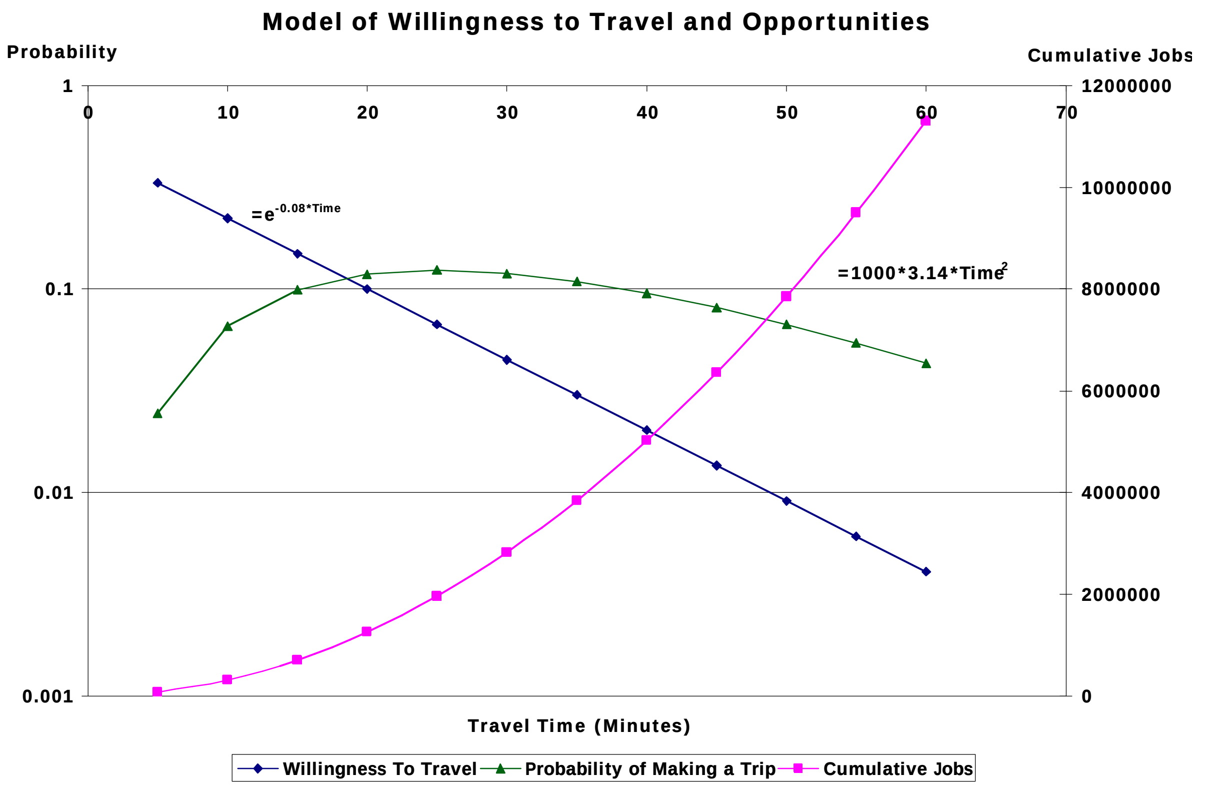
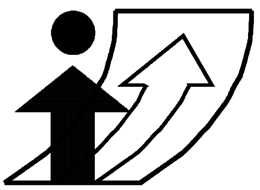


The Rational Locator Reexamined: Are Travel Times Still Stable?

David Levinson, University of Minnesota
Yao Wu, University of Minnesota
Peter Rafferty, SEH Inc.

Conference paper
Session XXX



Moving through nets:
The physical and social dimensions of travel
10th International Conference on Travel Behaviour Research
Lucerne, 10-15. August 2003

Rational Locator Reexamined: Are Travel Times Still Stable?

David Levinson

Department of Civil Engineering
University of Minnesota

500 Pillsbury Drive SE

Minneapolis, Minnesota 55455 USA
City

Phone: 01-612-625-6354
Fax: 01-612-626-7750
eMail: levin031@umn.edu

Abstract

The Rational Locator Hypothesis posits that individuals can, if they choose, maintain approximately steady journey-to-work travel times by adjusting their home and workplace. This hypothesis was coupled with the observation of long-term stability in automobile journey-to-work times in metropolitan Washington (those times were unchanged from 1957 through 1968 to 1988). Despite the increase of average commuting distance and congestion, trip duration remained constant or even declined when controlling for travel purpose and travel mode. This observation has significance, as it is important to know for travel demand analysis if there is an underlying budget, or even a regularity, as this helps us determine whether our forecasts are reasonable. To re-test the hypothesis, both inter-metropolitan and intra-metropolitan comparisons of travel times are made. For the inter-metropolitan analysis, a series of regressions on mean metropolitan travel time was conducted for the 65 largest metropolitan areas in the United States. The average commute time varies (positively) in these cities as a function of congestion and population density – both significant at the 99% confidence interval. Geographical area, population, and income were also significant at the 90% confidence interval. The intra-metropolitan analysis compared Washington DC data from 1968, 1988, and 1994, and Twin Cities data from 1990 and 2000. The results depend upon geography. For the larger Washington DC region, keeping the same geography shows little change in commute times, but using the larger 1994 area suggests an increase in travel times. However, the Twin Cities, starting from a much shorter travel time, shows a marked increase over the decade, using either the smaller or the larger geography.

Keywords

travel time budgets, travel behavior, travel survey, International Conference on Travel Behaviour Research, IATBR

Preferred citation

Levinson, David, Yao Wu, and Peter Rafferty (2003) The Rational Locator Reexamined: Are Travel Times Still Stable?, paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

1. Introduction

"Rational Locators," including both individual households and firms, respond to changes in transportation supply by siting themselves to reduce commuting times ... The key policy implication we see is that over the long term, individual Locators act rationally to balance total costs as measured in dollars and minutes, and total benefits, as measured in proximity, space, and other preferences. These individual calculations result in the polycentric, and dispersing, urban form that exists today throughout the United States. (Levinson and Kumar 1994)

The Rational Locator Hypothesis thus posits that individuals can, if they choose, maintain approximately steady journey-to-work travel times by adjusting their home and workplace. The hypothesis was coupled with the observation of long-term stability in journey-to-work times in metropolitan Washington (those times were unchanged from 1957 through 1968 to 1988). Despite the increase of average commuting distance and the congestion, trip duration remained constant or even declined when controlling the travel purpose and travel mode. The hypothesis that individuals and firms mutually locate to maintain travel times provides a mechanism to account for rising travel distances, rising congestion, but constant travel time or commuting time budgets. The idea of time budgets has been observed and posited as a basis for analyzing travel demand (e.g. Zahavi 1974, Zahavi and Ryan 1980, Zahavi and Talvittie 1980, Shafer 2000), been given an anthropological basis (Marchetti 1994), and disputed as being but one factor in a richer economic analysis (Tanner 1981, Prendergast and Williams 1981).

Levinson and Kumar (1994) noted that there was a great deal of under-utilized capacity, particularly for suburb-suburb trips in metropolitan Washington DC. Moreover, simply due to the greater travel speeds on suburban routes, additional demand on those routes, while making them more congested, may increase system average speed as the proportion of travelers using slow urban routes declines. However, the relative lack of road expansion in recent years in the United States, coupled with still growing demand and rising congestion, suggests that some of the excess capacity may have been absorbed. Figure 1 illustrates the discrepancy in the Twin Cities, for example, between traffic growth and road capacity growth. Can relocation still accommodate demand? Are traveler preferences for a travel budget or commute strong, weak, or non-existent?

The 2000 Census (as well as previous data) clearly indicates that average journey-to-work times vary among metropolitan areas in the United States. Why is this? Perhaps it is as simple as people in different metropolitan areas having different preferences. On the other hand, perhaps the differences are attributable to metropolitan land use and transportation characteristics, such as population density and congestion. Urban areas with greater populations generally appear to have worse congestion, but exceptions to this trend do exist. This paper explores whether major metropolitan characteristics are good predictors of mean journey-to-work times for cities in the United States.

If commuting times vary little over time within cities, then general characteristics of cities likely exist that have predictive power for the mean journey-to-work time. The stability within cities may simply be due to stability in their general characteristics (population, density, congestion, etc.); it may be due to inherent preferences of their residents; it may be due to researcher bias (a competent researcher can find some variable that remains unchanged over time); or it may simply be coincidence.

