001 NHTS is the most recent in the series of these national travel surveys, and it provides information about travelers and their characteristics, household composition, the amount and type of trips that people take every day, and selected information about household vehicles. The data include characteristics of all household trips, by all modes, and all purposes.

Data cases corresponding to 50 MSAs (Metropolitan Statistical Area) from the 2001 NHTS dataset were selected and the average trip length measured both in travel time and travel distance for home-based work trips within the selected 50 MSAs was tabulated. By comparing the average commuting trip length among MSAs, the hypothesis regarding relationship between trip length and urban form compactness was tested. Also, average transit access time and wait time were calculated based on the NHTS dataset in order to understand the transit accessibility within the 50 selected MSAs, and furthermore, could be used to produce a meaningful comparison of travel costs by automobile and transit.

Chapter 4 Analysis Results

4.1 Trip Length VS Transit Modes

Based on the analysis of the data from National Transit Dataset (NTD), the average trip length within four major transit modes are shown in Table 4.1. Definitions for transit modes from NTD is used for this analysis result and is shown as follows.

Metro Bus (MB): A transit mode comprised of rubber-tired passenger vehicles operating on fixed routes and schedules over roadways. Vehicles are powered by diesel, gasoline, battery, or alternative fuel engines contained within the vehicle.

Light Rail (LR): A transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail (HR). It is characterized by passenger rail cars operating singly (or in short, usually two car, trains) on fixed rails in shared or exclusive right-of-way (ROW), low or high platform loading, and vehicle power drawn from an overhead electric line via a trolley or a pantograph.

Heavy Rail (HR): A transit mode that is an electric railway with the capacity for a heavy volume of traffic. It is characterized by high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, separate rights-of-way (ROW) from which all other vehicular and foot traffic are excluded, sophisticated signaling, and high platform loading.

Commuter Rail (CR): A transit mode that is an electric or diesel propelled railway for urban passenger train service consisting of local short distance travel operating between a central city and adjacent suburbs. Service must be operated on a regular basis by or under contract with a transit operator for the purpose of transporting passengers within urbanized areas (UZAs), or between urbanized areas and outlying areas. Such rail service, using either locomotive hauled or self-propelled railroad passenger cars, is generally characterized by multi-trip tickets, specific station to station fares, railroad employment practices, and usually only one or two stations in the central business district.

As can be seen in Table 4.1, the average trip length for Local Bus is 4.6 miles, which is close to that for the Light Rail mode (3.9 miles). Heavy Rail has a longer average trip length (6.3 miles) and Commuter Rail, which usually serves commuting trips between downtown areas and suburban areas, has the longest average trip length (as high as 30.1 miles). The hierarchy of average trip length for these four modes is as expected.

As far as the standard deviation of trip length in these four transit modes, commuter rail has a significantly larger variance than the other three modes. Since Commuter Rail service primarily operates during "peak" travel times, usually the hours of 6:00 a.m. to 9:00 a.m. and again from 3:00 p.m. to 6:00 p.m., and trains generally run inbound to the city center in the morning and outbound to suburban areas in the evening. A high variance among nationwide commuter rail trip lengths for evening was expected. However, when standard deviations are expressed as functions of their respective means, three of the four modes produce values that are approximately 0.5. Only heavy rail deviates from this pattern at a value of 0.35.

Table 4.1 Average Trip Length in Miles (2006)

	Mean	Median	Range	Standard Deviation	Standard Deviation/ Means
Local Bus	4.6	3.9	14.6	2.5	0.54
Light Rail	3.9	3.5	6.4	2.2	0.56
Heavy Rail	6.3	5.8	8.9	2.2	0.35
Commuter Rail	30.1	27.6	59.3	14.8	0.49

Note: While calculating the average trip length for bus mode, those trips with trip length larger than 15 miles were excluded and the rest were analyzed, since bus trips with more than 15 miles trip length can be reasonably assumed as long distance commuting trips which are not typically served by metro bus. And it can be seen that for Metro Bus and Light Rail modes, average trip length is smaller than that in Heavy rail mode. Among all these four transit modes, Commuter Rail has the longest average trip length.

4.2 Transit Mode Share and Trip Length Frequency Distribution

The Census Transportation Planning Products (CTPP) is a set of special tabulations from decennial census demographic surveys designed to provide information to reveal characteristics of home-based work (HBW) trips. And the CTPP 2000 is divided into three parts.

- Part 1 contains residence end data summarizing worker and household characteristics
- Part 2 contains place of work data summarizing worker characteristics
- Part 3 contains journey-to-work flow data

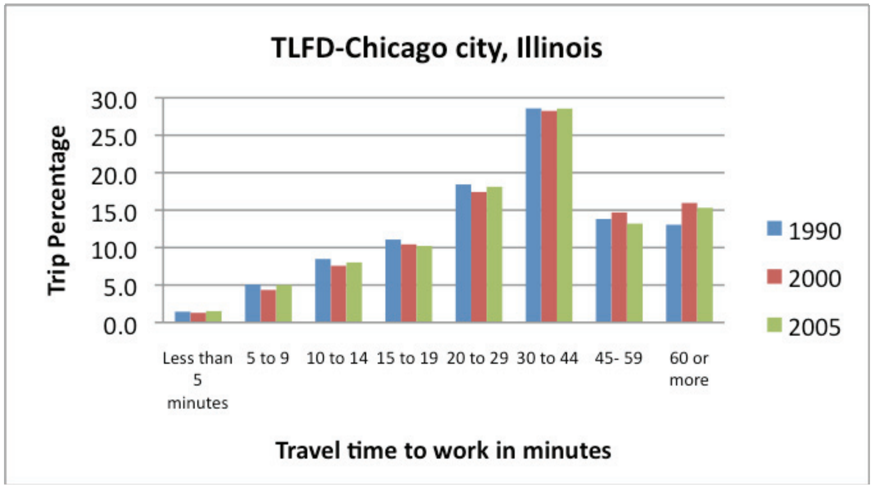
We chose large U.S. cities and studied the trip length frequency distributions and mode share distributions in 7 major cities, 8 Combined Statistical Areas and one Metropolitan Statistical Area shown in Table 4.2. The data employed for analysis comes from Part 1 of the CTPP 2000 where frequency distributions of mode to work and travel time to work for residents in specified areas are tabulated.

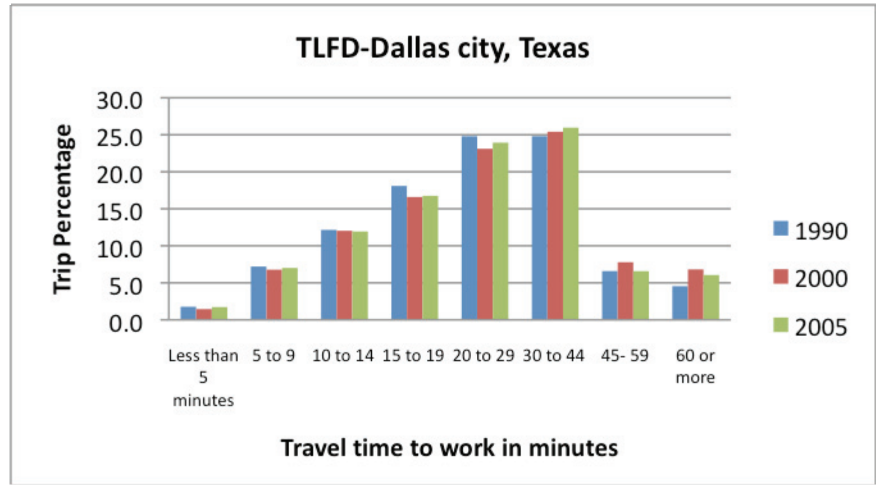
Table 4.2 Study Areas

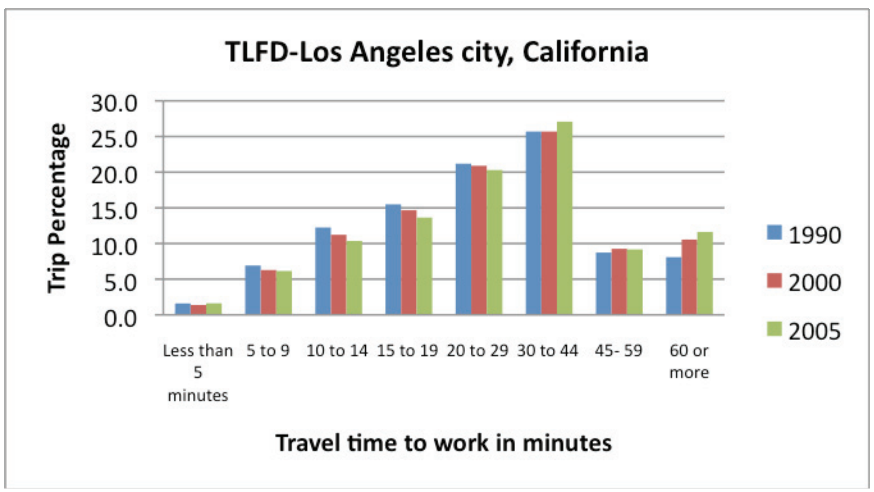
Study Areas		
Major cities	**Combined Statistical Areas**	**Metropolitan Statistical Areas**
Chicago, Illinois	Atlanta-Sandy Springs-Gainesville, GA-AL	Miami-Fort Lauderdale-Miami Beach, Fl
Dallas, Texas	Birmingham-Hoover-Cullman, AL	
Detroit, Michigan	Boston-Worcester-Manchester, MA-NH	
Houston, Texas	Detroit-Warren-Flint, MI	
Los Angeles, California	Los Angeles-Long Beach-Riverside, CA	
New York, New York	San Jose-San Francisco-Oakland, CA	
Philadelphia, Pennsylvania	Seattle-Tacoma-Olympia, WA	
	Washington-Baltimore-Northern Virginia, DC-MD	

