1 Historical Changes in Twin Cities Travel Behavior

Much has been made of the huge increase in vehicle miles traveled (VMT) that has taken place over the last few decades since the construction of the interstate highway system. However, as was discussed in the introduction, to look exclusively at distance traveled can give a misleading impression of the changes, or lack thereof, in travel behavior. Yacov Zahavi, in a series of travel behavior studies looking in part at the Twin Cities, was one of the first to note that large increases in mileage had not been accompanied by increases in time spent traveling. Indeed, between 1958 and 1970, the percentage increase in miles per traveler was almost exactly the same as the percentage increase in average travel speeds, while time remained essentially constant.

We recreate Zahavi's analysis for 1990, and find the same phenomena that he did: since 1970 speeds increased, distance traveled increased, and time spent traveling remained essentially constant. As during the 1960s, new high-speed roads made it possible to travel faster; people used this new freedom to move to larger, more remote houses, or to expand the range of places where they would consider working. Conversely, development spread out, making it necessary to travel more miles to reach a similar set of destinations, but higher travel speeds made it possible to do this without spending more time driving.

A quote from the report summarizing the 1970 Travel Behavior Inventory gives a good idea of the changes that had taken place during the time period covered by

Zahavi's analysis, making the constancy in behavior that he found seem all the more remarkable:

> The total 1970 built-up urban area includes about 483 square miles. Since 1958, 48% or 236 square miles were added. This represents the addition of almost as much urbanized area as was constructed in the past century. This remarkable expansion of developed areas, the building of freeways (nearly the whole regional interstate system existing in 1970 of 140 plus miles was put in between 1958 and 1970), and the adding of thousands of additional miles of streets and arterial highways made the 1958-70 period unique in the history of the metropolitan area.

By 1990 the built-up area was 996 square miles, another doubling in the span of 20 years, along with more highway construction and expansion. It is remarkable to consider that in 1958, when the built-up area was one quarter of its present size, when population density was much higher, and when commercial activity was much more concentrated in the downtowns, that travel behavior, in terms of mode shares and time spent traveling, was hardly any different than today. More people travel today, but evidence strongly indicates that people who didn't travel in the past were economically or socially constrained from doing so. Even in those supposedly less auto-oriented times, the people for whom driving was an option almost always chose to drive.

(A peripheral but interesting point is that a doubling of land area in 20 years is not unusual, although it appears huge on first viewing. Historical maps indicate that the land area of the Twin Cities has been doubling every 20 years ever since they began. This amounts to about a 3% annual growth rate, which given population and economic growth, is basically no higher than the growth of consumption of any other good.)

Given these results, it is interesting to examine the reasons for the huge increase in vehicle miles traveled between 1970 and 1990 (Table 2.1, Figure 2.1). Many people seem to believe that this increase took place because each individual drove more, and that driving more means spending more time in the car. This is, however, not quite right.

Table 2.1: Increase in VMT, 1970 to 1990

	1970	1990	% Change
Population, 7 counties	1.9M	2.3M	22 %
% Travelers	67 %	83 %	25 %
Time per day per traveler	67.5 min.	70.9 min.	5 %
Total person hours*	**1.45M**	**2.33M**	**60 %**
Average speed	17.1 mph	22.4 mph	31 %
Total person miles*	**24.8M**	**52.3M**	**111%**
Driver miles/total miles	66.7 %	76.9 %	16 %
Total vehicle miles*	**16.5M**	**40.2M**	**144 %**

* Rows in bold type are the product of the rows immediately above them. They do not correspond to the numbers cited in the Travel Behavior Inventory (TBI) summaries because the numbers in this table include only personal travel by residents of the region, while the TBI

The belief that VMT has increased because of basic behavioral changes is not supported here. Population is exogenous to travel behavior. Average speed is strongly influenced by technical considerations. The fraction of people who travel in a day is essentially a demographic phenomenon, as will be discussed in the next section. The decline in auto occupancy, leading to more vehicle or driver miles per person mile, may be partially due to a change in behavior. However, even this is in part due to demographics, namely a sharp decline in the number of children, who are responsible for a high fraction of trips as riders. Even the small increase in time per day per traveler is partially due to this: children travel less than adults, so having fewer of them will drive up the average even if nothing else changes.

2 Adult Auto Travelers in 1990

Chapter 2 extended Zahavi's analysis of the Twin Cities region to 1990 and found that average regional travel times did not change over a 30-year period during which regional land use changed dramatically. This supports a tentative conclusion that land use does not have that much influence over how much time people spend in their cars. However, an interesting secondary result was that there are differences in average travel times from one place to another within the region. This chapter will study the reasons for these variations, with the hope that examining differences within the region in more detail might cast light on ways that land use affects travel behavior – ways that are lost in the aggregation when the region is considered as a whole. More general questions of mode choice and whether motorized travel is used at all will be considered in the next chapter.

We consider three general travel descriptors and then one major factor that explains almost all of the observed differences across the region. The three descriptors are travel time, trips, and distance, all measured per traveler per day. Travel time is our primary concern, as it represents an explicit choice and commitment of resources by the traveler. The number of trips can in principle vary considerably within a given travel time budget, but surprisingly shows little variation across the region (although it has grown substantially in the past). Distance traveled is the product of travel time and speed; there is substantial variation across the region, and almost all of it arises from differences in speed.

The one factor that explains almost all the variation in average travel times is location, in particular where a person lives relative to major concentrations of employment. Jobs in the region tend to be relatively concentrated in the corridor between the two downtowns, and then out to the southwest of downtown Minneapolis. People who live near these job-rich corridors tend to have shorter commutes than those who don't. The critical point here is that what matters is the distance to *major* regional concentrations of jobs, not the distance to the closest job, or the closest office building. For the average resident of the urbanized area, there are 400,000-500,000 jobs that are closer to home than the job that person actually holds. This indicates that many people place a very high value on a preferred job or home location, compared to a short commute. These ideas are discussed in section 3.4, "Geography and Job Accessibility."

Throughout this analysis, we exclude anyone under age 18. There are both theoretical and practical reasons for this. From a theoretical standpoint, children in many cases do not make their own travel decisions; thus it is inappropriate to include them in an effort to understand the factors that influence travel decisions. Furthermore, both their "mandatory" and discretionary daily activities are fundamentally different from adults; their behavior, even when they can choose it, is likely to be motivated by different objectives.

The practical reason for excluding people under age 18 is that they do, empirically, behave differently. They make fewer trips and spend much less time per day (54 minutes vs. 74 for adults – although some of this difference might be because some households were surveyed during the summer when children were not in school). Their mode choices are completely different, as they are far more likely to ride as passengers in a car, or to ride a bus (in most cases school bus), and much less likely to drive. Thus including children in the analysis would substantially complicate the problem of comparing the behavior of different groups, since varying numbers of children could make it hard to discern differences among the adults. This is particularly important when comparing the city to the suburbs.

The final reason for ignoring children (or mostly ignoring them) is that they have little overall impact on the amount of travel by their parents. Adults with children make about half a trip a day more than adults without kids, but do not spend more time or cover more distance. They undoubtedly travel to somewhat different destinations, but in terms of their usage of the road system, this doesn't really matter. This surprising result is discussed at more length in section 3.2, "Trips per Day."

2.1 Total Daily Travel Time

This is the most significant of the facts about travel behavior, as discussed in the introduction, because it represents resource usage (time and road capacity) most directly. It is also interesting in that it exhibits surprisingly little variation, either across time, places, or types of people. For these reasons we examine this issue in some depth here.

As with other types of behavior, there are significant variations in individual daily travel times. Some people spend a great deal of time in their car on a daily basis, others spend little, and even a given individual will fluctuate from one day to another. Given this high degree of individual variation, it seems all the more remarkable that any *group* that one examines, whether defined by demographics, income, or home location, has an average travel time that falls within a fairly tight range. Even more surprising, even differences among groups that lead to substantial differences in other aspects of travel behavior have no impact on total travel time for that subset that uses cars.