However, the 2000 Census also shows that journey-to-work times have risen since 1990 for metropolitan areas, seemingly contradicting the travel time budget observations (Pisarski 2002). In part, this may be an artifact of metropolitan areas extending more broadly in space, thereby including more exurbanites in the analysis (increasing the sample of those with a known preference or tolerance of long commutes). Part may be due to changing preferences for travel time (people increasing their tolerance for long commutes). And part may be due to congestion rising faster than individuals can adapt by relocating (changing homes or jobs requires a significant transaction cost). Congestion within nearly every metropolitan area continues to worsen both in severity and duration (TTI 2001).

This paper conducts both an inter-metropolitan and an intra-metropolitan analysis to better understand the responses of individuals to changing travel environments. First, a general model is presented that we believe can be used to understand both sets of data in a consistent way. Then, the paper presents data that illustrate characteristics of metropolitan areas and the journey-to-work times. It shows that characteristics of the metropolitan area do largely explain the varying journey-to-work trends for any given metropolitan area. Some results are as expected, but others are counterintuitive. We then conduct two within-city analyses: a statistical analysis of the 1968, 1987-1988, and 1994 metropolitan Washington DC Household Travel Surveys, and the 1990 and 2000 Travel Behavior Inventories from the Twin Cities of Minneapolis and Saint Paul, Minnesota. This allows us to study the trend of commuting times and to understand the daily allocation of time among different activities, stratifying individuals by work status, gender, mode used, household structure, and metropolitan location. The implications for metropolitan transportation planning are not trivial, and some of these are discussed at the end of the paper.

2. Theory

We believe that individuals make choices to maximize their utility. However, what their utility comprises when considering journey-to-work trips is an open question. We believe that the utility of a particular destination depends on the opportunities at the destination and the relative travel cost, as well as traveler specific attributes. This implies that the gravity model will be correct in the aggregate. The model predicts specific relationships between resulting travel time, opportunity patterns, and network conditions.

Figure 2 illustrates the idea that the observed journey-to-work time distributions result from combining willingness to travel and the attraction of greater opportunity. Employment opportunities increase roughly with the square of the distance (or time) traveled from a point (up to a point) assuming uniform density and no edges to the region. This while not strictly true, is consistent with the idea that number of jobs available will be greater in a ten-minute radius than a one-minute radius in any metropolitan area. The analogy is that the area of a circle (of job opportunity) increases with the square of the radius (trip distance). However, as travel time increases, commuters are less willing to travel – the classic friction factor of the gravity model, interaction declines as the cost of interaction (distance, travel time, dollars) increases.

This gravity model suggests several things. First, as city size increases, mean commuting time increases (we have a left-truncated distribution, so as the right branch extends outward, the average must increase). However, the increase is non-linear, so as cities get larger, additions have a smaller and smaller effect on travel time. This is illustrated in Figure 3. This suggests the gravity model implies diminishing marginal returns to job opportunities at the edge, since each additional job is less and less likely to be taken and thus less likely to increase travel time.

Second, the model, if in a gravity formulation, is largely independent of density – except to the extent that density changes network speed. A uniform density increase increases the utility of traveling each time band (5 minutes, 10 minutes, etc.) proportionately, and thus does not change the distribution of travel time. Third, if preferences shift, mean travel time will change inward or outward. Fourth, if congestion rises, more opportunities will be farther away in terms of travel time, and fewer nearby – implying that average commuting time rises.

One might think that a large city with great density means greater accessibility to jobs within a given travel time. Therefore, by controlling for congestion, and assuming comparable transportation infrastructure, higher density implies a lower average journey-to-work time. Consistent with this idea, the intervening opportunities model would make a different prediction than the gravity model about the effect of uniform density increases (higher density would suggest shorter trips in an intervening opportunities model, after controlling for population and congestion). However, if commute time preferences are inelastic, people may take advantage of the density and accessibility to trade off travel time for a better job or house and to maintain their commute time.

3. Inter-Metropolitan Comparisons

This section analyzes differences between cities, with regression models, using data largely from the United States Census Bureau 2000 Census. The Census data that are particularly relevant for this study include population, housing, metropolitan area size, housing and population densities, income measures, and journey-to-work times. The Texas Transportation Institute (TTI) provided the measures of congestion for all the metropolitan areas in this section.

The Census Bureau defines Metropolitan Statistical Areas (MSA), Primary Metropolitan Statistical Areas (PMSA), and Consolidated Metropolitan Statistical Areas (CMSA). Of the 65 metropolitan areas included in this study, 39 are MSAs and 26 are PMSAs. This study does not use any CMSAs because the data from the Texas Transportation Institute correspond only to MSAs and PMSAs.

The Texas Transportation Institute's 2001 Urban Mobility Report covers 68 U.S. cities with populations above 100,000.[i] They base their analysis chiefly on the Federal Highway Administration's Highway Performance Monitoring System. We use their Roadway Congestion Index (RCI), which provides a general measure of vehicle travel relative to roadway capacity on major roadways.[ii]

Commuting time is most correlated with population or housing, but not at all correlated with metropolitan spatial extent. Perhaps this suggests that as cities expand, they generally keep up with transportation infrastructure, or people choose to live no farther from work than they might in a small city. As expected, a positive correlation exists between commuting time and congestion. However, a positive relationship between commuting time and density contradicts both the gravity and the intervening opportunities models, although it may be related to density being a surrogate for both total population and for congestion levels. Lastly, a positive correlation exists between income and commuting time, raising the question of whether the wealthy really spend more time commuting, and if so, why? After all, the wealthy have a higher value of time and should be able to use their income to reduce their travel time. However it suggests, if we believe the gravity model, that wealthier individuals have a higher tolerance for longer trips, suggesting a smaller α in their friction factor: $e^{-\alpha t}$.

The correlations between all of the variables are screened to eliminate redundancy and interdependence between variables. Judging by their high correlation, population and housing units are effectively the same variable. The same is true for population density and housing density. Because of this, the regression includes just one variable in each pair (the population variables). Other correlations are what one would expect, and the remaining independent variables are independent of one another.

In the regression model, the mean travel time to work is the dependent variable. The remaining are potential independent variables. The interaction (second order) terms are also considered as candidates for independent variables. The predictive power of each variable is estimated using linear regression.

The travel time distributions for each metropolitan area clearly suggest a Poisson distribution. Besides, the Poisson model being common in transportation, estimating the travel time distribution with a Poisson model has two advantages. The first is that it is appropriate for categorical data, which is what the Census Bureau provides, as discussed below. The second advantage is that estimation is straightforward because just one parameter describes the Poisson distribution. One dependent variable is convenient and greatly simplifies regression. The Poisson distribution maximum likelihood parameter is estimated for every metropolitan area. Figure 4 depicts typical commute times and Poisson estimations for the first two cities in the sample. Table 1 shows the range of estimated parameters for all metropolitan areas in this study. All Chi-Square goodness of fit statistics are significant at the 0.01 level, so we do not reject the Poisson model.

As mentioned, all interaction terms were examined, but none significantly contributed to the model, and especially without introducing co-linearity. The regression equation ultimately estimated and presented in this paper is:

$$T = \beta_0 + \beta_1 \times C + \beta_2 \times P + \beta_3 \times D + \beta_4 \times A + \beta_5 \times I$$

Where: T is the mean journey-to-work time, C is the congestion index, P is the population, D is the population density, A is the metropolitan area, and I is the median household income.

Table 2 shows the results of the regression. Because the magnitudes of the independent variables vary so much, the first column lists normalized coefficients for ease in comparison. The F-statistic is 29.59 (probability < 0.001), and the adjusted R-Square is 0.69 (R-Square = 0.71). All variables are significant at the 0.07 level or better. Despite what some may consider a gross aggregation, that is, looking only at metropolitan areas, the model is very simple yet has significant explanatory power. The R-Square value indicates that just 30% or so of the variability in mean commuting time remains to be explained by excluded factors.

One would expect to see positive coefficients for the congestion index, population, and metropolitan area, and that is what occurs here. One would not necessarily expect to see the positive coefficients for density and income, which we also observe.