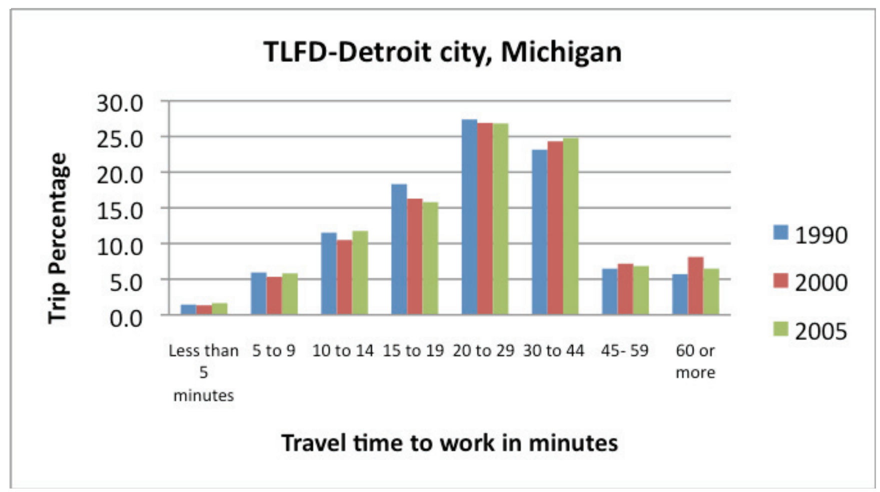
The Trip Length Frequency Distributions in the years 1990, 2000 and 2005 and Mode Share Distributions in the years 2000 and 2005 for all selected areas are shown as Figures 4.1, 4.2, 4.3 and 4.4.

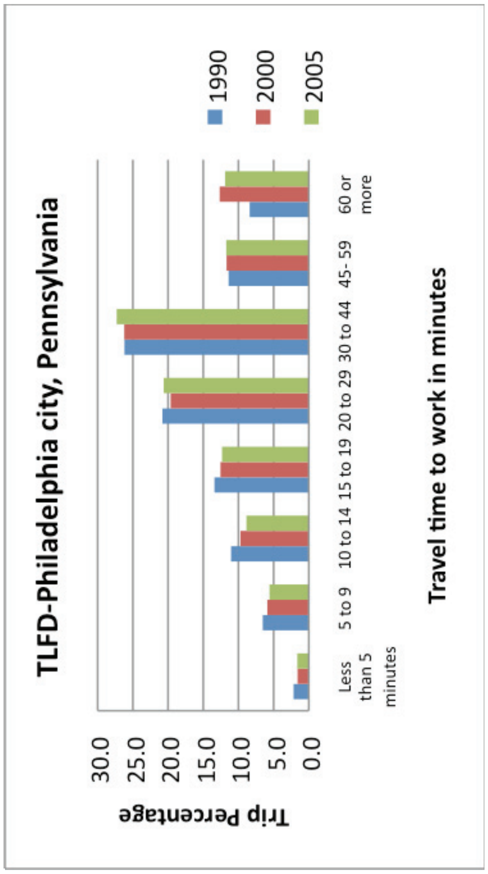
Figure 4.1 Trip Time Frequency Distributions for major cities (1990, 2000 and 2005)

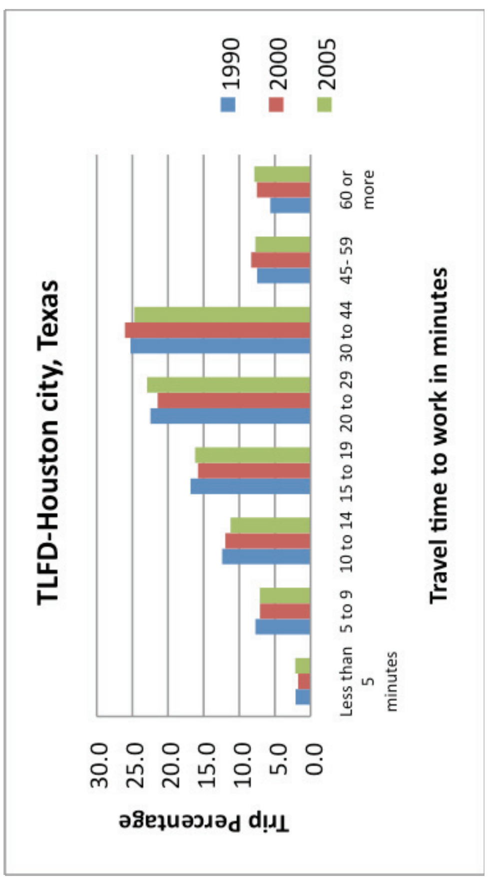









TLFD-Philadelphia city, Pennsylvania
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005