Two examples can illustrate this point. There is a substantial difference between workers and non-workers in the likelihood that a member of each group will travel by a motorized mode in a given day. More than 90% of workers travel each day, while only about 70% of non-workers do. Nonetheless, members of each group, on the days when they do travel, spend about the same amount of time (workers, 75 minutes; non-workers, 71). Non-workers are less likely to travel, but if they do, they spend about the same amount of time as workers.

The second example is location. People who live close to downtown Minneapolis are substantially more likely to use alternate modes than are people who live elsewhere. A considerably smaller fraction of the population in this part of the region relies exclusively on the auto. But the people who do use only autos spend about the same amount of time each day in a car as do auto users in outer ring suburbs.

While total auto mileage is lower in dense areas, this is mostly because speeds are lower, not because people spend less time driving. The other major difference between high- and low-density residents is not that the first group takes shorter trips (in the sense of less time), but that they use the auto to make the trip less frequently. People in high-density areas in general use the shorter distances to expand their choices, not to reduce their trip length. (There is evidence, however, that time spent in other modes counts against auto time. This issue is discussed in the next section.)

In dividing the population according to various criteria, the method that yielded the greatest variations in average travel times was by location, specifically by distance of the home from the nearest downtown. The number of minutes of travel per day rises in a very clear way as distance from the center increases, from about 69 minutes for workers who live within four miles of a center, to just under 80 minutes for those who live more than 25 miles out.

The question is this: why would distance from the center matter? Income is traditionally thought to be an important determinant of travel behavior; incomes rise as distance increases, so the effect might just arise incidentally from the correlation with income. Alternately, population and employment densities decline as distance increases; perhaps density differentials explain the difference. Another possible explanation is that the ratio of jobs to workers is much higher in the central part of the region; thus centrally-located residents can more easily find work close to home, while at least some outlying residents must drive into more central areas.

A simple exercise in looking at differences between group averages yields some surprising insights. It appears that the apparent influence of distance arises exclusively from longer commute times. Non-commute time varies hardly at all by location.

Figure 3.1 breaks the population down according to the distance of the home from the nearest downtown. This shows both commute and non-commute times holding steady until the 10-13 mile range, at which point commute times start a steady increase, while non-commute times remain basically constant and perhaps even decline slightly. Regression analysis (detailed results in the appendix) confirms that non-work travel time, either by workers or non-workers, does not vary in any systematic way with local or even regional variations in land use.

Given that non-work travel time does not vary much, we focus our attention first on explaining commute times. We used linear regression to find the extent to which commute times are influenced by job, retail, and population density, income, and job access, where job access means the ratio of jobs to people within a given distance. It turns out that job access is by far the best explainer of commute times. When taken alone, it explains much more of the variation in commute times across zones than do either income or density. And when the different factors are regressed together, density is generally not statistically significant (or has the wrong sign), while the effect of income is significant but very small (0.2 minutes for $10,000 in additional income). (The appendix gives specific regression results.)

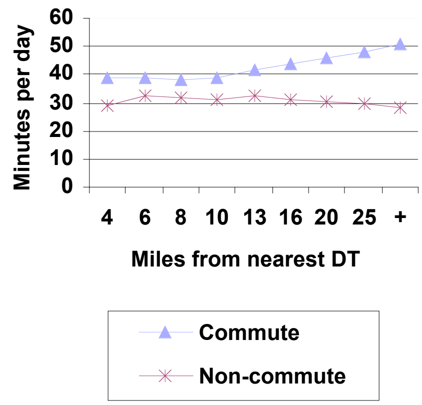


Figure 2.1: Worker travel times by home location

Despite the unique importance of job access in explaining commute times, it is worth bearing in mind that even job access is surprisingly insignificant as an influence. Average one-way auto commute times from the center to the edge of the region vary only over a range of about 19-25 minutes, while job access (defined here as the ratio of jobs to people within a 20-minute radius of the home) varies by a factor of three. (Other ways of defining job access, including simple number of jobs, did not explain the data as well.) An interpretation of the regression results says that increasing the number of jobs within 20 minutes of a zone by 10%, while holding the population constant, would reduce average commutes by about one minute. (And since these jobs would have to come *from* somewhere, such a move would likely increase commute times somewhere else in the region.) Again, when more jobs are easily accessible, people just expand their range of choices, rather than shortening their commutes.

Why do job and population density appear to have no impact on commute times? The easiest way of seeing this is by noting (in Figure 3.2 and Table 3.4) that the innermost ring (out to four miles) is three times denser than the ring from eight to ten miles out, yet commute times do not increase at all (in fact they decrease slightly). By contrast, the number of jobs per person varies hardly at all across this range, and this lack of variation corresponds closely to observed commute times. (Overall, from central city to remote rural areas, density varies by a factor of 1,000, and average commute times increase by six minutes over this range.) While land is much less densely developed in the suburban locations, speeds are also higher, which keeps the number of jobs within a given commute time basically constant out to a ten-mile radius. Also, while there are fewer jobs per square mile, there are also fewer people competing for them, so the overall availability of jobs does not change much for the first ten miles from downtown. This begins to change at the 10-13 mile ring, which is also where commute times start to increase.

This situation may be inevitable. Firms, for many reasons, prefer to locate in the central parts of urban regions. With a few exceptions, firms get less value from being close to the edge, while many people seemingly get more. Given this, it is probably unavoidable and possibly desirable that the outer edge of the built-up area will have more residents than jobs.

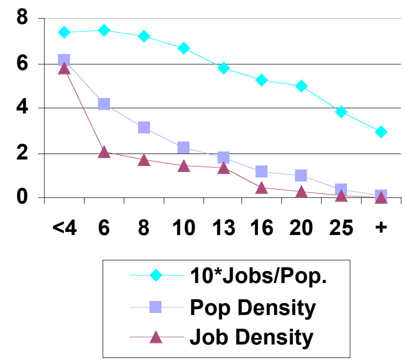


Figure 2.2: Density (1000/sq.mi.) and job access by distance from center

It is also surprising that income matters so little. Intuitively one would think that higher income people would be willing to drive farther to work; perhaps this is offset to some extent by higher income people having more choice among jobs. The other factor that implies that commute times might be longer for high-income people is that total travel times are slightly longer; apparently most of the difference arises from non-work travel.

Variations in non-commute travel by workers are almost entirely random. To the extent that there is any systematic variation from one location to another, it arises because workers with longer commutes tend to spend less time on non-work travel. An extra minute of one-way commute time is associated with about 45 seconds less total non-commute time. The greatly superior shopping and other opportunities available in the center of the region do not induce the local residents to spend less time on non-work travel; if anything they spend a little more. The travel time budget, rather than convenient access, seems to be the operative influence here.

The same general point, that land use has little impact on non-work travel choices, arises when examining travel by non-workers. It is influenced by income, which is reasonable and even expected, and by distance from the city center. However, measures such as access to retail or employment (as a measure of opportunities more generally), or various measures of density, are not statistically significant as determinants of variations in travel time.

One possible explanation for this is that the sample is self-selected. That is, the observed differences in behavior might not arise from characteristics of land use but rather from the people who live there. People with a higher tolerance for driving are more likely to move to outlying areas where they will be likely to spend more time driving. Presumably high-income people, for example, could afford to live closer in (since many low-income people do) if they wished to. It is important to bear in mind that the differences are not huge. The range of non-worker daily travel time is from 67 to 76 minutes. And as with non-commute travel by workers, essentially all of the observed variation is random.

2.2 Trips per Day

While each auto traveler makes substantially more trips than was the case in the past (from 3.6 to 4.6 between 1958 and 1990), total time per traveler has not increased; apparently people are making more trips and spending less time on each one. And interestingly, despite this large variation over time, there is very little variation at present. For an *adult* auto traveler, the average number of trips per day is about 4.7; virtually no way of dividing the population yields much range on either side of this.

Consider income, for example. With the exception of the lowest income group (<$15,000), which also had much lower-than-average daily travel times, the variation is from 4.5 trips at low income to 4.8 at high income. Looking at distance from the center, the range is from 4.45 at less than five miles, to 4.85 at 10-15 miles, then dropping again to 4.4 at more than 20 miles.