The constant term is the greatest contributor to commuting time and is the most significant of the independent variables. This indicates a large underlying determinant of commuting time that is largely independent of metropolitan characteristics and congestion in the sample. Redmond and Mokhtarian (2000) posit a positive utility to commutes, suggesting why commutes are higher than are minimally necessary to locate everyone relative to their workplace. This constant term may suggest the minimum temporal separation between home and work, related both to location constraints and to positive utility. In rural areas, and where congestion is non-existent, the limited job opportunity may affect the constant term.

The congestion index has both a substantial and significant effect on commuting time. The next largest contributor is income, though this is not extremely significant. This supports, and is supported by, other research suggesting that wealth translates to more time in the car. Population and population density are both positive contributors to mean travel time to work. Again, this is supported by other research that finds metropolitan density does not necessarily reduce travel time for commuters. Lastly, metropolitan area is the smallest and least significant predictor of mean commute time.

4. Intra-Metropolitan Comparisons

The second major analysis considers within city changes over time. The previous section illustrated that we can understand much of the differences between cities' mean journey-to-work time as a function of population, density, area, congestion, and income.

4.1 Data

The data used in this study include 1968, 1988, and 1994 household travel surveys in the metropolitan region of Washington DC and 1990 and 2000 home interview surveys of the Twin Cities metropolitan area. The data collection methodologies for these two regions are largely the same: a weekday was assigned to each of the randomly selected households and information on the demographic, socioeconomic, and trip making characteristics of the residents was gathered (Metropolitan Washington Council of Governments, 1997). The 1968 survey used in-person interviews, 1987-88 was mail-out, mail-back, and 1994 was a computer aided telephone interview (CATI). For the Twin Cities, the 1990 and 2000 surveys were mailed out, and the day after the travel day, interviewers called the participating households to obtain and record the travel information for each household member, and enter it into the computer.

Each dataset contains a household file, a person file, and a trip file. The household file records vehicle ownership, household size, and household income; the person file records gender, age, and work status; the trip file includes the locations and purposes of the origin and destination of each trip, transportation mode, vehicle occupancy, departure time, and arrival time.

The 1988 survey of Washington DC consists of a sample of 8,000 households and 55,000 trips; the 1994 data involved 5,000 households making over 40,000 trips. The 1990 home interview survey in Twin Cities area was based on 9,700 households and 98,000 trips; the 2000 survey includes 6,200 households and 58,000 trips.

For the analysis of the change of the activity patterns, only the behavior of adults (aged from 18 to 65) is considered. Six activities are defined for this study: home, work, work-related, shop, other, and travel. In order to exclude outliers in the analysis, only travelers who started the day from home and returned home at the end of the day are considered; workers are defined as people who made work trips during the survey day, and all individuals who did not work that day are counted as non-workers.

As for the Washington DC data, because of the comparison purpose with the results from 1968 and 1988 data, the modes of transportation are divided into auto-1, auto-2, auto-3, and transit. While auto-1 refers to a car with only one person (drive-alone), auto-2 has two people (driver and passenger), and auto-3 has three or more (driver and two or more passengers). As for the Twin Cities data, the purposes and modes are treated in a slightly different manner, which will be discussed below.

The jurisdictions of metropolitan Washington DC for which data were collected in 1988 include the District of Columbia; Montgomery and Prince George's counties in Maryland; Arlington, Fairfax, Loudoun, and Prince William counties in Virginia; and the cities of Alexandria, Falls Church and Fairfax in Virginia. In 1994, the area was expanded to include Calvert, Charles, and Frederick counties in Maryland; Fauquier and Stafford counties in Virginia; and Manassas City and Manassas Park City in Virginia. Similarly, the metropolitan Twin Cities data for 2000 were collected on a larger geographic area than the 1990 data. In 1990, seven counties were used: Hennepin, Ramsey, Dakota, Anoka, Washington, Scott, and Carver. While in 2000, this number expands to 20 (adding Chisago, Goodhue, Isanti, Le Sueur, McLeod, Mille Lacs, Rice, Sherburne, Sibley, Wright, Pierce, Polk and St. Croix). To examine changes in travel times, the results of the more recent survey are used while both controlling for geographic area and using the larger survey area (no control).

Figure 5 shows the breakdown of the gender and work status for the adults (age 18-65) in Washington and Twin Cities metropolitan regions. For Washington, the sample size of 1994 is slightly smaller than that of 1988, and the percentage of each category only shows little variation. The overall employment rate for women increased from 78% to 82%, while the male labor force participation rate remained at 86%. In the Twin Cities, the overall employment rate for women increased from 73% to 83%, and for men it increased from 90% to 92%.

4.2 Activity Patterns

Three parameters are used in the study of the activity pattern: activity duration, activity frequency, and frequency distribution. Activity duration is the time spent at an activity, which shows how the 1440 minutes in a day are allocated to different activities for different groups of people. The frequency is the average number of times a person did a certain activity. The frequency distribution is the percentage of individuals making 0, 1, 2, and 3+ trips for each activity. The duration of each activity is calculated by subtracting the arrival time from the departure time of the next trip. To estimate the duration of the last (or first) activity, assume that the person will make the first trip on the following day at the same time as that of the previous day. The duration of the last activity is obtained by adding 1440 minutes to the departure time of the first trip and then subtracting the arrival time of the last trip.

Mean activity duration for the Washington metropolitan region is summarized in Table 3; for the Twin Cities area, the same cuts are in Table 4. In both Tables, the parameter is classified by the work and gender status for each activity. An examination of median (rather than mean) values gave the same implications, also activity frequencies were calculated, but these tables are not shown for reasons of space.

The following sections discuss the changes in the activity patterns in the Washington DC metropolitan region from the year 1988 to year 1994 (the changes from 1968 to 1988 are discussed in Levinson and Kumar 1995), and in the Twin Cities area from 1990 to 2000.

Table 3 shows that workers and non-workers, males and females spent less time at home in the Washington area. The reduction for male workers is 38 minutes and for female workers it is 31 minutes. However, the frequency for home trips increased. The working time apparently increased significant by 27 minutes in 1994. For female workers, the number increased by 29 minutes. The amount of time spent at home declined by about the same as the amount of time increased at work. Simply put, workers work more at the expense of lost leisure time.

One should be suspect of such a large change over such a short period. Maybe subtle (or not subtle) changes in the survey methodology affected this result. However, increased time at work is shown from 1990/91-1995 (a similar period) in the Nationwide Personal Transportation Survey as well, for male workers rising from 338 to 365 minutes, for female workers rising from 284 to 313 minutes (Levinson and Kanchi 2002) – a virtually identical change (though from a smaller base). Note that this change occurred just before the widespread adoption of the Internet, which we expect will cause marked differences in time allocation, so some other explanation is warranted. The 1990/91 NPTS was conducted during a recession and the Gulf War, which may have had some impact (lowering time at work, increasing time at home), while the 1995 study was during a boom. However, the Washington DC data (1987/88 and 1994) were both during economic expansions.

The Twin Cities data show similar patterns but different magnitudes. As shown in Table 4, workers in this area worked more in 2000 than in 1990, but not as much as those in the Washington region. The increase in this decade for both men and women was approximately 10 minutes. As in Washington, people spent less time at home. For non-workers, the time is reduced by 50 minutes.

The trend of shopping durations for Washington residents is generally decreasing except for male non-workers, which showed a slight increase from 31 to 33 minutes. It is expected that the growth of income would increase shopping activities. The duration did not increase. However, it is interesting to notice that the frequency of shopping actually increased for all groups of people. This means that the average duration for each shopping activity decreased. People made more frequent, yet shorter, shopping trips. It is especially obvious for male workers, for whom the daily shopping frequency is 0.32, a 45% increase from 1988, while the duration decreased from 10 minutes to 8 minutes. So, in 1994, the average duration for each shopping activity for male workers is only the half the amount as in 1988. Twin Cities residents shopped more often but the shopping duration increased for men and decreased for women. Twin Cities workers made shorter shopping trips in 2000 than 1990.

Other activities include school, childcare, pick up/drop off, health care site, personal business site, restaurant, friend's home, entertainment places, etc. The duration of other activities for Washington residents went in opposite directions for workers and non-workers. Workers had less time to enjoy the other activities, though non-workers, on the other hand, spent more time on them. The frequencies increased for all people, meaning that, like shopping, workers had shorter average durations for other activities. For non-workers, the increase in frequency is not proportional to the increase in the duration, which results in longer other activities.