TLFD-Houston city, Texas
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

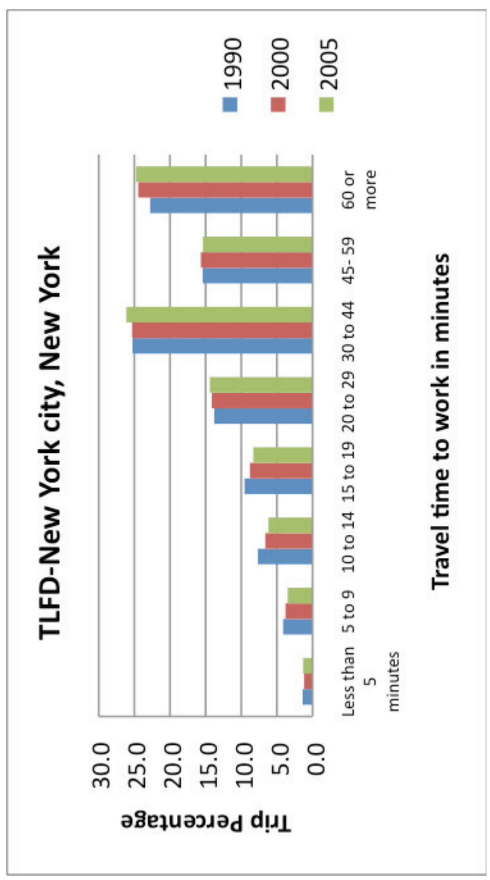
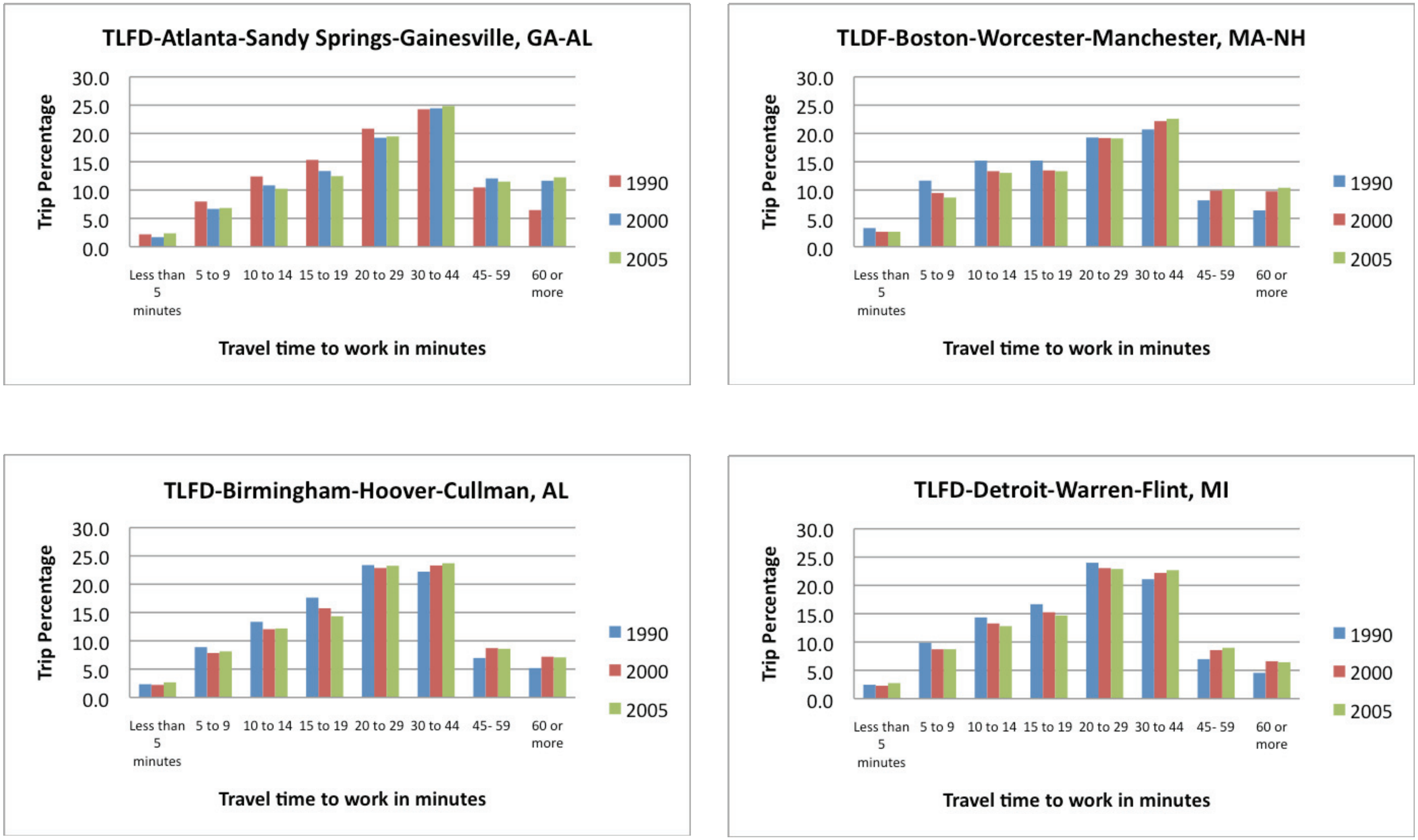
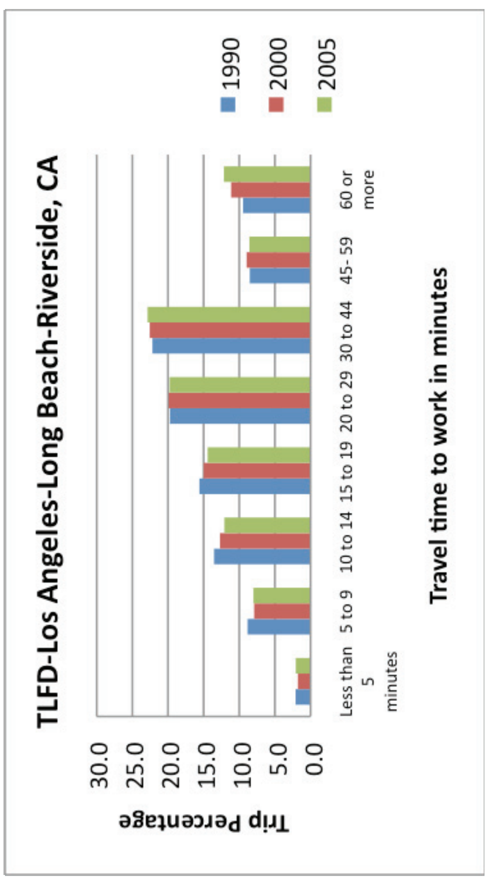
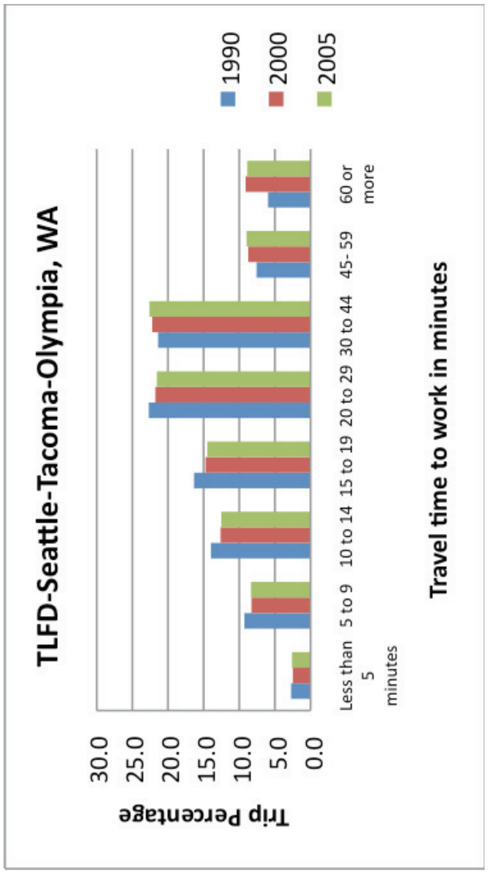
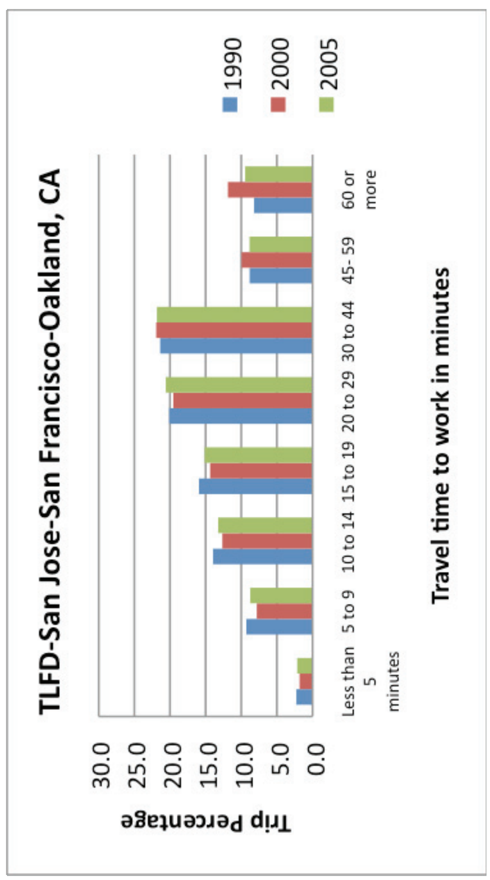

TLFD-New York city, New York
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

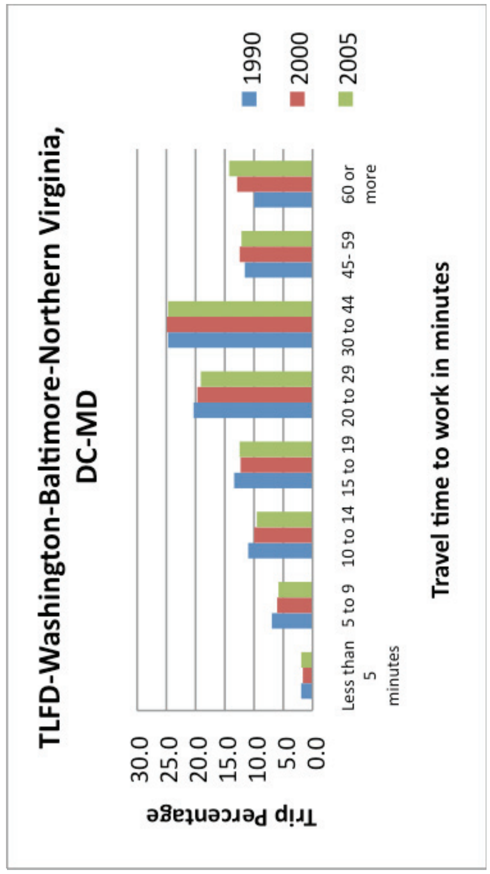
Figure 4.2 Trip Length Frequency Distributions for Combined Statistical Areas and Metropolitan Statistical Areas (1990, 2000 and 2005)

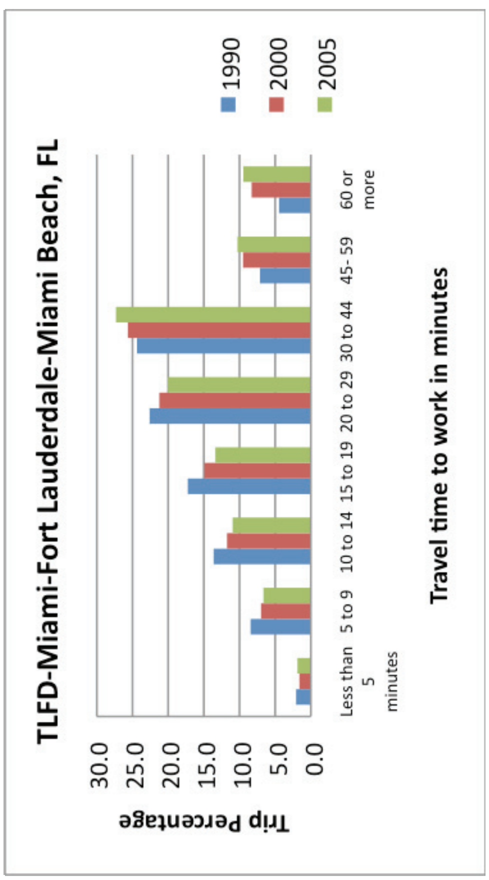



TLFD-Los Angeles-Long Beach-Riverside, CA
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005


TLFD-Seattle-Tacoma-Olympia, WA
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

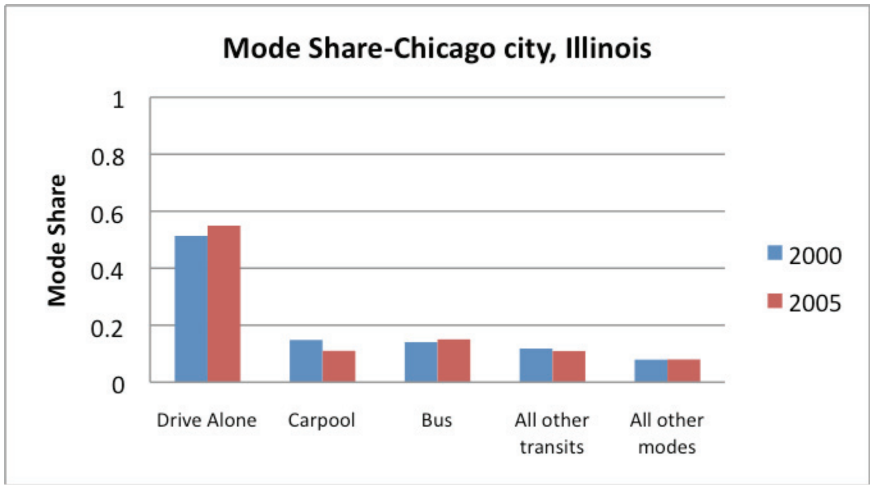

TLFD-San Jose-San Francisco-Oakland, CA
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