There appear to be three factors that influence the number of trips that a given individual makes; each of these appears to have its effect in a discrete fashion. If a person is poor (defined here as household income less than $25,000), that person will make fewer trips than a person with an income above this level. If an adult has children in the household, that adult will make more trips than one without children. Finally, people who don't have jobs make more trips than people with jobs.

These factors account for about half the observed variation in trip quantities across the region. There is still a puzzling phenomenon in which the number of trips per auto traveler increases from the central city out to about ten miles, then declines, dropping considerably in the outermost rural areas. Some might argue that central city residents are substituting walking for driving trips, but this seems unlikely to be a good explanation of the lower trip rates in rural areas. Farmers often work "at home" and hence don't have commuting trips, but even rural non-workers make fewer trips than their urban counterparts. Perhaps trips are necessarily longer from remote rural areas, thus residents must make fewer trips to keep their total travel time from rising unpleasantly high.

It is interesting to examine in more detail the impact of children on travel by adults. Both in forecasting and in popular discussion, household size is taken as an explainer of trip quantities. However, while the presence of children may pull down the average number of trips per person (because children make fewer trips), when analysis is restricted to adults, it turns out that it is the presence of children, rather than household size itself, that matters (Table 3.1).

Table 3.1: Effect of children on number of trips

Children:	0	1	2	3+
1 adult	4.4	5.3	5.4	-
2 adults	4.4	4.7	5.0	5.2
3 adults	4.5	4.9	5.0	5.1

Apparently having a child in the household adds about half a trip per day for every adult in the household, and more than this for single parents (although those two cells are relatively small samples). The fact that trip quantities for adults is insensitive to the number of adults in the household implies that household size may be less important than is commonly thought as an input to the forecasting process. It may be the case that if we know how many adults there will be, then we can predict how many trips will be made without the additional step of figuring out how many households they will organize themselves into.

It is even more interesting to look at the total daily travel time for these categories (Table 3.2).

Table 3.2: Effect of children on total daily travel time

Children:	0	1	2	3+
1 adult	71	82	74	-
2 adults	73	74	75	74
3 adults	76	76	80	76

It seems that while people with children make more trips than those without, they do not spend more time doing it. (While the 82 minutes for one-adult, one-child households is large, it seems likely to be a small-sample aberration, since the number goes back down to 74 when another child is added.) For two-adult households, the increase in trips from 4.4 to 5.2 as the number of children increases from zero to three or more, results in essentially no change at all in total daily travel time. As would be expected, parents make more trips, but contrary to expectations, they don't seem to spend more time doing it.

2.3 Total Daily Travel Distance

Distance is travel time multiplied by speed. That is, unlike other ways of describing travel, it is a combination of behavior and technology. This is an important point. It is natural, but generally incorrect, to assume that twice as many miles means twice as much time (a change in behavior). But in fact, variations in mileage arise almost entirely from variations in speed (technology-induced). Because of this, and because we have already analyzed the determinants of travel time, this section on distance is devoted largely to understanding what factors influence average speed.

The belief that variations in distance arise from variations in travel time implies an underlying belief that everyone travels at about the same average speed. This seems plausible and even obvious; wherever you drive, everyone else is going at about the same speed that you are. The mistake in the logic, of course, arises from the fact that traffic moves at different speeds on different roads, and people don't all allocate their time to fast and slow roads in the same proportion. While I am driving as fast as the car next to me now, we may not be going the same speed five minutes from now when we are on different roads.

The most obvious influence on average travel speeds is the location of one's home, in that relatively more driving tends to be near there. Streets are narrower and the grid denser in the central cities; thus speed limits are lower and stop signs and traffic signals are encountered more frequently. Further from the center, the road network was developed later, and thus was often designed more explicitly to accommodate higher-speed auto travel. Perhaps more importantly, densities are lower and thus intersections more widely spaced. Thus, generally speaking, the further from the center of the city one lives, the faster one will be able to travel on average.

The other important general fact that emerges from analysis is that work trips are faster than non-work travel. Work trips are longer than others, and are more likely to use freeways or other high-speed roads. This speed difference is substantial and holds regardless of location or any other factor.

As can be seen in Figure 3.3, commute speeds are four to five miles per hour higher than other trips almost everywhere. Non-commute trips, that is, trips by workers excluding trips to and from work, are generally slightly faster than trips by non-workers, although this could be somewhat due to demographic and economic differences between the two groups.

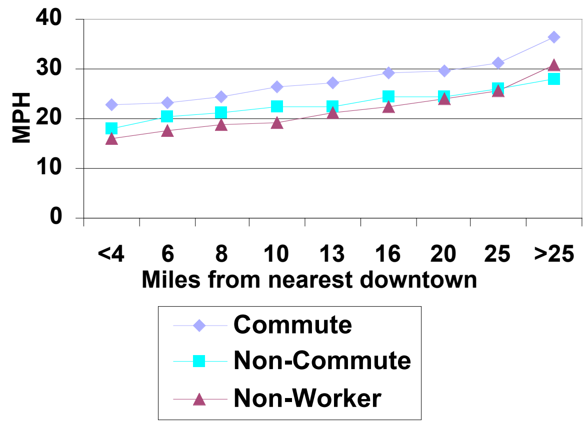


Figure 2.3: Speed by location

For both work and non-work travel, the same factors matter. The most important factor for both types of travel is the distance of the home from the nearest downtown. This descriptor is no doubt standing as a proxy for the general types of roads that one is likely to encounter in ordinary daily driving. A second important factor is the density of development around the home, which has the effect of making speeds lower as it increases.

In general, all types of density (employment, retail, and population) have the effect of reducing speeds as they increase. It is interesting to note, however, that the effect of a given increase in retail density is at least twice as big as a corresponding increase in general employment or population density. This is logical; the number of trips generated is much higher for a retail job because these jobs imply many customers for each worker. It leads one to wonder, though, about the virtues of mixed use development. Having retail mixed in with neighborhoods will make trips to those particular establishments somewhat easier for local residents (although maybe not for customers coming from outside), but it will also tend to slow down every other trip those locals make. This is a point that should be more carefully studied and discussed.

Two other factors exerted a smaller, but statistically significant influence on speed of travel. People with higher household income traveled on average at higher speeds than those with lower income (recall that we are considering only auto travelers here – the difference is not because low-income people are riding the bus). More strangely, increasing age was associated with lower speeds. This was not just leisurely retiree drivers. Average speed was highest for the 18-30 age group, and decreased consistently for every subsequent group. It appears that somehow people use different types of roads as they age (or as their income changes); there may be implications for traffic forecasting and highway investment.

It is helpful to summarize the sources of the large differences in miles per person between the central city and outer suburbs or rural parts of the region. Table 3.3, which shows the average values for all adult travelers in two parts of the region, illustrates very directly the point that the vast majority of the large difference in daily miles traveled between the center and edge of the region results from higher travel speeds rather than from more time in the car. (The "rural" column is not a large sample, but the increases in both travel time and speed are quite regular as distance from downtown increases, so there is no reason to believe that these numbers are misleading.) Distance alone is not a very useful descriptor of system usage, since so much of it is technological rather than behavioral, in the sense that it depends mostly on the characteristics of the road system rather than the people using it. (It appears that a simple way to reduce aggregate VMT would be to reduce speed limits on every road, and install more intersections with poorly-timed traffic signals.) In any case, distance is an output rather than an input; that is, it measures what we're accomplishing rather than how many resources we're using. Increased mileage might not be a bad thing if it can be achieved while reducing resource usage and costs more generally. Conversely, reduced mileage might not be a good thing if it happens because of speed reductions due to congestion.