Both the duration and frequency of other activities increased for all groups of Twin Cities residents. This is another major difference from the Washington data, but for each individual other activity, workers made it shorter while non-workers made it longer. The workers in the Twin Cities had more leisure time compared to workers in Washington DC.

The time spent at travel increased for all groups of people, and so did the number of trips. For the same geographic area, the travel time for all people went from 93 to 98 minutes, a 5 percent increase; while for whole survey area in 1994, the number is 100 minutes.

The results for metropolitan Washington show that the workers worked more, thus spent less time at home, shopping, and other activities, though the frequencies of those activities increased. They made shorter outside-home trips. Non-workers, however, due to the possible income increase of the household, spent more time at shopping and other activities and less time at home.

The overall number of trips in the Twin Cities went down mainly because the decrease in work-related trips and home trips. However, the time spent at travel went up from 84 minutes to 90 minutes when controlled for the same geographic area. When the analysis moves to the larger area, the travel time remains the same.

This interesting finding is elaborated upon by our analysis of the change in travel time. In order to study the change of travel times, trips are stratified by purpose and mode. For Washington DC data, the seven purposes are: home to work, work to home, home to other, other to home, work to other, other to work, and other to other. The travel modes are auto-1, auto-2, auto-3, and transit, which are defined above. The purposes for Twin Cities are home-based work (HBW) -- trips that have one end at home and one end at work, non-home-based work (NHBW), home-based other (HBO), and non-home-based other (NHBO), and the modes are cars and buses.

4.3 Travel Patterns

As noted earlier, previous studies showed that the auto drive-alone commuting times remained constant between 1968 and 1988 in the Washington metropolitan region. Table 5 summarizes the average travel time in peak period and sample size for the metropolitan region by mode and by purpose for 1988 and 1994. Results with control and no control for the geographic area are compared.

In the seven purposes, the trips of home to work or work to home are always longer than trips with other purposes. As shown in Figure 6, the travel time for these two purposes has remained constant over the six year for the drive-alone mode (auto 1). The average time for home to work trips stayed at 29.6 minutes and for work to home trips, it remained at slightly over 33 minutes. However, for the modes with higher occupancy, the travel time for these two purposes increased. (Examining medians rather than means gives the same basic conclusion).

Figure 6 also compares the commute time with and without control for geographic area. As expected, all the trips using the larger geography took a longer time. For the Twin Cities, as summarized in Table 6 and Figure 6, the average travel time of home-based-work trips for drive-alone commuters increased from 22.6 minutes in 1990 to 27.2 minutes in 2000. For the other three purposes, travel times show the same pattern as the home-based work trips. Furthermore, travel times increase by the same amount using either the same geographic area for 2000 or the larger geographic area.

We compare intra-county work trips to try to control for origin and destination location. This is shown in Figure 7. Perhaps work trips are taking longer due to people traveling farther. This seems not to be the case in the Twin Cities. Greater shares of trips were intra-county in 2000 than 1990. Moreover, every intra-county pair had higher travel times in 2000 than 1990. While it is possible to make a longer trip while remaining within the same county, we suspect the real factor is rising congestion - increasing trip durations faster than people can relocate to manage their commutes. It is also possible people are indifferent to small changes in commute times below a threshold (say the 30 minutes or so Washington DC has), and so strong preferences have yet to kick in.

5. Summary and Conclusions

This paper posits the possibility that major metropolitan-wide characteristics can predict a substantial amount of the variability of mean journey-to-work times. It has been argued that commute times are getting worse over time, but other research has contradicted this claim, at least within a metropolitan area. It has been argued that mean journey-to-work times are independent of density, congestion, and other factors, and rather subject to a simple budget. This paper refutes that claim through a regression of mean journey-to-work times on several of these metropolitan characteristics. A mere handful of these characteristics explain roughly 70% of the variation in mean journey-to-work time among 65 major metropolitan areas in the United States.

First, there is a substantial and significant constant term, which implies that even in the presence of high accessibility and the absence of congestion, commuters may still choose to live a given distance from their workplace. This large positive constant term suggests the possibility a minimum (rather than a maximum) commute budget – an idea related to Redmond and Mokhtarian's (1999) positive utility for a commute.

Second, the metropolitan congestion level is a significant and positive contributor to mean journey-to-work time. This implies that if congestion is improved, people may not simply move farther away (sprawl), but commute times may improve (a 1% increase in the congestion index increases travel time by 0.06 minutes in the regression, which is a 0.24 elasticity). Also looking at times (using NPTS data), Levinson and Kanchi (2002) found a very small -0.064% change in travel time with respect to a 1% capacity expansion. This is also consistent with findings in the induced demand literature, which suggests that 1% increase in capacity leads to a 0.2 – 1.0% increase in travel distance (Dunne 1982, Goodwin 1996, McCarthy 1997, Hansen and Huang 1997, Dowling and Colman 1998, Noland 1999, Noland and Cowart 2000, Barr 2000, Fulton et al. 2000, Marshall 2000). The data in this paper suggest one cannot point to transportation infrastructure investment as futile in addressing congestion or travel times.

Third, metropolitan population, area, and median income are positive, but weak contributors to mean journey-to-work times. This is as expected because people are more able to satisfy their ideal employment desires in larger metropolitan areas with more opportunities, and thus increase their income.

Fourth, density at a metropolitan scale has a small, but significant and positive effect on mean journey-to-work time. This implies that metropolitan-wide density increases cannot be used to achieve travel time reduction. Other planning tools such as jobs and housing balance, sufficient transportation investment (for all modes), mixed-use development, and localized density increases were not examined in this paper.

It was previously observed in metropolitan Washington DC, over the same geographic area, the average commuting times remain stable between 1968 and 1988 despite the increase in commuting distance and congestion. (And the numbers are the same as found in 1957 by Whyte.) Fixing the area for 1994 to be consistent with the area from 1988 shows commuting times that are statistically equal (and for drive-alone commuters, identical). Nevertheless, considering the new larger metropolitan area, the commuting times in 1994 show a 10% increase over 1988. Overall, time spent traveling rose as well (by 5 minutes in the same area, 7 minutes in the larger area), thus continuing a trend from 1968 (time spent traveling between 1968 and 1988 increased from 72 to 95 minutes).

In the Twin Cities, commuting times (and total travel times) rose between 1990 and 2000, but remain lower than the times in Washington DC. Similarly, U.S. Census data for most metropolitan areas show higher times in 2000 than 1990, but most metropolitan areas increased in size, raising the question of whether these rises are statistical artifacts due to changing geography. However, the gravity model predicts that a smaller city is more likely to see an increase in travel times than a larger one, and Washington remains larger than the Twin Cities.

What do these results imply for metropolitan transportation planning? One could suppose that there is a travel time budget, under which are many people, in many areas. So long as commuters are well under the budget, they will not necessarily make decisions to maintain or reduce commuting duration. But when the budget is reached, unwillingness to travel more may dominate other considerations. However, to call this a budget may overstate the case; the gravity model's friction factor suggests some people will make long trips while opportunities are there, and others will not; it is simply a matter of individual preferences. People will be willing to travel farther in areas with more opportunities (large cities), but as cities grow in size, the amount of extended travel exhibits diminishing marginal returns. Imposing a budget on metropolitan models is wrong, although incorporating real, congested travel times in travel demand (trip distribution, mode choice) modeling (ensuring an equilibrium between supply and demand) still seems warranted.

These findings do raise interesting questions concerning geographical analyses of this type. Clearly expanding the region increases commuting times, as exurbanites have longer commutes than those who live closer in. To the extent that the recent rise in commuting times is associated with simply increasing the area considered "metropolitan", it is a statistical artifact. But when times increase within the same geographical boundaries because of congestion, or a willingness to spend a greater time traveling to achieve other objectives (e.g. a larger house), we have a more severe problem. As most metropolitan areas are growing faster than population, that may indicate an increasing willingness to trade-off time for space, or an incapacity to rationally relocate to compensate for rapidly rising congestion.

6. References

Barnes, G. and Davis, G. (1999) Understanding Urban Travel Demand: Problems, Solutions, and the Role of Forecasting. Report #2 in the Series: Transportation and Regional Growth Study CTS 99-02, Center for Transportation Studies, University of Minnesota.