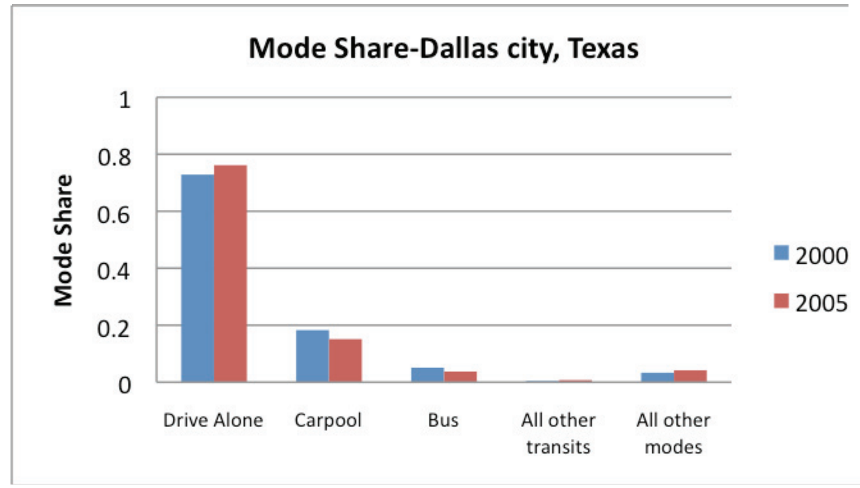

TLFD-Washington-Baltimore-Northern Virginia, DC-MD
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

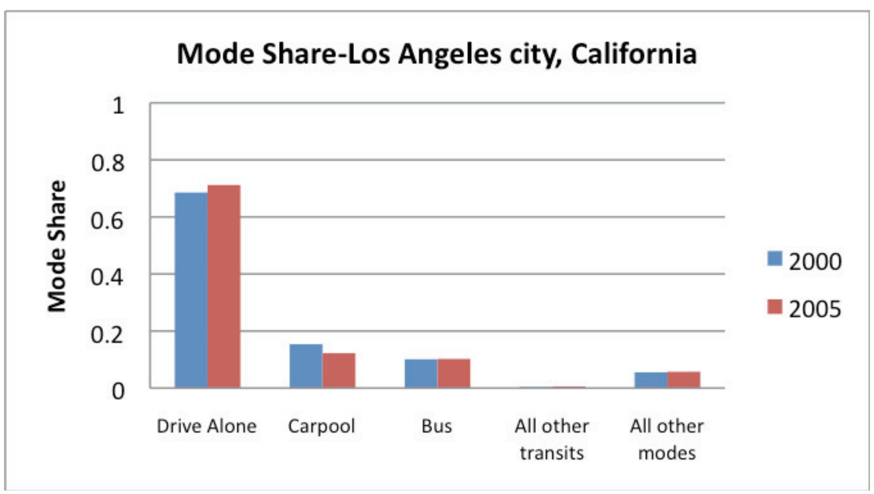


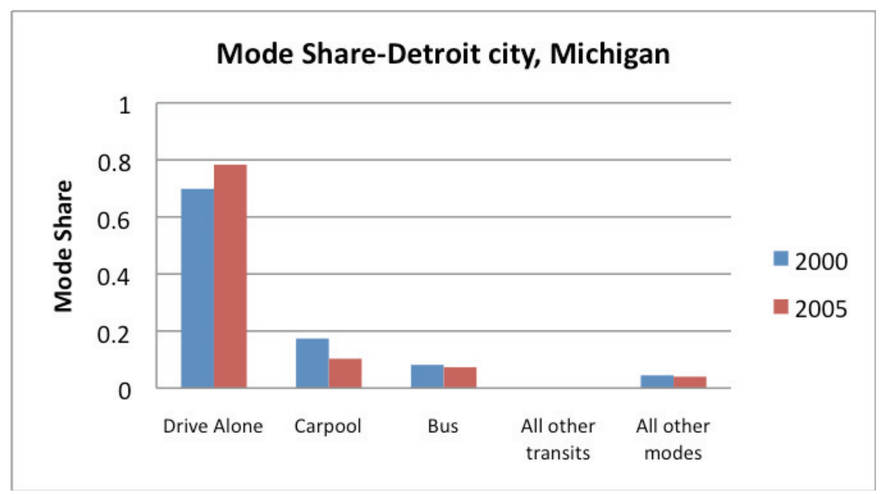
TLFD-Miami-Fort Lauderdale-Miami Beach, FL
Trip Percentage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Less than 5 minutes
5 to 9
10 to 14
15 to 19
20 to 29
30 to 44
45- 59
60 or more
Travel time to work in minutes
1990
2000
2005

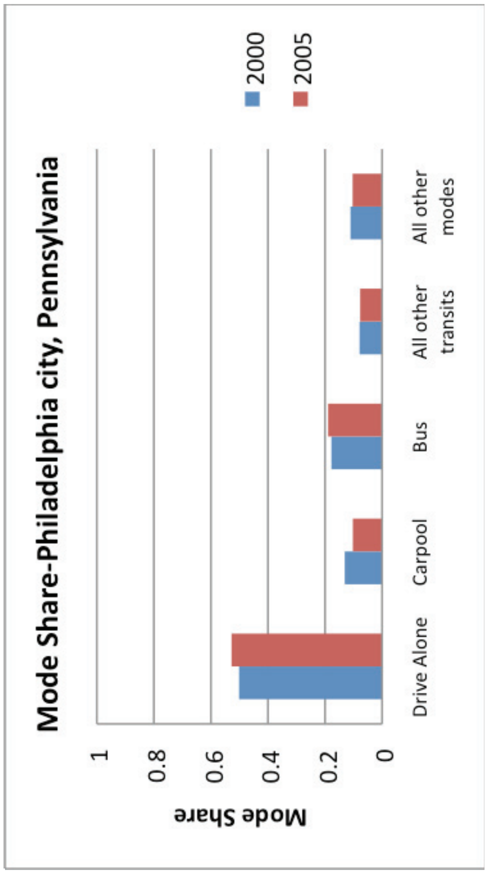
Figure 4.3 Mode Share Distribution for major cities (2000 and 2005)

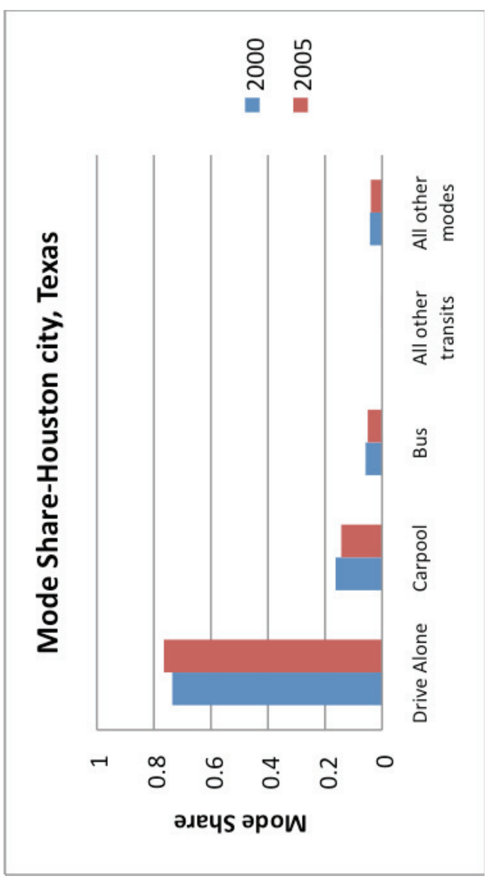









Mode Share-Philadelphia city, Pennsylvania
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005


Mode Share-Houston city, Texas
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005