Table 3.3: Travel time, speed, and distance

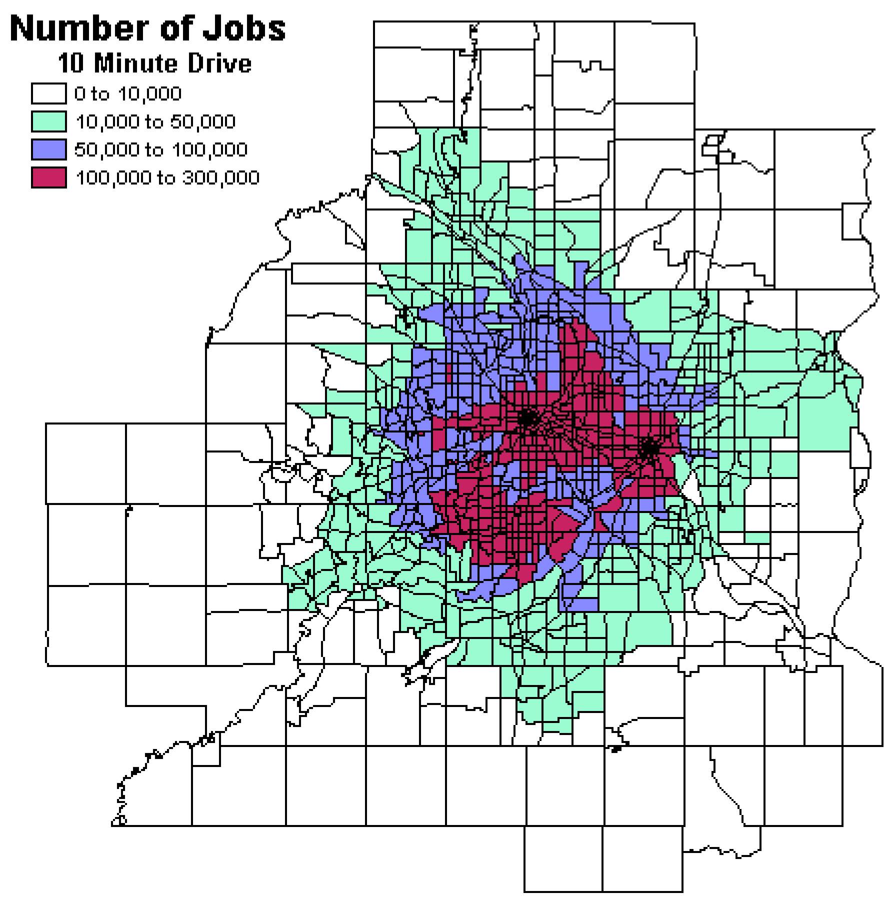
	Cent.City (<4 Miles)	Rural (>25 Miles)	% Diff.
Travel Time (min.)	67.7	79.8	17.9%
Avg. Speed (mph)	18.7	33.9	81.3%
Distance (miles)	20.9	43.4	107.6%

Differences in travel behavior across individual auto travelers can be ascribed to two broad categories: demographic and economic characteristics of the individual such as age and employment status, and characteristics of the places where the individual lives and works. This latter category includes such factors as job access, population density and quality of transit service. In the next section we describe some of the more important factors and give a general sense of the kinds of impacts they have.

2.4 Geography and Job Accessibility

Access to jobs, in a regionwide rather than a local sense, is an important influence on travel behavior. A substantial fraction of non-auto trips originate or end in one of the downtowns or the University of Minnesota. Because central city residents are closer to these areas, they are more likely to work in them and make trips to them, and hence are more likely overall to use alternate modes. This, it turns out, explains a substantial part of the lower level of driving exhibited by central city residents.

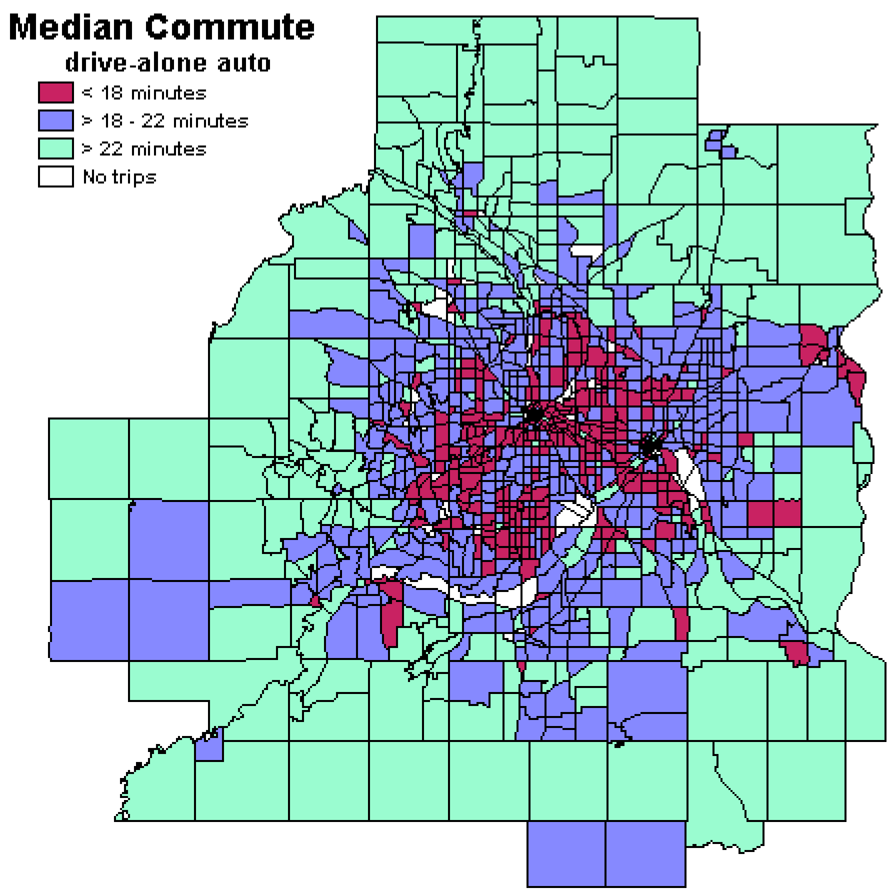
On the other side of the accessibility spectrum, people who live in outer ring suburbs (more than ten miles from the nearest downtown) are farther away from the bulk of the region's jobs than are more centrally located residents (Map 3.1). Half the region's residents live more than ten miles from the nearest downtown, while half the jobs are less than seven miles out. Thus, for people who live in this part of the region, not only are there fewer jobs to choose from, but there are relatively more people competing for them. As a result, residents of these areas must drive farther on average to work. And this turns out to explain almost all of the higher level of driving seen in residents of outer ring suburbs.



Map 3.1: Job accessibility from home locations

The central part of the region and the southwest suburbs have the best job access. Half the region's jobs are located less than seven miles from a downtown. See reference maps in appendix.

The primary point that emerges from this analysis of job access is that there are very large differences in job accessibility (even within the urbanized area), but that these lead to relatively small differences in commute times (Map 3.2). Apparently good job access is like high-speed freeways: people tend to use the better access to expand the range of jobs that they choose from rather than to shorten their commutes. Conversely, people with worse job access simply choose from a smaller selection, so as to keep their commute time from becoming inordinately long. Figures 3.4 and 3.5 show that while access varies by several times from the center to the edge of the built-up area, median commute times vary by only about 30%.



Map 3.2: Median auto commute times

Low times correspond roughly to areas of good job access. There is little variation across the built-up parts of the region. See reference maps in appendix.

Obviously at every location there are people with very long commutes, and others with short ones, but the *typical* commute time from a given home location varies hardly at all from one part of the urbanized area to another. While many zones have average commutes under 18 minutes, virtually none go below 16. A range of 16 to 22 minutes describes essentially the entire urbanized area. This is particularly interesting in the areas of excellent job access. People living in these areas had in excess of 100,000 jobs within a ten-minute drive of their homes, yet the median person in these areas typically chose to drive about twice this far.

This has important implications for a key idea of modern planning. It is commonly thought that long commutes are to some extent due to the separation of jobs and housing. But our analysis does not support this idea. There are two primary points. First, the presence of a large number of nearby jobs does not noticeably increase the probability of working close to home (Table 3.4).