Barr, C.L. (2000) "Testing for the Significance of Induced Highway Travel Demand in Metropolitan Areas" Transportation Research Board 79th Annual Meeting Preprint CD-ROM, Transportation Research Board, National Research Council, Washington DC, January 2000.

Becker, G. (1965) A Theory of the Allocation of Time. The Economic Journal 75, 493-517.

Douglas, G.B. (1997) Urban Design, Urban Form, and Employee Travel Behavior. Sixth Transportation Research Board Conference on the Application of Transportation Planning Methods 1997

Dowling, R.G. and Colman, S.B. (1995) Effects Of Increased Highway Capacity: Results Of Household Travel Behavior Survey. *Transportation Research Record* 1493**,** 143-149.

Dowling, R.G. and Colman, S.B. (1998) "Effects of Increased Highway Capacity: results of a Household Travel Behavior Survey", *Transportation Research Circular, no.481: Highway Capacity Expansion and Induced Travel-Evidence and Implications*, 21-32, Transportation Research Board, National Research Council, Washington DC, February 1998.

Dunne, J.P. (1984) Elasticity Measures and Disaggregate Choice Models, *Journal of Transport Economics and Policy*, 18,2**,** 189-197.

Fulton, L.M., Meszler, D.J., Noland, R.B. and Thomas, J.V. (2000) Statistical Analysis of Induced Travel Effects in the U.S. Mid-Atlantic Region. Transportation Research Board 79th Annual Meeting Preprint CD-ROM, Transportation Research Board, National Research Council, Washington DC, January 2000.

Giuliano, G. (1995) The Weakening Transportation-Land Use Connection. Access, Spring 1995: 3-11

Giuliano, G. and K. A. Small (1993) Is the Journey-to-work Explained by Urban Structure? Urban Studies, 30 (9): 1485-1500

Goodwin, P.B. (1996) Empirical Evidence on Induced Traffic. *Transportation*, 23, 23-54.

Hansen, M. and Huang, Y. (1997) "Road Supply And Traffic In California Urban Areas." *Transportation Research: Part A, Policy and Practice*. 31A,*3* 205-218.

Jones, Peter. 1990. Developments in dynamic and activity-based approaches to travel analysis, *Oxford studies in Transport*.

Kain, J. F. and G. R. Fauth (1977) The Effects of Urban Structure on Automobile Ownership and Journey-to-work Mode Choices. Transportation Research Record 658: 9-17

Kraan M. 1997. In search for limits to mobility growth with a model for the allocation of time and money, *Activity-based approaches to travel analysis*: 89-115.

Levinson, David and Seshasai Kanchi. (2002) Road Capacity and the Allocation of Time. *Journal of Transportation and Statistics* (accepted for publication and in press)

Levinson, D. M. (1998) Accessibility and the Journey-to-work. *Journal of Transport Geography*, 6 (1): 11-21

Levinson, David and Ajay Kumar. (1994) The Rational Locator: Why Travel Times Have Remained Stable, *Journal of the American Planning Association* 60,3: 319-32.

Levinson, David and Ajay Kumar. 1995. Activity, travel, and the allocation of time, *Journal of the American Planning Association* 61,4: 458-469.

Levinson, H. S. (1963) Effects of Density on Urban Transportation Requirements. Highway Research Record, Highway Research Board, 1963

Loudon, W. R. (1997) Census Journey-to-Work Long-form Survey: Does it support state and Metropolitan Transportation Planning? Transportation Research Board Conference Proceedings 13, vol. 1

Luk, James Y.K. and Edward Chung. (1997) *Induced Demand And Road Investment: An Initial Appraisal*. Vermont South, Victoria: Australian Road Research Board.

Mackie P.J., Jara-diaz, S.and Fowkes A.S. (2001) The value of travel time savings in evaluation. *Transportation research part E*, 37.

Marchetti, C. (1994) 'Anthropological Invariants in Travel Behavior' *Technological Forecasting and Social Change* **47** 75-88

Marshall, N.L. (2000) Evidence of Induced Demand in the Texas Transportation Institute's Urban Roadway Congestion Study Data Set. Transportation Research Board 79th Annual Meeting Preprint CD-ROM, Transportation Research Board, National Research Council, Washington DC, January 2000.

McCarthy, P. S. (1997) "The Role of Captivity in Aggregate Share Models of Intercity Passenger Travel", *Journal of Transport Economics and Policy,* 31,3 293-308.

Metropolitan Council, Minnesota Department of Transportation Regional Transit Board, Transportation Advisory Board. (1997) Twin Cities metropolitan area travel behavior inventory, 1990 home interview survey methodology and results.

Metropolitan Washington Council of Governments. (1997) 1994 COG/TPB household travel study for the metropolitan Washington region, technical report and documentation.

Milone, R. J. (1993) An Analysis of Income Stratified Work Trip Distributions for Washington DC. Fourth National Conference on Transportation Planning Methods Applications Compendium

Noland, R. B (1999) Relationships Between Highway Capacity and Induced Vehicle Travel. *Transportation Research Board 78th Annual Meeting Preprint CD-ROM,* Transportation Research Board, National Research Council, Washington DC, January 1999.

Noland, R. B. and Cowart, W.A. (2000) Analysis of Metropolitan Highway Capacity and the Growth in Vehicle Miles of Travel**.** *Transportation Research Board 79th Annual Meeting Preprint CD-ROM,* Transportation Research Board, National Research Council, Washington DC, January 2000.

NuStats Partners. (2001) Twin Cities metropolitan area travel behavior inventory, 2001 home interview survey technical report.

Pisarski, Alan. (2002) Testimony For "Mobility, Congestion and Intermodalism" before the United States Senate Committee on Environment and Public Works March 19, 2002 Washington DC http://www.senate.gov/~epw/Pisarski_031902.htm

Prendergast, L.S. and Williams, R.D. (1981) Individual Travel Time Budgets, *Transportation Research* 15A, 1:39-46.

Purvis, Charles. (1995). Changes in Regional Travel Characteristics and Travel Time Expenditures in the San Francisco Bay Area: 1960-1990. *Transportation Research Record* 1466:99-110.

Redmond, Lothlorien S. and Mokhtarian, Patricia L. (1999) The positive utility of the commute: modeling ideal commute time and relative desired commute amount. *Transportation*. Dec 1999.

Shafer, Andreas (2000) Regularities in Travel Demand: An International Perspective *Journal of Transportation and Statistics.* Volume 3, Number 3 1-31.

Shunk, G. A. (1995) Uses of Census Data for Travel Research. *Transportation Research Board Conference Proceedings* 4: 68-74

Tanner, J.C. (1981) *Expenditure of Time and Money on Travel. Transportation Research*

15A, 1:25-38.

Texas Transportation Institute (2001) The 2001 Urban Mobility Report. The Texas A & M University System. http://mobility.tamu.edu

United States Census Bureau (2002) 2000 Census Statistics http://www.census.gov

Vivier, J. (2001) Mobility and Accessibility – Complementary or Contradictory Objectives? *Public Transport International*, 50 (5): 4-11

Whyte, William H. Jr. (ed.). (1957) *The Exploding Metropolis.* Berkeley, CA: University of California Press.

Zahavi, Yacov and James Ryan. (1980) Stability of Travel Components Over Time, *Transportation Resarch Record* 750: 19-26.

Zahavi, Yacov and Talvittie, Antti. (1980) *Regularities in Travel Time and Money Expenditures Transportation Research Record* 750: 13-19.

Zahavi, Yacov. (1974) *Travel Time Budget and Mobility in Urban Areas, Federal Highway Administration*, Washington DC, U.S. Department of Transportation, May 1974, NTIS PB 234 145.