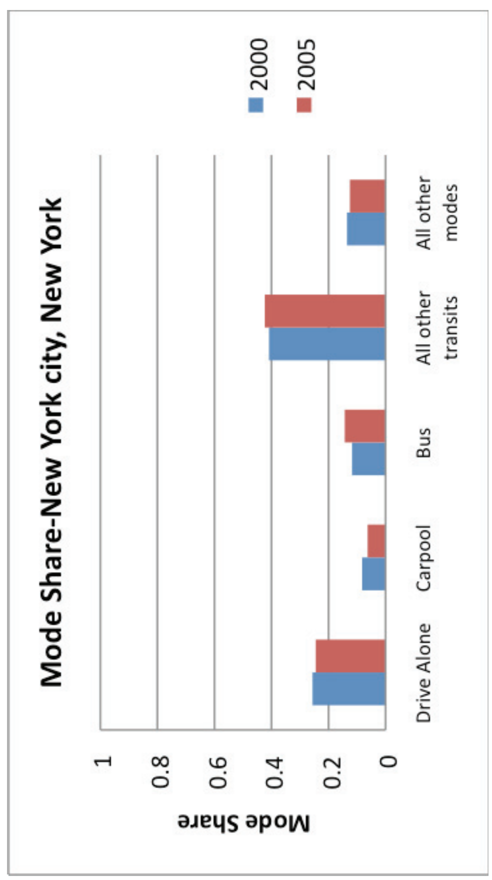
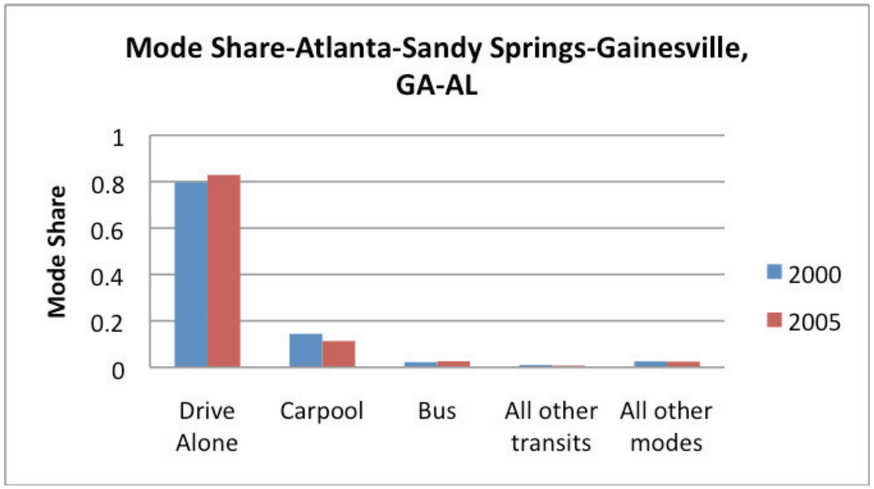
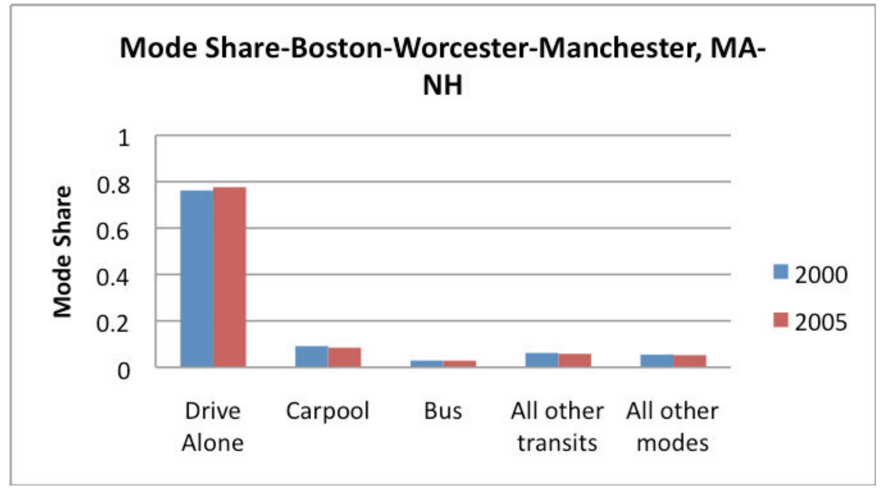
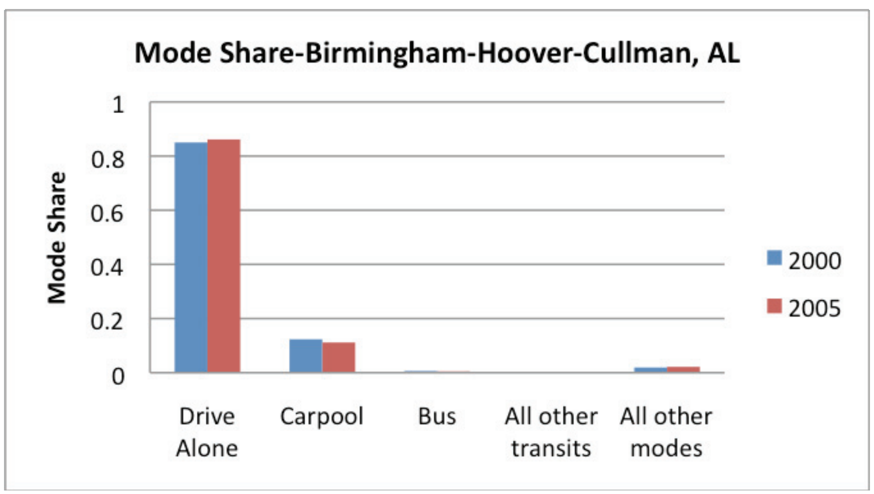
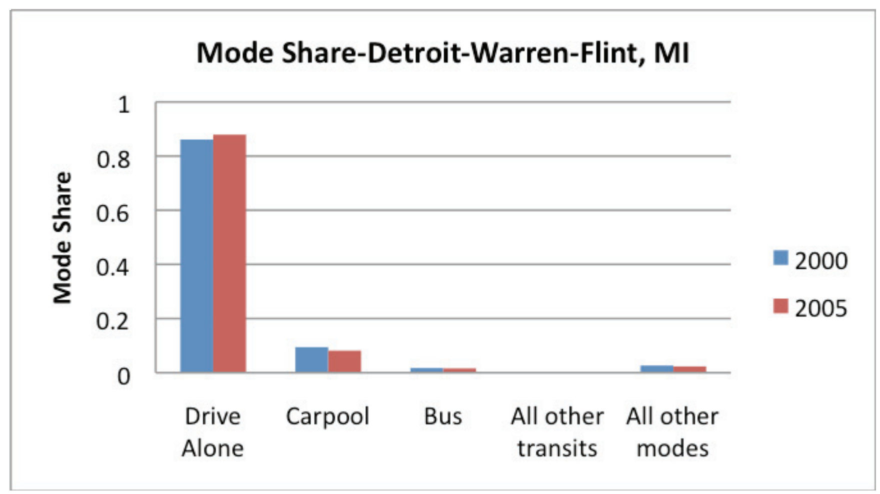

Mode Share-New York city, New York
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005

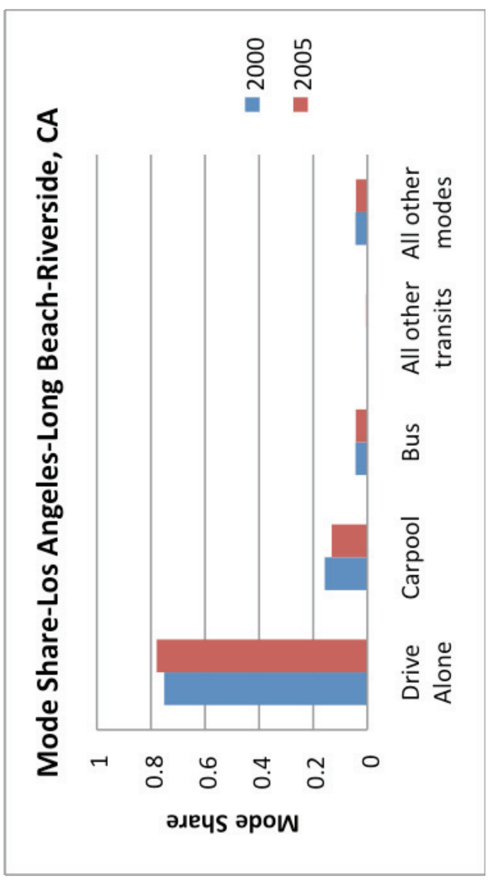
Figure 4.4 Mode Share Distributions for Combined Statistical Areas and Metropolitan Statistical Areas (2000 and 2005)