Table 3.4: Commuting statistics

	Central Cities	<10 mile suburbs	<20 mile suburbs
Ave. no. of jobs, < 1 mile	6703	2744	1625
Percent < 1 mile commute	12%	10%	9%
Ave. no. of jobs, <10 minutes	138,000	89,000	49,000
Percent < 10 min. commute	22%	26%	23%
Percent <10 min. (model)	41%	39%	32%
Ave. reported commute minutes	19.6	19.0	21.8
Ave. no. of jobs, <20 minutes	524,000	434,000	241,000

The second point is the one hinted at above. To claim that the problem is separation of jobs and housing implies that people are taking the closest available (suitable) jobs, but still must drive substantial distances to get to them. But people clearly do not take the closest available job. Almost everyone in the built-up part of the metro area has at least a quarter of a million jobs within a 20-minute (at congested speeds) drive of home, yet nearly half of workers reported traveling farther than this to work. Are all of these 250,000 jobs unsuitable, or unavailable? And if they are, then what difference would it make if they were mixed in with housing rather than zoned into separate (and generally more accessible) areas?

One possible issue is that perhaps central city job access is not as good as our measures might indicate. When we calculated the number of jobs within ten minutes, we measured time based on the congested times between zones as predicted by traffic forecasting models. Given these assumed travel times, the number of people working within ten minutes of home (in the fifth row of the table) is substantially higher than the number who actually report that their drive took less than ten minutes. The difference between model times and reported times is especially large for central city residents. One possible explanation is that out-of-vehicle time is longer in the central cities, due to the difficulty of finding (or affording) convenient parking downtown. However, if this is the case, then the number of jobs within ten minutes may be considerably lower than we have assumed here, based on the forecasting model.

Regardless of how job access is measured, comparing the first, third, and last rows of the table gives some insight into the reasons for long commutes. Even in the central cities, for most people there simply are not very many jobs within walking distance of home, especially compared with the number available if one is willing to drive ten minutes. Then, as a mathematical point, to double the time one is willing to drive will roughly quadruple the amount of area that can be covered (a circle of radius two has four times the area of a circle of radius one), and thus will roughly quadruple the number of jobs that one can choose from. Alternately, if one has a job and is looking for a home, the number of choices increases with the square of the distance traveled. Thus accepting a longer range of travel will both make it easier to find a job or home, and makes it more likely that one will be happy with the job or home that is chosen. While there may be people who prefer a short commute and are willing to restrict the jobs they consider to achieve this aim, clearly for the great majority of people choice is more important than a short commute. This, not a lack of nearby jobs, seems to be why people commute long distances.

Another point to consider is that while there are more nearby jobs in the central cities, there are also more nearby people who might be expected to compete for them. While this is true, it turns out in fact to further support the point that central city commutes should be shorter than they are, if job access were the only consideration. While population *is* denser in the central cities, jobs are relatively denser still. That is, in the central cities, not only are there more jobs within a given distance of home, but there are relatively fewer people competing for them. Surprisingly, this is true of low-wage as well as higher paid work.

Central city residents not only have more nearby jobs, but they have more nearby jobs per person (Figure 3.4). This imbalance is especially pronounced among higher income workers. Low-income workers and jobs, contrary to popular belief, are actually much better balanced by location than are their counterparts with higher incomes, although in both cases central city residents are better off than suburban dwellers.

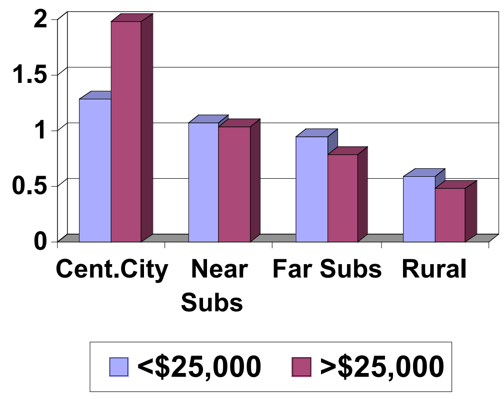


Figure 2.4: Jobs per resident worker, by personal income

Another interesting and perhaps counterintuitive point that emerges from this analysis is that low-income workers are surprisingly well spread throughout the region, rather than being especially concentrated in the central cities.

The first interesting point from Figure 3.5 is that in all locations, the majority of low-income (<$25,000) workers come from high-income (>$25,000) households. The second is that in all locations, the total number of low-income workers exceeds the number of high-income. The third is that while low-income households are relatively concentrated in the central cities, in absolute numbers there are more in the suburbs.

An important implication of these charts is that building “affordable” housing in the suburbs would not be especially helpful to low-income households as far as job access is concerned. While there are not a lot of low-income *households* in the suburbs, there are plenty of low-income *workers*, entering the workforce as the second or third wage earners of higher-income families. Truly low-income people seeking suburban jobs would have to compete with all these (very likely better qualified) non-poor but still low-wage workers. There are more low-wage jobs *per low-wage worker* in the central cities.

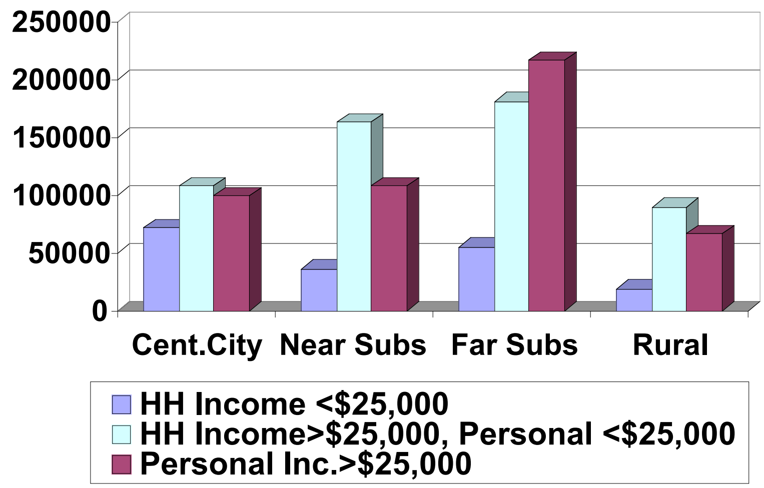


Figure 2.5: Number of workers, by household and personal income

The general point of this digression into income levels and job access is that the generally good balance of jobs and people in general is not contradicted by noticeable imbalances arising from inappropriate matches of wages and skills at particular locations. It appears that not only are there plenty of nearby jobs at most locations, but these jobs match, in a general sense, the skills of the local residents. People probably live far from their jobs because they value a particular job or house more than a short commute. Indeed, high-income people, who as a group are most likely to be able to afford to move closer to their jobs if they want, are in fact the group with the worst job access.

3 All Travel (All People, All Modes) in 1990

This chapter attempts to find the reasons why people in different places make different choices about whether to travel and what mode to use, to quantify the differences observed across the region, and in particular to identify the role of land use.

The previous two chapters focused largely on auto travelers, who constitute the vast majority of the population in the Twin Cities. The primary findings were that average daily travel times for this group have not varied much historically, and do not vary much currently across the region; and that the observed variations arise from poor access to the regional job base from outlying areas.

This chapter moves beyond this limited analysis to examine travel in general in 1990. One of the most widely held beliefs about high density neighborhoods is that people are able to complete trips by modes other than auto. That is, even if the average auto traveler is about the same everywhere, the average *person* may not be, if fewer people use autos or they use them less frequently in some parts of the region. Thus the purpose of this chapter is to understand *all* the factors that influence the amount of auto travel, in particular to see whether auto travel may be reduced by use of alternate modes even if total travel time doesn't vary much.

We find evidence that this is true, although the difference across the region again is not very large. The average adult living in the central cities spends about 45 minutes a day driving a car, compared with 50 minutes for the average inner suburb adult resident. The difference arises from two main sources. Central city residents are slightly less likely (about 3%) to use motorized transport in a given day, and those that do are more likely to use transit and (to a much smaller extent) carpool.

The main finding is that land use does impact transit use, but that commercial land use appears much more significant as a determinant of mode choice than does residential density. The point basically is that a fairly small area of the region, consisting of the two downtowns plus the University of Minnesota, attract a wholly disproportionate share of alternate (non-auto) mode use. Indeed, about 30 of the 1165 traffic zones in the region (less than 1% of the total land area) attract more than 60% of the region's bus trips. (These are the two downtowns and the University of Minnesota.) A large share of walking and biking trips also go to these zones. Thus people who live close to these zones are much more likely to use alternate modes than are people who live further away. This happens both because increasing distance makes walking and biking (and to some extent transit) more difficult, and because people who live farther away from a place are less likely to travel there at all.