Appendix A: Figures

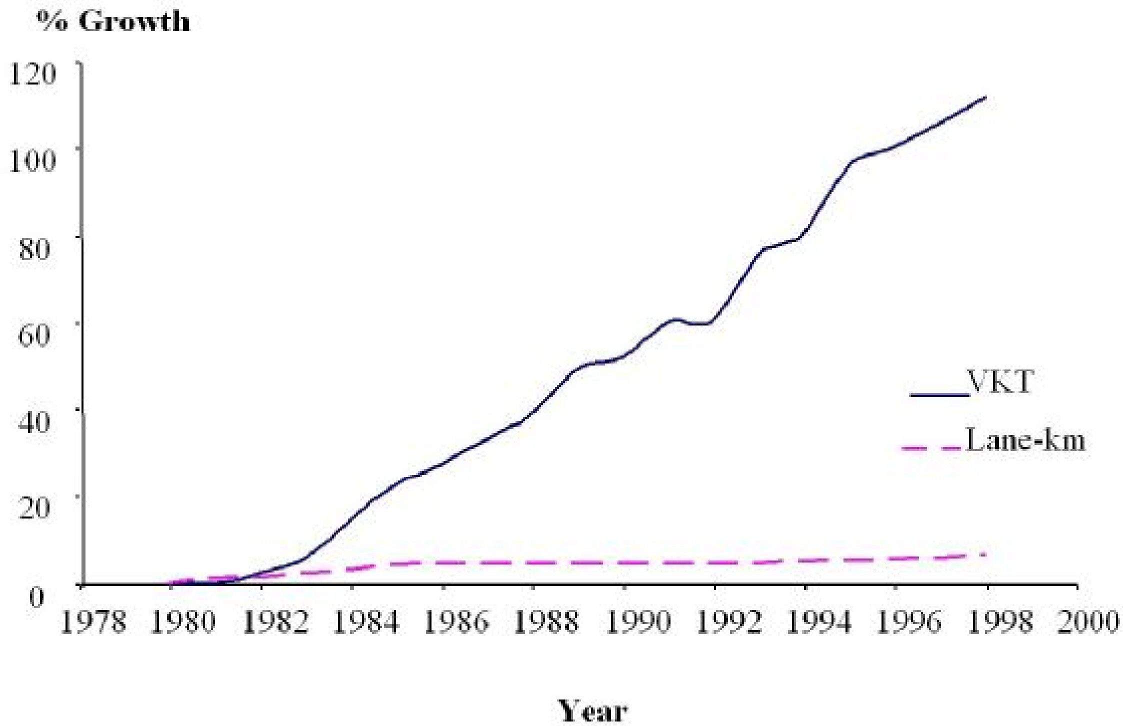


Figure 1. Vehicle-Km Traveled (VKT) Vs. Lane-Km Growth in the Twin Cities

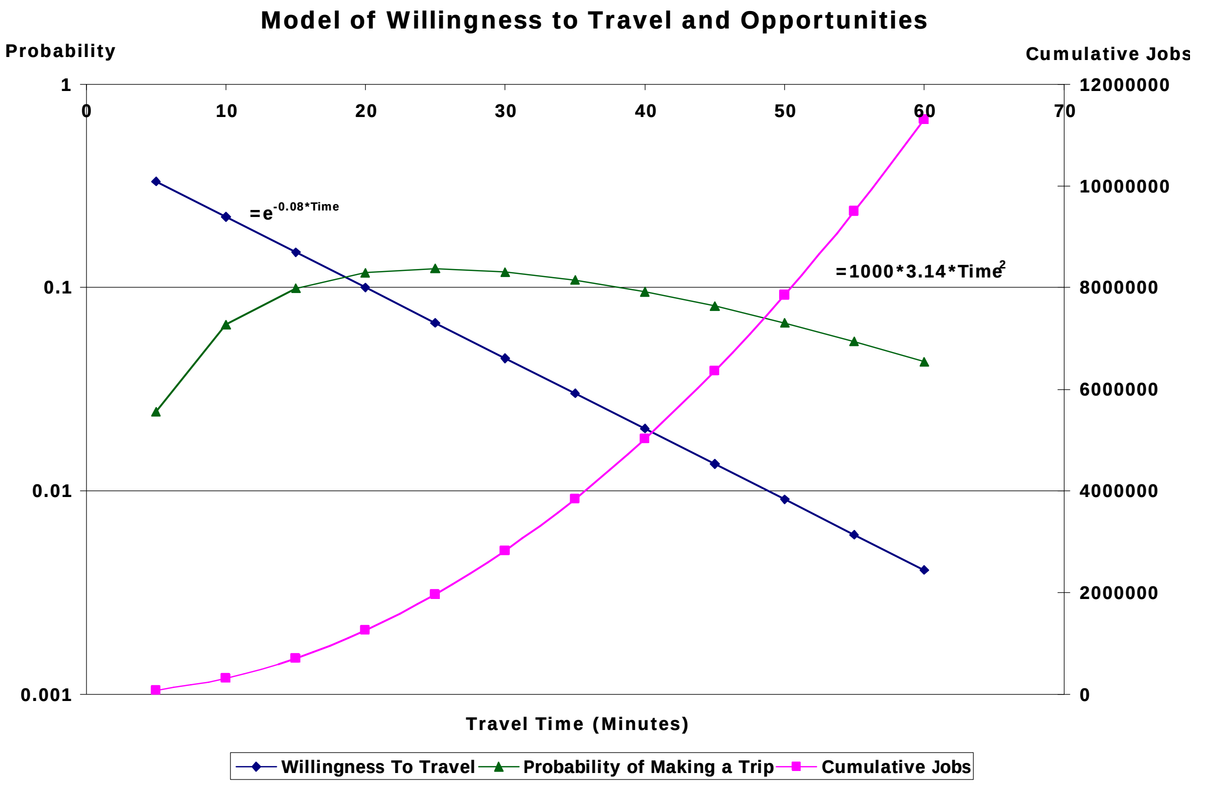


Figure 2. Trip Probability Illustration

Figure 3. *Travel Time and City Size*

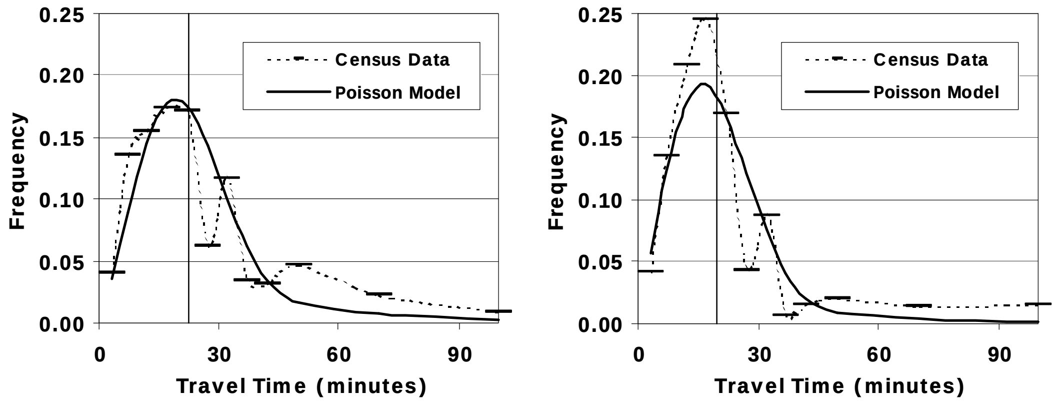


Figure 4. *Travel to Work Times for Albany and Anchorage (vertical line is the mean)*