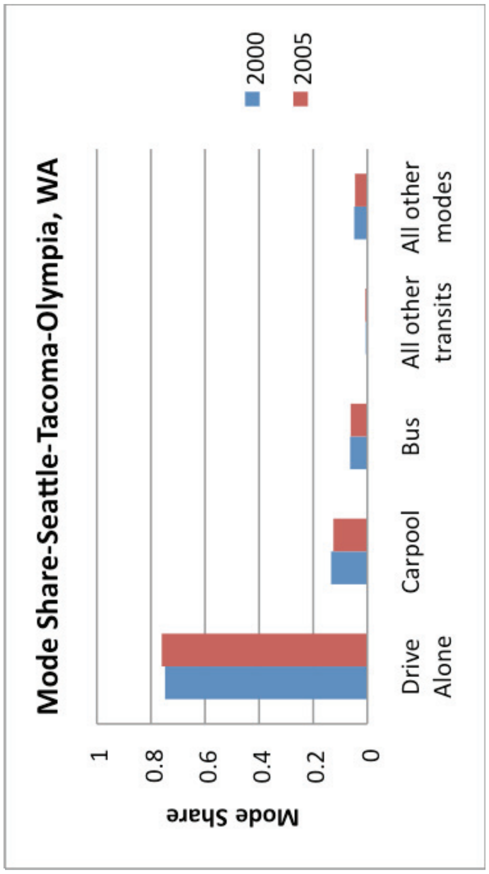


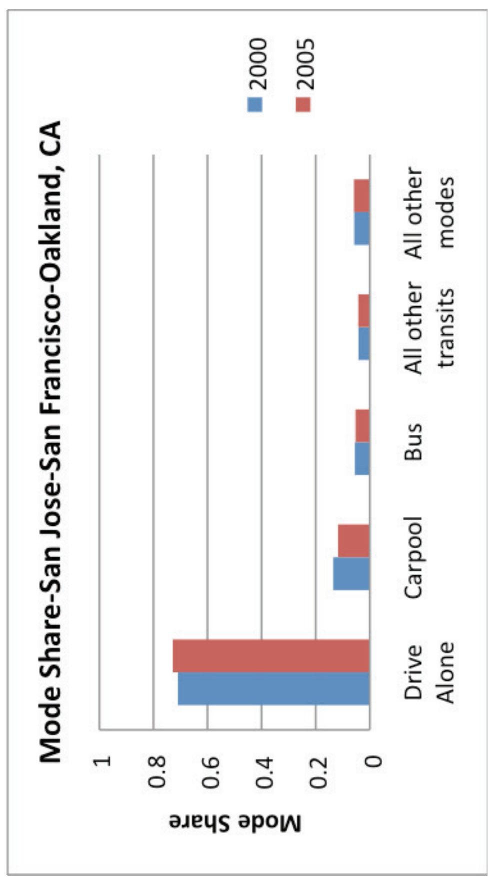


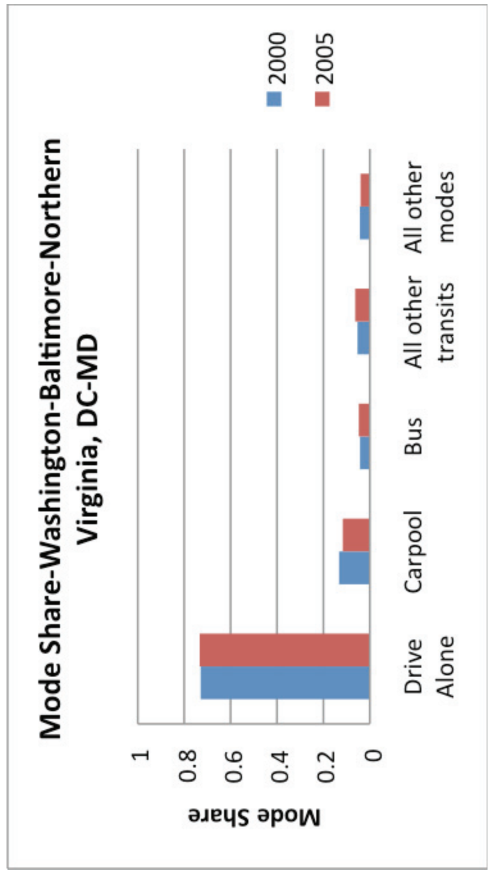


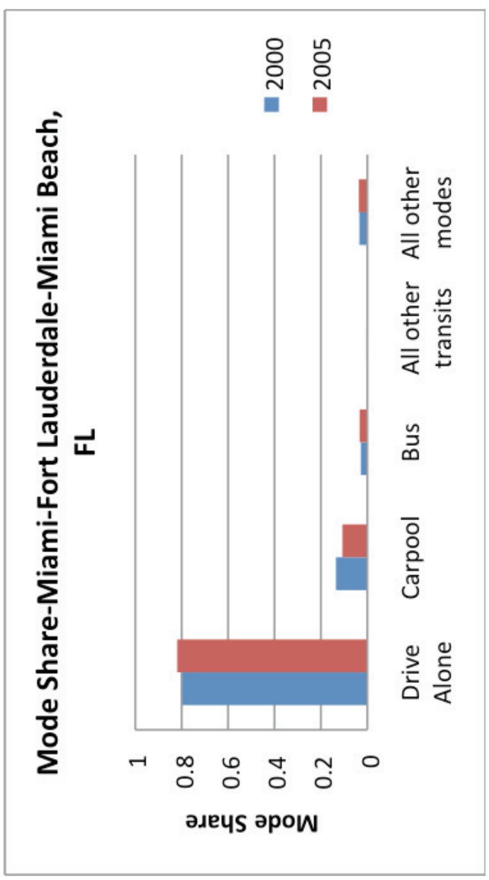



Mode Share-Los Angeles-Long Beach-Riverside, CA
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005


Mode Share-Seattle-Tacoma-Olympia, WA
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005


Mode Share-San Jose-San Francisco-Oakland, CA
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005


Mode Share-Washington-Baltimore-Northern Virginia, DC-MD
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005


Mode Share-Miami-Fort Lauderdale-Miami Beach, FL
Mode Share
1
0.8
0.6
0.4
0.2
0
Drive Alone
Carpool
Bus
All other transits
All other modes
2000
2005

The data of Figure 4.1 indicate TTFDs in the years 1990, 2000 and 2005 basically followed the same pattern in all selected major cities except New York City. In all the other major cities, the frequency of commuting trips increased with their respective trip length intervals including the less than 5 minutes interval through the 30-44 minutes interval, and those trips ranging from 20 to 29 minutes and from 30 to 44 minutes account for the top two largest fractions among all home-based work trips. In New York City, however, trips with trip length longer than 60 minutes constitute almost the same proportion as those in 30 to 44 minutes, and trips in 45 to 59 minutes time interval were 15% of all trips, which is significantly higher than other cities (usually 6% to 8%, Chicago, IL and Philadelphia, PA, with more than 10% of all trips in the 45-59 minutes time interval).

Across time, the data of Figure 4.1 also indicate: (1) Percentages decreased for categories up to 30 minutes; (2) Percentages increased for categories greater than 30 minutes; and (3) The 60 minutes or more categories showed the largest increase. All these changes indicate that trip times increased from 1990 to 2005.

For Combined Statistical Areas and Metropolitan Statistical Areas (Figure 4.2), TLFDs in the year 1900, 2000 and 2005 have the same pattern as those of the major cities, where the frequencies of commuting trip categories decreases for categories less than 30 minutes, but increases for categories greater than 30 minutes. This tends to demonstrate a pattern of increasing trip times.

For Mode Share Distribution of all major cities in the year 2000 and 2005, the data of Figure 4.3 indicate decreasing mode share for all categories except Drive Alone. New York City is the exception in that the Drive Alone share decreased, while bus and other transit mode shares increased. Also, in New York City, other transit modes (excluding local bus) have the largest mode share, while for all the other major cities, Drive Alone is the dominant mode for commuting trips, and usually accounts for an approximate 70% mode share. Chicago and Philadelphia have smaller Drive Alone mode shares (about 50%) and larger transit mode shares, likely reflecting greater transit availability.

For Combined Statistical Areas and Metropolitan Statistical Area (Figure 4.4), Mode Share Distributions in the years 2000 and 2005 have the same pattern as those of most major cities, where Drive Alone has the dominant mode share. It increased over the five-year period. Since these data reflect characteristics of an area larger than the respective city, in every case, carpool has the next largest mode share after Drive Alone.

Detailed Mode Share information is listed in Table 4.3 where mode share of “Drive Alone” and “Transit” for specified areas are listed across time. Among those major cities, New York, NY has the largest transit share (52.6% in 2000, 56.7% in 2005) with Chicago, IL (25.9% in 2000, 26.0% in 2005) and Philadelphia, Pa (25.7% in 2000, 26.6% in 2005) ranked next to it. All three cities have a good reputation and long history for being transit-oriented, and besides local bus, they all provide rail transit modes, which are in another way showing their transit-friendliness in terms of transit mode diversity. Meanwhile, among those Combined Statistical Areas and Metropolitan Statistical Areas, San Jose-San Francisco-Oakland, CA, Washington-Baltimore-Northern Virginia, DC-MD and Boston-Worcester-Manchester, MA-NH have larger transit shares than other CSAs and MSAs. Also, these three CSAs are well-known for resident positive perception of public transportation.

Table 4.3 Mode Share for Major Cities in 2000 and 2005

Mode Share for Major Cities in 2000 and 2005				
Mode Share in percentage (%)	2000		2005	
	Drive Alone	Transit	Drive Alone	Transit
Chicago, IL	51.3	25.9	54.9	26.0
Dallas, TX	72.8	5.5	76.2	4.5
Detroit, MI	69.9	8.3	78.3	7.3
Houston, TX	73.6	5.9	76.5	5.2
Los Angeles, CA	68.6	10.5	71.2	10.8
New York, NY	25.6	52.6	24.5	56.7
Philadelphia, PA	50.1	25.7	52.8	26.6
Mode Share for Combined Statistical Areas in 2000 and 2005				
Mode Share in percentage (%)	2000		2005	
	Drive Alone	Transit	Drive Alone	Transit
Atlanta-Sandy Springs-Gainesville, GA-AL	79.7	3.3	82.9	3.3
Birmingham-Hoover-Cullman, AL	85.0	0.7	86.2	0.5
Boston-Worcester-Manchester, MA-NH	76.2	9.1	77.6	8.7
Detroit-Warren-Flint, MI	86.1	1.8	87.9	1.6
Los Angeles-Long Beach-Riverside, CA	75.1	4.8	77.9	4.7
San Jose-San Francisco-Oakland, CA	71.0	9.7	72.9	9.5
Seattle-Tacoma-Olympia, WA	74.8	6.9	76.0	6.9
Washington-Baltimore-Northern Virginia, DC-MD	72.9	9.5	73.3	11.0
Mode Share for Metropolitan Statistical Areas in 2000 and 2005				
Mode Share in percentage (%)	2000		2005	
	Drive Alone	Transit	Drive Alone	Transit
Miami-Fort Lauderdale-Miami Beach, Fl	79.8	3.3	81.9	3.7

Table 4.4 suggests that among the selected major cities, the three most transit-oriented cities, which are New York (NY), Chicago (IL) and Philadelphia (PA), have the largest proportion of work trips with travel times greater than one hour. This relationship between a well-developed transit system and longer work trip times can be explained in two ways. On one

hand, since transit users usually spend more time to access and wait for transit, the transit mode is relatively more time-consuming than the auto mode. Also, in these three cities more work trips occurred by transit and the proportion of longer work trips increased. On the other hand, since congestion in these cities might be severe, travel time for work trips is longer than that in other cities. Therefore, residents choose to use transit instead of auto mode in order to avoid the congested auto system.