Because the areas near the downtowns and the university are conveniently located, they tend to be densely developed. However, while we can't claim to have analyzed this question from every possible angle, our findings to this point lead us to believe that it is the convenient location, rather than the density of development, that makes the difference. To clarify and support this point is an obvious avenue for further research. The difference between the two points of view is critical from a policy standpoint. If we are right, then simply increasing density will make little difference to travel patterns. What will matter is increasing the density of areas that, because of their location, have the potential to generate low travel rates.

3.1 Traveling vs. Staying Home

A basic problem in understanding travel behavior is to determine the factors that influence whether a person is a traveler at all. Traveling is defined here as making a trip by motorized vehicle: car, bus, motorcycle, or taxi (this would also include rail if this option were available). Walking and biking are not considered here. Except for trips to work we have no information on use of these modes in the Twin Cities. However, evidence from other similar cities indicates that excluding these modes is probably not creating too much bias in the results. The Nationwide Personal Transportation Survey (NPTS) of 1995 specifically asked about travel by nonmotorized modes. In cities the size of the Twin Cities only about 1.5% of people reported traveling by nonmotorized modes but not by motorized modes. That is, in almost all cases when people don't travel by motorized modes, it is not that they are walking places instead of driving, it is that they don't travel at all.

3.1.1 Relevant Factors

Whether a person travels in a given day seems to be almost entirely determined by whether that person is employed or not. Adults who are employed have a 92% probability of traveling; adults who are not employed have a 70% chance. Differences in travel rates by other dimensions (age, household size, etc.) are fully explained by differences in employment rates. It is possible to predict travel rates of almost any subgroup within 2-3% by simply multiplying the fraction that are workers by 0.92 and the fraction that are nonworkers by 0.70.

Surprisingly, while older people are less likely to travel, the difference is essentially entirely due to the fact that they are less likely to have jobs (Table 4.1). Age seems to have no additional influence on this particular aspect of travel behavior.

Table 4.1: Probability of motorized travel by age

Age	Predicted	Actual	% Diff.
19-29	0.88	0.84	4.8 %
30-54	0.88	0.89	-1.9 %
55-64	0.81	0.81	-0.3 %
65 +	0.73	0.71	1.9 %

Again, differences in employment rates track well with differences in traveling rates by income (Table 4.2). The one significant difference (indeed, the only group of any kind that was poorly predicted) is people in households with income under $15,000. Zahavi discussed money as another constraint on travel behavior, and perhaps that is what is happening here. That is, it could be that the other groups earn enough income that the money constraint is no longer binding, and only the time budget influences travel behavior, while the lowest income group is still constrained by lack of money as well.

Table 4.2: Probability of motorized travel by income

Income	Predicted	Actual	% Diff.
<$15,000	0.78	0.70	11.0 %
$15,000-25,000	0.81	0.81	-0.8 %
$25,000-45,000	0.85	0.86	-1.4 %
$45,000+	0.88	0.89	-1.3 %

Employment rates do not vary much by distance from the city center. As a result, the predicted probability of motorized travel does not exhibit as much variation as actually occurs (Table 4.3). Nonetheless, the variation by location is surprisingly small given the widespread belief that the central cities are far more conducive to non-motorized modes. It is also interesting that the actual rate of motorized travel is lower than the predicted value in rural areas, where people don't use non-motorized modes much.

Table 4.3: Probability of traveling by home distance from city center

Miles from center	Predicted	Actual	% Diff.
<5	0.85	0.82	2.6 %
5-10	0.85	0.85	-0.3 %
10-20	0.87	0.88	-1.7 %
20+	0.86	0.84	2.5 %

3.1.2 Historical Changes

While employment rates seem strongly correlated with the probability of travel, the question remains of why the probabilities are what they are. For example, the probability of traveling for non-workers must have increased since 1970, since the overall rate of travel including workers at that time was only 67%, compared to 70% for non-workers now. The important question for forecasting purposes is this: how stable is this rate, and what factors influence it?

The case can be made that the rise in this rate was a one-time result of the oldest generation, who were far less likely to travel than younger people, being replaced in the population by a new generation which traveled more at the population average. Another important factor seems to have been greatly increased mobility of children, possibly due to higher auto ownership by their families, and to the increased likelihood that older children will have jobs. The final factor influencing the probability of traveling was widespread entry into the workforce by women, which moved them into the higher travel category.

We don't know the probability of travel by age in 1970, but it is possible to make an educated guess based on trip rates then and now. It appears that the probability of traveling by age quartile might have been something like 0.5, 0.9, 0.8, 0.4 in 1970, while it is about 0.8, 0.9, 0.9, 0.7 now. This would lead to an overall rate in 1970 of 0.65, which is consistent with the known total rate from then.

Given that travel probabilities are now virtually constant across all ages (the lower rate among the elderly is because they are less likely to work, not because they make different travel choices), it seems plausible to claim that the rates will not change much in the future, in the absence of large changes in employment rates. Another way of testing this hypothesis is to determine if there are groups within the current population with much higher than average probabilities of traveling. These could be considered to be "leading" groups, which others will eventually catch up to.

Workers in every group have about a 0.92 probability of traveling. For non-workers, almost all groups are within 1-2% of 0.7, with two significant exceptions.

First, non-workers in the 30-39 age group have a probability of traveling of 0.79. While this is much higher than older age groups, it seems unlikely to represent the leading edge of a new trend, since the next younger group, the 19-29 year-olds, has a probability of 0.55, which is far below the average. These variations seem more likely to be a result of lifecycle factors than an indication that the 30-39 group is a sign of the future.

A more important factor is income. Here the probability of traveling among non-workers ranges from 0.63 for incomes under $15,000, to 0.70 for $15-25,000, to 0.72 for $25-35,000, to 0.75 for more than $35,000. This makes it appear that the overall rate of travel for non-workers could rise as high as 0.75 as incomes rise and monetary constraints on travel become less binding. For still higher income, the rate does not continue to rise, giving some confidence that 0.75 might represent an upper bound.

3.2 Determinants of Mode Choice

The final general issue that significantly influences the amount of auto travel in the region is the choice of travel mode. Modal decisions play an important role in generating measurably different driving rates when central city residents are compared with suburbanites. Since these differences are a primary point of emphasis among advocates for central-city-type neighborhoods, it is important, if these differences are to be exploited effectively in other contexts, to understand how big they are and from what sources they arise.