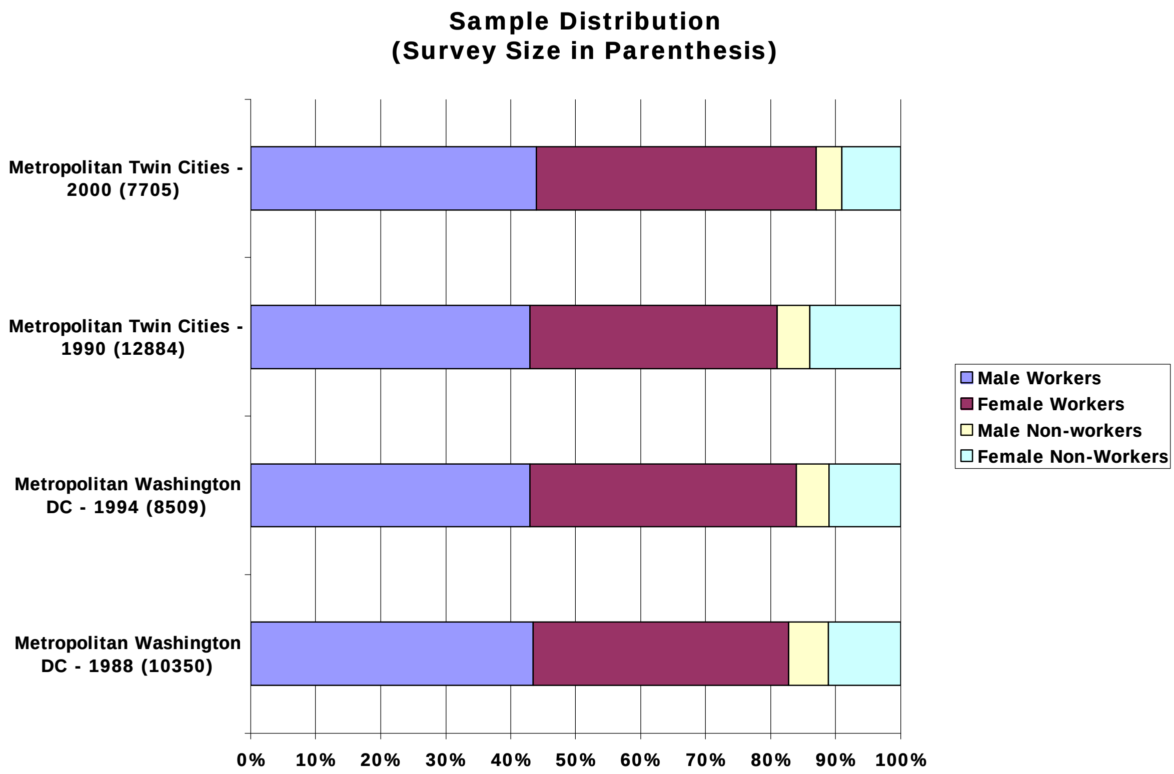


Figure 5. *Sample Distribution*

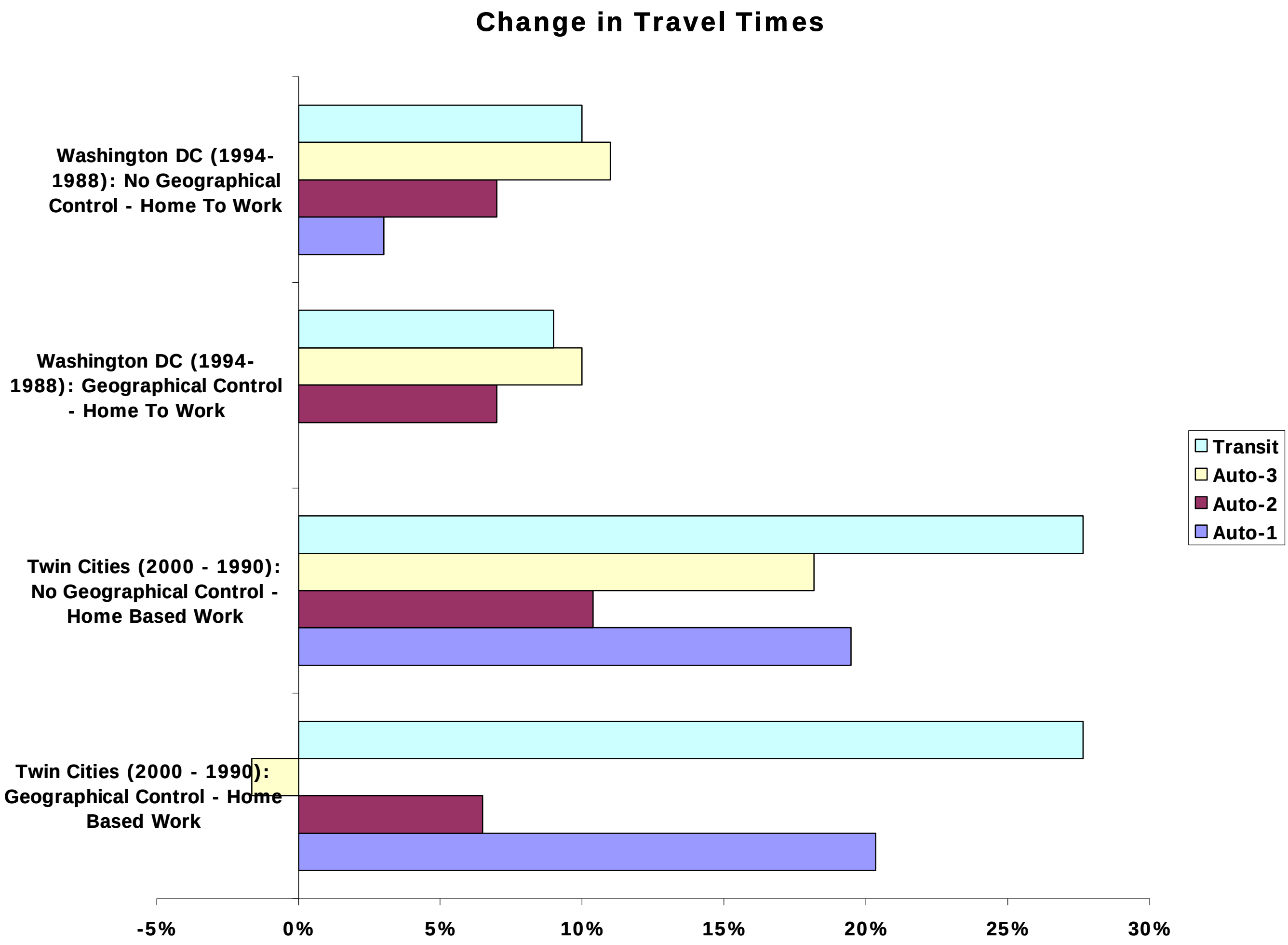


Figure 6. *Change in Travel Time*

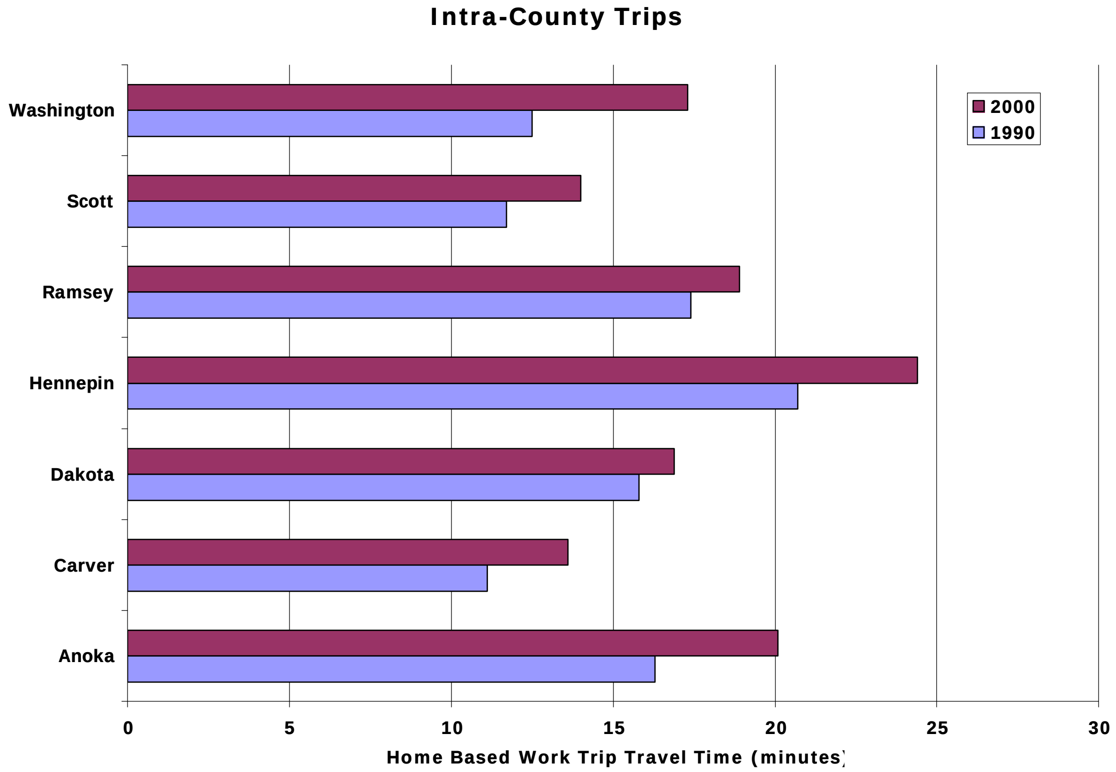


Figure 7. *Intra-County Drive-alone Home-based Work Trip Travel Time (minutes)*

APPENDIX A2. TABLES

Table 1. Data Summary

Variable	Mean	Std. Dev.	Minimum	Maximum
Mean Commute (minutes)	25.7	3.7	19.1	41.0
Congestion Index	1.00	0.17	0.69	1.52
Population	2,088,800	1,922,507	291,288	9,519,338
Population Density (persons/sq. mi.)	730.6	1,046.8	39.7	8,158.7
Housing Units	828,115	724,601	119,654	3,680,360
Housing Density (units/sq. mi.)	290.1	411.3	16.7	3,223.8
Area (sq. mi.)	4,490.4	5,760.6	751.4	39,719.1
Median Income ($)	42,714	8,313	23,992	76,752