However, the relationship between mode share and trip time for work trips in CSAs and MSAs is not clear. Across time, the top three CSAs and MSAs with larger proportions of long duration work trips (one hour or longer) include both transit-oriented areas - Washington-Baltimore-Northern Virginia (DC-MD); San Jose-San Francisco-Oakland (CA); and auto-oriented areas - Atlanta-Sandy Springs-Gainesville (GA-AL); Los Angeles-Long Beach-Riverside (CA). In addition, the fraction of one hour or longer trips increased across time in all areas except San Jose-San Francisco-Oakland (CA).

Table 4.4 Trip length analysis for Major Cities in 1900, 2000 and 2005

Trip length analysis for Major Cities in 1900, 2000 and 2005									
Percentage (%) for work trips with	1990			2000			2005		
	> 20 min	>30 min	>60 min	> 20 min	>30 min	>60 min	> 20 min	>30 min	>60 min
Chicago, IL	73.9	55.5	13.1	76.3	58.9	16.0	75.2	57.1	15.3
Dallas, TX	60.8	36.0	4.6	63.1	40.0	6.8	62.5	38.6	6.1
Detroit, MI	62.7	35.4	5.7	66.5	39.6	8.1	65.0	38.1	6.5
Houston, TX	60.9	38.4	5.7	63.4	41.9	7.5	63.3	40.4	7.9
Los Angeles, CA	63.7	42.5	8.1	66.4	45.5	10.6	68.2	47.9	11.6
New York, NY	77.3	63.5	22.8	79.6	65.5	24.5	80.7	66.3	24.8
Philadelphia, PA	66.8	46.0	8.4	70.2	50.6	12.7	71.6	50.9	11.9

Trip length analysis for Combined Statistical Areas in 1900, 2000 and 2005									
Percentage (%) for work trips with	1990			2000			2005		
	>20 min	>30 min	>60 min	> 20 min	>30 min	>60 min	> 20 min	>30 min	>60 min
Atlanta-Sandy Springs-Gainesville, GA-AL	66.6	46.3	10.0	70.0	50.3	12.9	70.2	51.1	14.3
Birmingham-Hoover-Cullman, AL	57.8	34.4	5.2	62.1	39.2	7.2	62.6	39.4	7.1
Boston-Worcester-Manchester, MA-NH	54.6	35.3	6.4	61.1	41.9	9.8	62.3	43.2	10.4
Detroit-Warren-Flint, MI	56.6	32.6	4.6	60.5	37.4	6.6	61.0	38.1	6.4
Los Angeles-Long Beach-Riverside, CA	59.9	40.2	9.5	62.6	42.7	11.1	63.4	43.6	12.1
San Jose-San Francisco-Oakland, CA	58.5	38.4	8.2	63.3	43.8	11.9	60.7	40.1	9.5
Seattle-Tacoma-Olympia, WA	57.6	34.9	6.0	61.8	40.1	9.1	62.0	40.5	8.9
Washington-Baltimore-Northern Virginia, DC-MD	66.6	46.3	10.0	70.0	50.3	12.9	70.2	51.1	14.3

Trip length analysis for Metropolitan Statistical Areas in 1900, 2000 and 2005									
Percentage (%) for work trips with	1990			2000			2005		
	> 20 min	>30 min	>60 min	> 20 min	>30 min	>60 min	> 20 min	>30 min	>60 min
Miami-Fort Lauderdale-Miami Beach, Fl	58.6	36.0	4.5	64.7	43.5	8.3	67.1	47.1	9.5

4.3 Trip Time Frequency Distribution Hypothesis Testing

In this section, Chi-square tests were performed to test the null hypotheses: (1) Trip Time Frequency Distributions(TTFD) for all areas for two time periods (2000 and 2005) follow the same patterns; and (2) Trip Time Frequency Distributions (TTFD) for two or more areas at the same time point follow the same patterns. It is usually assumed that cities or MSAs with highly developed transit systems tend to be more compact and therefore, TTFD in these areas would have fewer long duration trips (that is a shorter tail on the right-hand side) compared to the other areas. However, the results showed that the null hypotheses cannot be rejected at the 95% confidence level, which means that statistically, in the years 2000 and 2005, work trips in all the areas studied shared similar Trip Time Frequency Distributions. Additionally, for all specified areas, the Trip Time Frequency Distributions follow the same patterns across time. This may be due to the fact that people try to manage their commuting travel time by considering the same factors, including available transportation modes and congestion.

4.4 Trip Length VS Population and Transit Availability

Average trip length for home-based work trips measured both in time and distance with the NHTS 2001 data were tabulated for 50 MSAs (Appendix 1) in the US. Also, a new variable TRANSUM was calculated from the NTD data which indicates how many transit modes are available in each respective MSA. To get the TRANSUM variable, first three dummy variables were created indicating whether in the specified MSA there is Light Rail Service, Heavy Rail Service or Commuter Rail Service, and then generated the TRANSUM variable by adding up the three dummy variables. So, for TRANSUM, "0" means there is only bus service and the larger the value for TRANSUM, the more available transit modes. Together with the TRANSUM variable, population data for 2000 from Census is introduced in the national dataset.

In Figure 4.5, each blue line shows the average trip distance for home-based work trips in the respective MSA's, and populations of the MSAs increase from left to right. The green and red plots (spanning 2 standard deviations around the means) represent the 95% confidence interval about the means. In Figure 4.6, the travel time information for home-based work trips is shown. Travel time and travel distance for home-based work trips in all selected MSAs vary only slightly. For all these 50 MSAs, average trip distance for work trips in the 50 MSAs ranged from 10.0 to 16.8 miles with an average of 13.0 miles, while travel time for work trips ranged from 18.8 to 32.2 minutes, with an average of 23.3 minutes.

It is noticed, both in Figure 4.5 and Figure 4.6, that the first half of the MSA's followed almost the same pattern. The mean travel distance and travel time for work trips were almost constant in those MSAs, and variance for travel time and travel distance follow the same pattern.

Standard deviations of travel distance increase with standard deviations of travel time. However, the second half of the MSA's was different from that of the first half. First, average travel distance for work trips in those MSAs was almost the same as the first half, but average travel time for work trips increased with population in these MSAs. Secondly, standard deviations for work trip travel time in those MSAs increased slightly with population, but standard deviations for travel distance in the second half of the MSAs seemed to have no pattern.