3.2.1 Transit

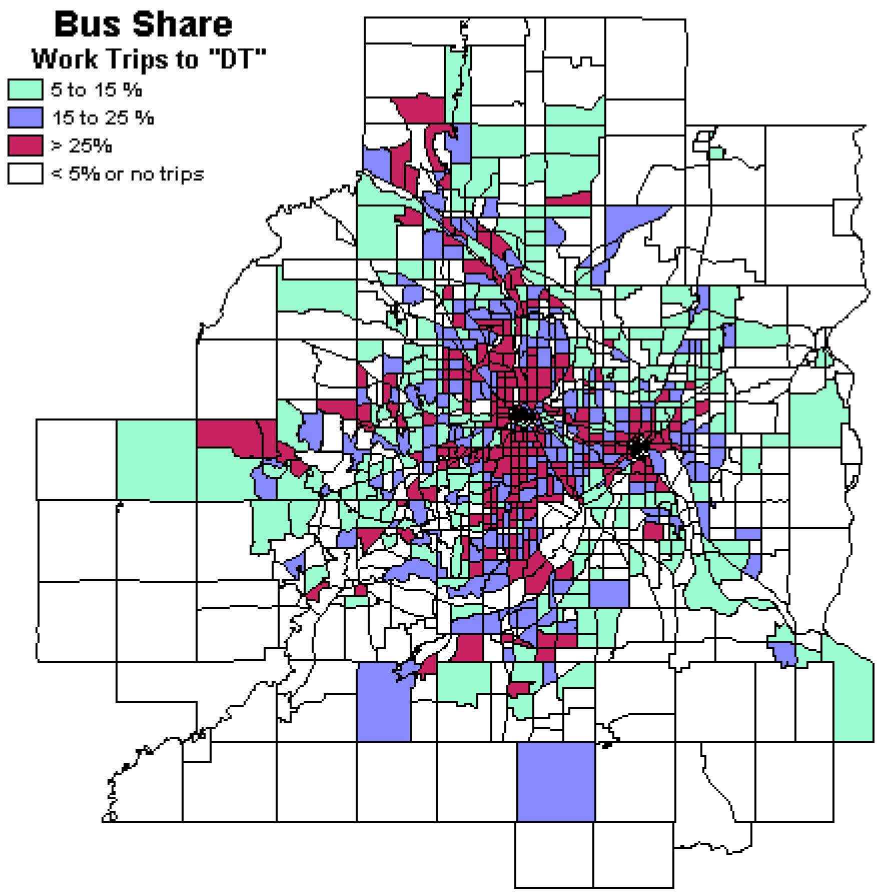
Central city residents use transit far more frequently than do suburbanites, using transit for 6.4% of their trips compared with 1.7% in the suburbs. (This includes both adults and children. Transit means public buses, not school buses or vanpools.) The reason for this is typically believed to be land use patterns: higher densities make it possible to maintain a denser bus network, and this in turn makes it easier to access the system. Because people can easily walk to the nearest bus stop, they are more likely to use transit than are suburbanites, who must often drive or be driven to a place where they can catch a bus.

The facts here are not disputable, but the explanation is. The fact that cities are higher density, and that they have higher transit shares, does not in itself prove that one caused the other, even though it may be logical. At the very least, it is necessary to examine at least some alternative explanations. The two considered here are differences in income, and in destination choice.

The first of these is simple to explain. Low-income people (household income below $25,000) are three times as likely to use transit for a given trip than are people with incomes above this level. And as discussed in the last section, while low-income people are not exclusively confined to the central cities, they do make up a considerably higher fraction of the population there than they do in the suburbs. This does in fact explain some of the difference in transit shares.

More of the difference, however, is explained by the second, more subtle issue of destination choice. A majority of transit trips either originate or end in "downtown" (defined here as the dense commercial area of downtown Minneapolis, downtown St. Paul including the Capitol area, and the three campuses of the University of Minnesota). Residents of the central cities are more likely than suburbanites to travel to these areas, for two reasons. First, people who work or attend school in these areas have more reason to live relatively nearby, which tends to concentrate them in the central cities. (This phenomenon happens in suburban job areas as well, although in that case obviously it leads to employees concentrating in suburban residential neighborhoods.) Second, people everywhere tend more often to seek shopping or recreational opportunities close to home, which for central city residents sometimes means downtown or the University.

What emerges from analysis is that trips to or from "downtown" are ten times more likely to use transit than are other trips, *regardless of the location or density of the residential neighborhood on the other end of the trip*. Trips between "downtown" and suburbs have a transit share in excess of 15%; this is true even in many outer ring suburbs. On the other hand, even central city residents are relatively unlikely to use transit for trips that do not go to or from downtown. The combination of the facts that trips downtown are more likely to use transit, and that central city residents are more likely to make trips downtown, explains much of the difference in transit usage rates between central city and suburbs.

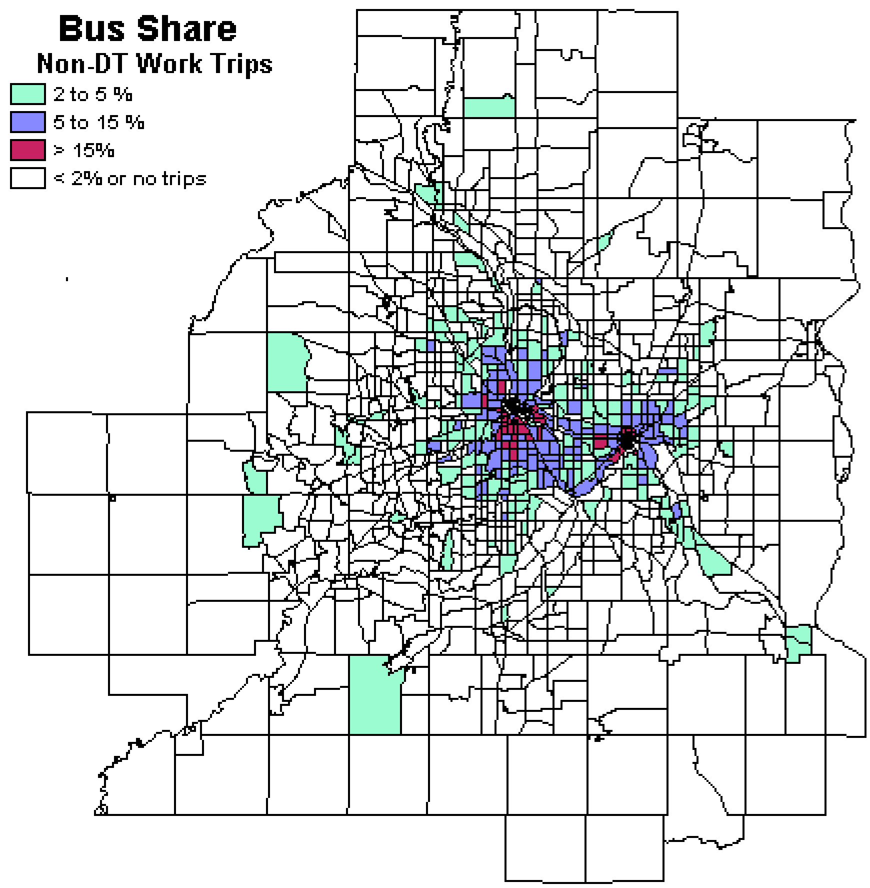


Map 4. 1: Bus share, work trips to extended downtown

Share exceeds 15% far beyond the dense areas of the central cities. See reference maps in appendix.

Map 4.1 shows the bus share for work trips going to our conceptual "downtown" (including the central downtowns of Minneapolis and St. Paul, and the University of Minnesota). The casual observer, used to believing that transit is insignificant in the Twin Cities, can hardly help but be astonished at this picture. The bus share for work trips to these areas is in excess of 15% over an area that extends in every direction far beyond the traditional high-density, "transit-friendly" areas of the central cities. From downtown Minneapolis, there is an unbroken corridor of high transit share extending 15 or 20 miles or more in most directions.

Given the low residential densities prevailing over most of this area, it seems inevitable that most of these people must be driving or riding in a car to a place from which they catch the bus downtown. If people are indeed this willing to drive to a bus stop, then perhaps the supposed need for high density housing to generate bus ridership ought to be reconsidered. It appears, in fact, that the density (and likely the cost of parking) at the *work* end of the trip is a far more influential factor.



Map 4. 2: Bus share, work trips to non-downtown destinations

Share exceeds 5% only in parts of the central cities. See reference maps in appendix.

Map 4.2 furthers this point. This shows the bus share for work trips to places other than "downtown." Here only a very small area generates shares in excess of even 5%, and local residents will recognize that much of this area is the low-income neighborhoods of north and near south Minneapolis. The data we used to make this map did not allow us to distinguish between low- and high-income households, but given our results elsewhere, we can only believe that the high transit share areas of the map would shrink considerably if just higher-income households were considered. Table 4.4 shows the striking difference between households of different income levels in mode choice, regardless of the home or destination neighborhood.

Table 4.4: Transit share by household income, trip ends (all trips)

	<25,000$	>25,000$	Total
Central city/downtown	51.9%	20.6%	26.8%
Central city/non-downtown	6.3%	1.9%	3.0%
Central city total	12.3%	4.7%	6.4%
Suburban/downtown	35.0%	14.8%	16.2%
Suburban/ non-downtown	1.8%	0.6%	0.8%
Suburban total	3.4%	1.5%	1.7%

Table 4.4, while compelling as a demonstration of the importance of income and destination in determining mode choice, is not helpful in understanding how much difference these factors make to the total shares. To see this, an exercise was performed in which the fraction of trips to each destination by each income level (for example, trips downtown by low-income people) was set to be the same for central city residents as for suburbanites, while keeping mode share for each type of trip at the levels shown above. In other words, we want to know what would happen if the shares of high- and low-income households were the same in both places, and people in both places were equally likely to travel downtown. Defining a "type" of trip to be a combination of an income level and a destination, there are four types of trip. Table 4.5 shows the percentage of each type of trip in each location; the numbers add up to 100% within the central city box and within the suburb box.