Table 2. Regression Results for Mean Commuting Time

Variable	Norm. Coeff.	Coefficient	t-stat	Prob.
[Constant]	0.560	1.44×10^{1}	7.37	0.000
Congestion Index	0.236	6.08×10^{0}	2.88	0.006
Population	0.038	4.65×10^{-7}	1.96	0.055
Population Density	0.044	1.54×10^{-3}	4.19	0.000
Area	0.018	9.13×10^{-5}	1.84	0.071
Income	0.106	6.38×10^{-5}	1.87	0.067

Table 3. Mean activity durations per day, in minutes, for 1968, 1988 and 1994, Washington DC Metropolitan Area, adults 18-65

		Work outside home				Non-workers			
		Male		Female		Male		Female	
Activity	**Year**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Home	1968	786	143	831	135	1120	220	1225	164
	1988	799	150	826	153	1143	196	1165	187
	1994	761	131	795	129	1093	219	1155	190
	1994(full)	760	133	797	132	1104	219	1158	194
Work	1968	515	143	487	116	0		0	
	1988	472	173	447	165	0		0	
	1994	499	145	476	133	0		0	
	1994(full)	498	149	473	133	0		0	
Work-related	1968	0		0		0		0	
	1988	0		0		0		0	
	1994	20	72	10	49	0		0	
	1994(full)	21	75	10	48	0		0	
Shop	1968	7	24	10	32	27	62	52	77
	1988	10	41	13	41	31	62	50	90
	1994	8	28	13	28	33	75	47	77
	1994(full)	8	27	13	28	34	75	47	76
Other	1968	44	100	29	76	217	214	101	143
	1988	61	118	62	112	187	187	140	156
	1994	47	78	47	75	220	204	154	165
	1994(full)	46	77	48	76	207	197	149	163
Travel	1968	88	51	82	48	76	58	62	50
	1988	99	63	92	61	80	64	85	73
	1994	104	57	99	56	93	69	85	67
	1994(full)	108	60	100	57	95	73	86	72

Table 4. ***Mean activity duration per day, in minutes, for 1990 and 2000, Twin Cities metropolitan area, adults 18-65***

		Workers				Non-workers			
		Male		Female		Male		Female	
Activity	**Year**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Home	1990	777	127	816	137	1092	227	1176	182
	2000(7county)	777	128	802	131	1044	248	1122	200
	2000(full)	775	130	805	132	1045	248	1124	202
Work	1990	485	143	466	129	0		0	
	2000(7county)	494	133	476	127	0		0	
	2000(full)	497	136	476	125	0		0	
Work-related	1990	29	81	11	45	83	168	14	68
	2000(7county)	14	58	9	43	96	188	33	112
	2000(full)	14	57	9	43	91	185	32	112
Shop	1990	7	22	15	32	21	43	41	61
	2000(7county)	8	20	14	32	26	53	36	57
	2000(full)	8	20	14	30	25	52	38	64
Other	1990	53	85	55	79	144	167	131	144
	2000(7county)	56	87	56	83	168	189	161	157
	2000(full)	55	90	54	82	171	191	158	156
Travel	1990	88	53	77	43	101	82	78	59
	2000(7county)	90	53	84	45	106	95	87	57
	2000(full)	90	55	83	46	107	95	88	60

Table 5. Average travel time in minutes and sample size (N) for the metropolitan Washington region by mode and by purpose (a.m. and p.m. peak period)

Mode	Year		PURPOSE Home to Work	Work to home	Home to other	Other to home	Work to other	Other to work	Other to Other
Auto-1	1988	Time	29.6	33.4	17.8	21.6	26.4	23.8	17.7
		N	2332	1598	774	870	578	343	415
	1994 (7co)	Time	29.6	33.3	16	16.5	25.9	21.4	14.3
		N	1434	1082	705	716	474	226	335
	1994 (full)	Time	30.5	35.2	17.2	17	26.8	22.2	15.5
		N	1940	1466	892	952	645	313	433
Auto-2	1988	Time	31.6	35.7	16.8	19.3	23.6	29.5	16.6
		N	208	131	567	390	110	71	271
	1994 (7co)	Time	33.8	40.4	17.1	16.7	31.7	25.3	16.8
		N	299	192	559	408	111	56	220
	1994 (full)	Time	33.7	42.5	17.3	16.9	30.4	24.7	17
		N	400	260	742	539	148	80	305
Auto-3	1988	Time	37.8	43.1	18.8	19.2	29.8	28.9	18.6
		N	405	335	565	400	161	86	241
	1994 (7co)	Time	41.7	45.7	20.1	17.3	42.7	36.5	16.5
		N	151	111	341	233	34	20	114
	1994 (full)	Time	41.8	48.6	19.2	17.9	41.3	39.2	17.6
		N	176	148	473	322	48	28	157
Transit	1988	Time	43.2	49.6	35.8	37.5	38.4	31.5	34.7
		N	751	617	70	92	124	54	33
	1994 (7co)	Time	47	54.5	57.8	44	47.1	43.7	55.4
		N	441	366	63	59	83	33	17
	1994 (full)	Time	47.4	55.3	58.5	44	48.5	46.1	55.6

Table 6. Average travel time in minutes and sample size (N) for the metropolitan Twin Cities region by mode and by purpose (a.m. and p.m. peak period)

Mode	Year		PURPOSE: Home-based Work	Non-home-based Work	Home-based Other	Non-home-based Other
Auto-1	1990	Time	22.6	18.6	14.8	13.0
		N	8250	3606	6184	1376
	2000 (7co)	Time	27.2	21.9	17.6	15.0
		N	3859	1499	3017	1052
	2000 (full)	Time	27.0	21.3	17.8	15.4
		N	4722	1839	3729	1315
Auto-2	1990	Time	23.1	22.7	14.7	14.3
		N	775	539	3519	1095
	2000 (7co)	Time	24.6	21.3	16.4	16.7
		N	232	157	1485	561
	2000 (full)	Time	25.5	25.0	16.4	16.2
		N	271	199	1819	689
Auto-3	1990	Time	24.2	24.8	14.9	14.5
		N	134	149	1969	669
	2000 (7co)	Time	23.8	20.8	15.7	16.0
		N	42	46	800	219
	2000 (full)	Time	28.6	21.9	16.5	16.0
		N	55	56	976	286
Bus	1990	Time	32.9	26.3	29.2	20.8
		N	295	249	73	29
	2000 (7co)	Time	42	28.1	33.7	24.4
		N	190	109	43	132
	2000 (full)	Time	42	28.5	33.2	24.8
			193	113	44	135

7. End Notes

---

[i] The Census Bureau provides journey-to-work data for 330 MSAs and PMSAs with populations over 100,000. However, three metropolitan areas from the Urban Mobility Report are not included in the journey-to-work Census statistics. These three are Laredo, TX, Louisville, KY, and Norfolk-Virginia Beach, VA-NC. The data set therefore contains 65 observations.

[ii] TTI also defines a Travel Rate Index (TRI) which "shows the additional time required to complete a trip during congested times versus other times of the day." For our purposes, the TRI is too sensitive to the relationship between population or number of trips and the available roadway capacity. A small city and a large city may have similar TRIs if the relative availability of roadway capacity is similar. The Congestion Index is a better measure of general mobility for the purpose of this investigation. In addition, the journey-to-work generally takes place around a peak travel period, and the RCI does represent the travel conditions during these times. Nonetheless, a future study may find interesting results while incorporating the TRI. Road network expanse, or roadway density, is available from the Texas Transportation Institute (TTI) but is not included because TTI has shown it to be a very poor predictor of congestion and travel time.