Figure 4.5 Work Trip length in Distance with 95% confidence interval

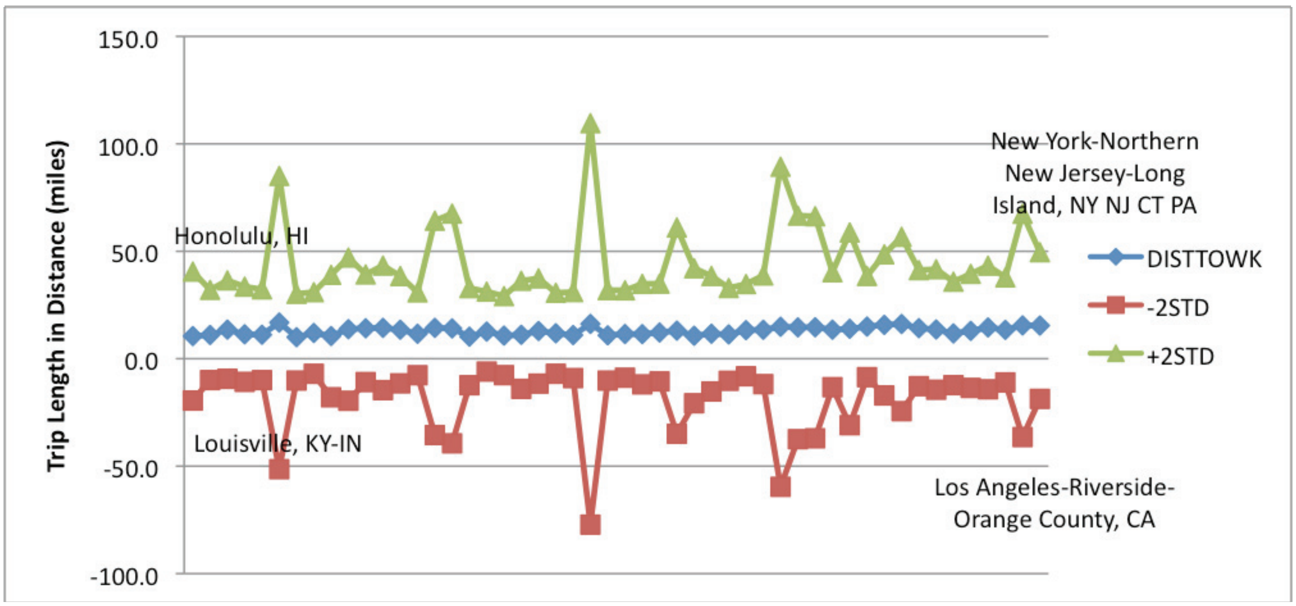
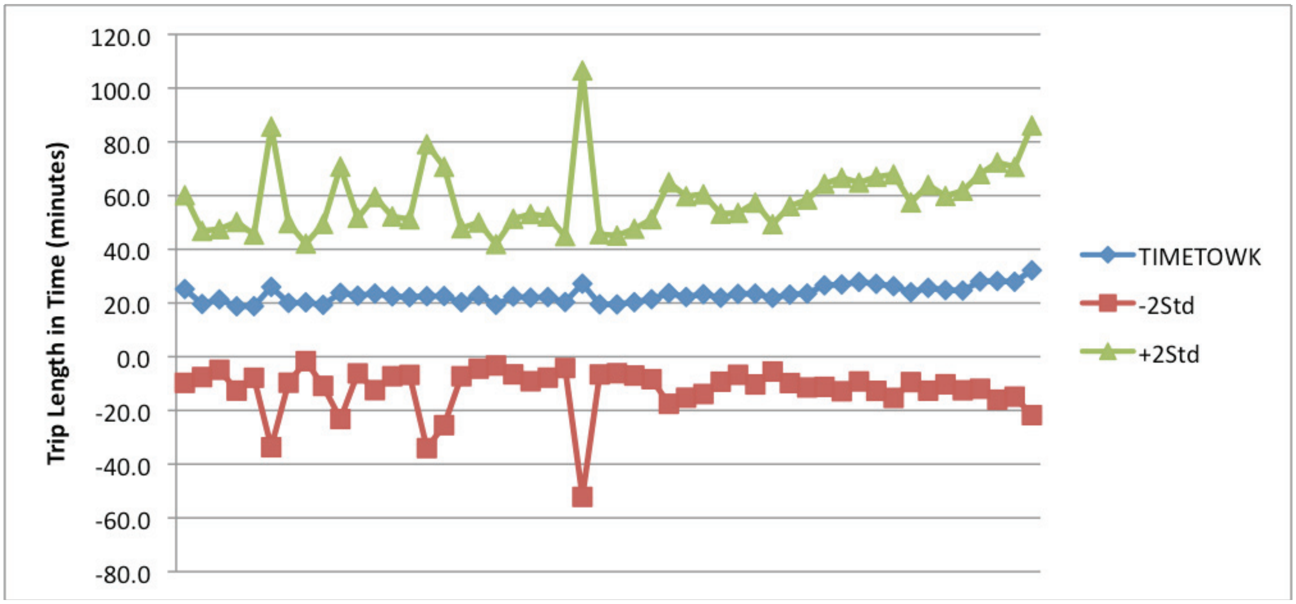


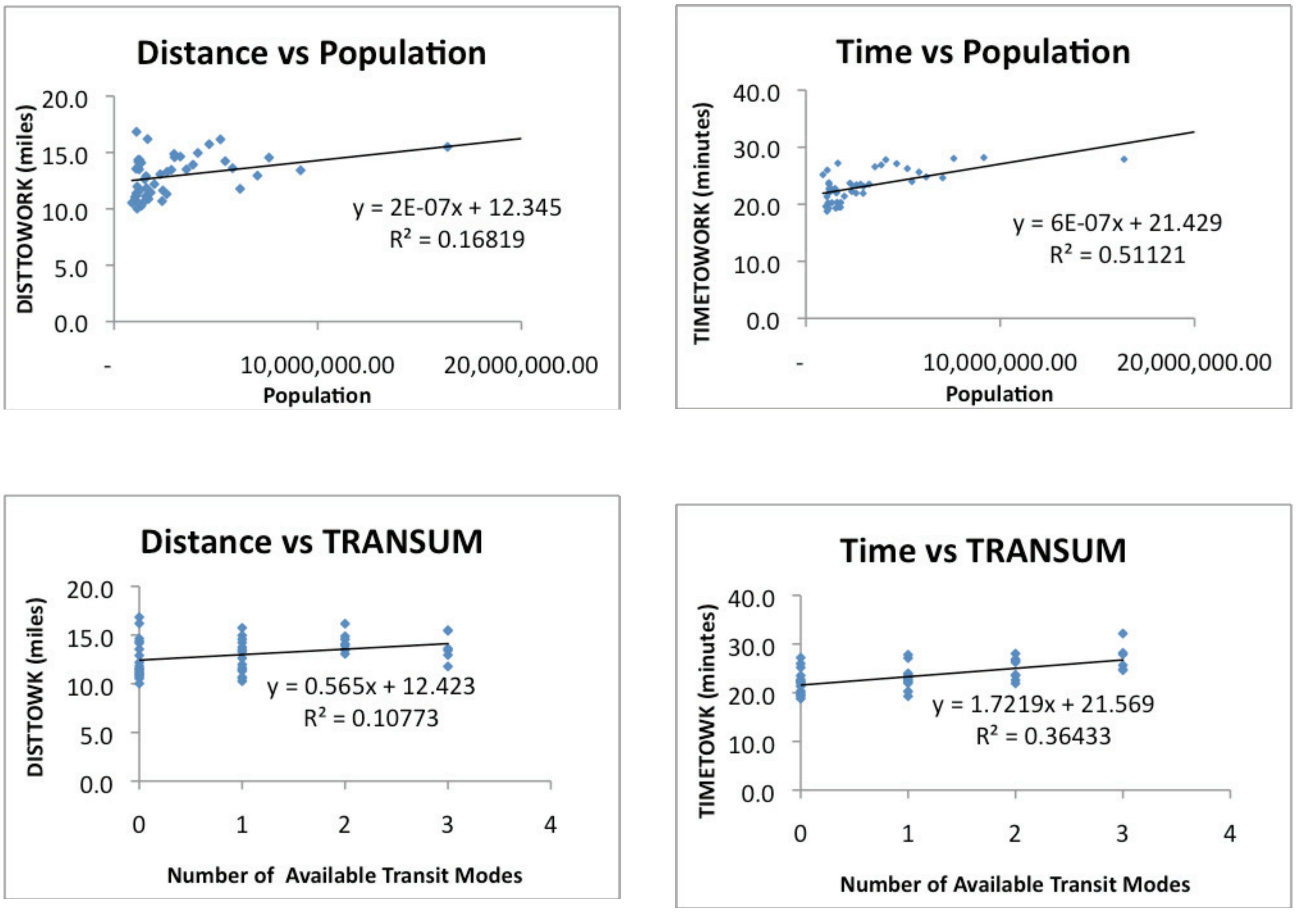
Figure 4.6 Work Trip Length in Time with 95% confidence interval



The identification of a relationship between Population and Transit availability versus work trip length was investigated. Linear regression analyses were performed to find a relationship between work trip length versus population and transit availability.

From Figure 4.7, mean travel time for work trips increase with population and the TRANSUM variable which means for MSAs with larger populations, people tend to travel longer distances for work trips. For MSAs with more transit modes, people are likely to travel greater distances and times to work. With increasing population, people tend to spend more time and distance for home-based work trips, and with more transit modes available in their MSA, people are likely to have longer duration and longer distance work trips. It is as expected, since MSAs with larger population usually have larger land area, correspondingly, the fraction of residents that need to or have to travel further is higher than in MSAs with smaller populations. Therefore, the proportion of longer distance work trips is also higher in MSAs with larger population. Similarly, if more transit, especially rail service, is available, more commuters are willing to live in suburban areas and endure longer work trip travel distances and times.

Figure 4.7 Regression of Trip Distance and Trip Duration on Population and TRANSUM



Chapter 5 Conclusions

Based on the analysis of three datasets – National Transit Dataset, Census Transportation Planning Products and National Household Travel Survey, the following conclusions were developed:

A traditional hierarchy of transit modes arranged by traveler trip length might include local bus, light rail, rapid rail (heavy rail) and commuter rail (regional rail). Based on NTD data, the average trip length for these four modes are: local bus (4.6 miles), light rail (3.9 miles), heavy rail (6.3 miles), and commuter rail (30.1). This result supports the common belief that traveler trip lengths increase from local bus, light rail, rapid rail to commuter rail.

Trip Time Frequency Distributions for home-based work trips in all major cities selected in this study followed the same pattern, except in New York, NY. In all the other major cities, work trips with durations in the 20-29 and 30-34 minute intervals represent the largest proportions of all work trips, while in New York (NY), work trips in the longer than 60 minute category are approximately twice as frequent as in any other city. Additionally, in virtually all cities from 1990 to 2005, frequencies decreased in all categories less than 30 minutes and increased in categories greater than 30 minutes. Meanwhile, Trip Time Frequency Distributions for home-based work trips in all selected MSAs also followed the same pattern. These results contradicted our assumption that cities or MSAs with different urban forms or transit history might have different Trip Length Frequency Distributions, and showed that at an aggregated level, there is no statistically significant difference among TLFDs for work trips in the selected areas.

Average work trip length for all the 50 MSAs in the National Household Travel Survey data also showed that travel time and travel distance for home-based work trips in all selected MSAs are very similar. For all 50 MSAs, average work trip distance ranged from 10.0 to 16.8 miles with an average of 13.0 miles, while travel time for work trips ranged from 18.8 to 32.2 minutes with an average of 23.3 minutes. Also, from the linear regression functions with trip length as dependent variable, work trip time and distance tends to increase with increasing population. Work trip time and distance tend to increase, also, as the number of transit modes increase.

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