Table 4.5: Fraction of total trips by income, destination

	<25,000$	>25,000$
Central city/downtown	2.7%	11.7%
Central city/non-downtown	17.7%	67.9%
Suburban/downtown	0.5%	5.3%
Suburban/ non-downtown	9.4%	84.7%

In the experiment, then, the percentage of trips by low-income central city residents to downtown was set to 0.5% of total trips by central city residents, to equal the percentage of this type of trip by suburban residents. The mode share for this type of trip was kept at the observed level of 51.9%. This adjustment was then applied to the other three types of trips by central city residents, to make the likelihood of that type of trip equal to the level observed in the suburbs, while leaving the mode share unchanged.

Table 4.6 shows that fully one-third of the transit mode share for central city residents is due to the fact that they are much more likely to make trips downtown than are suburbanites (they are more likely to travel downtown by all modes, not just transit). The overall transit share for low-income drops from 12.3 to 8.5, while high-income drops from 4.7 to 3.0, when destination choices are set to be equal to those made by suburban residents.

Table 4.6: Normalized central city bus shares (all trips)

	<25,000$	>25,000$	**Total normalized**	Total observed
Downtown	(51.9%)	(20.6%)	**23.3%**	(26.8%)
Non downtown	(6.3%)	(1.9%)	**2.3%**	(3.0%)
Total normalized	**8.5%**	**3.0%**	**3.5%**	(6.4%)
Total observed	(12.3%)	(4.7%)	(6.4%)	

Holding income levels similar to those in the suburbs has a significant impact on mode share for non-downtown trips (from 3.0 to 2.3), which are the vast majority of the total (by all modes), even in the central cities. Overall, when both income and destination differences are controlled for, nearly half of the central city bus share disappears. The normalized share, at 3.5%, is still twice as high as the suburban share of 1.7%, but increasing transit share by 1.8% does not seem like a particularly strong argument for higher residential density. It is certainly less compelling than the quadrupling implied in the unnormalized share of 6.4%; and it is much less striking than the 20% share created by the high job densities of the downtowns and the University.

The most important conclusions to be drawn from these numbers seem to be that the characteristics of residential neighborhoods seem to have much less impact on mode choice than is usually thought, and that characteristics of the destination have a great deal more. For both income levels, trips downtown are ten times more likely to use transit than trips to other destinations, and in the suburbs the difference is 20 times. Suburban residents traveling downtown are six to seven times more likely to use transit than are central city residents (of the same income level) traveling to a non-downtown destination.

A possible problem with this line of reasoning is that transit service in the Twin Cities is very focused toward serving the downtowns. Thus a reasonable case could be made that there is little bus share to non-downtown destinations because there are not very many buses going to these places. There is a chicken and egg problem here. Is sparse non-downtown bus service the cause of low non-downtown bus shares, or is it an effect, a response to lack of interest in these routes? This is a question that we cannot yet answer. However, it should be noted that a major part of the reason why bus service downtown is so much better is because there are so many more people that want to go there. It would be extremely costly to provide equally good service to most other places because there is insufficient job density to provide an adequate customer base for good bus service.

Simple regression analysis (detailed results in the appendix) supports the idea that simple residential population density doesn't impact transit use very much. These regressions consider transit share by home zone, without considering (except indirectly) the income level of the riders or the destination of the ride. So if anything some of the effect of these other factors is being captured as being the result of population density. Nonetheless, while population density is statistically significant as an influence on transit share, *the influence is not very big*. Increasing the density of a square-mile area by 1,000 per square mile (a big density increase in a residential neighborhood) is associated with somewhat less than a 1% increase in transit share to work (for example, from 5% to 6%), other things held constant (or conversely, a decline in auto share from say 90% to 89%). Analysis of other cities (Barnes, 2001) shows that this general relationship holds across the U.S.

The apparent lesson here is that, at least in the Twin Cities, increasing land use in commercial areas is more likely to impact transit usage than is higher residential density. This is partially because higher commercial densities will likely encounter less political opposition, but also because commercial densities can be driven much higher, and many more people impacted. Furthermore, high commercial density appears to be nearly a necessary condition, while high residential density is merely helpful. The example of suburban residents traveling downtown shows that if people have a compelling reason to take the bus, they will find a way to take it, even if their home neighborhood is not "transit-friendly" according to the usual criteria. And the example of non-downtown trips by central city residents shows that if the destination is not well served by transit, not many people will use it, no matter how transit friendly their home neighborhoods might be. Another way of looking at this is that it is not a high population density *per se* that makes transit viable; rather it is a high density of people *traveling to the same destination*. Such high "destination-densities" may also exist at some places in the suburbs.

It is worth dwelling a moment on this point. Transit is a reasonable competitor to the auto in cases where the bus can fill itself with a small number of stops, drive directly to the destination, and discharge all the passengers with an equally small number of stops. If the bus has to stop 15 times at the beginning of the route, or at the end, the trip will simply be too time consuming to be competitive for anyone with a car at their disposal. The question then is: how is it possible to achieve this ideal low-stop scenario? First, the end of the route needs a densely built area with a large number of jobs within easy walking distance of the bus route. In downtown, because the buildings are tall and close together, there are tens of thousands of jobs within walking distance of any bus route. In suburban areas, by contrast, buildings are generally short and separated by large surface parking lots, so that a bus would have to stop at every building individually, and each building would be the destination of fewer people.

What about the home end of the trip? Here the well-known formula is high housing density, so that many people will be within walking distance of the bus route. But there are two points against this idea. The first is that mentioned above, that people do not in fact seem that unwilling to drive their cars to catch the bus. It seems not improbable that this might be because once they get to the bus, it drives directly to their destination. A bus that stops within walking distance of your home is probably also stopping within walking distance of many other people's homes; the convenience of walking to the bus may be cancelled by the inconvenience of stopping dozens of times to pick up other people who have done the same thing. (A friend of the author has a local route downtown close to her home, but she chooses to drive a mile to a place where she can catch an express bus.)

The second point against high home density as a promoter of transit use is that, as mentioned earlier, it is important not only to have a lot of people, but to have a lot of people going to the same place. Having 10,000 people in a square mile, but traveling to 9,000 different destinations, does not make transit particularly viable. And highly dispersed work locations are in fact the case over most of the region. In practice it appears, especially in the suburbs, that people solve this problem by creating temporary density, by driving their cars to designated "high-density" areas (bus stops), which may not be particularly close to any of their homes. It may be possible, by exploiting this idea, to provide good bus service to high-density suburban job centers surrounded by low-density housing. Further increasing the density of the suburban job centers would make this task easier yet.

Although it certainly needs further study, these results imply that transit share could be increased by greater focus on providing good service to popular but "expensive" suburban destinations, such as those subject to severe congestion, perhaps sacrificing some service to residential areas. These results also suggest that land use policy, to the extent that increased transit usage is an objective, ought to focus on increasing the density of commercial areas and perhaps show less concern with residential development patterns.

It could be objected that driving to the bus will not help reduce pollution since much of the emissions occur in the first few minutes. But the "cold-start" penalty seems like a problem that can be solved by technology. (Hybrid-electric or fuel-cell vehicles would pollute no more at the beginning of the trip than at any other time.) And if emissions were more proportional to trip length, then an extensive park-and-ride system could have a significant impact on total emissions in addition to its more immediate and potentially sizeable effect on congestion. Given that the alternative seems to be that people don't ride the bus at all for most trip destinations, then a park-and-ride system at least wouldn't make pollution any worse. Finally, while parking spaces would still be needed, at least some of them would be moved out of commercial areas, making even higher job densities feasible.

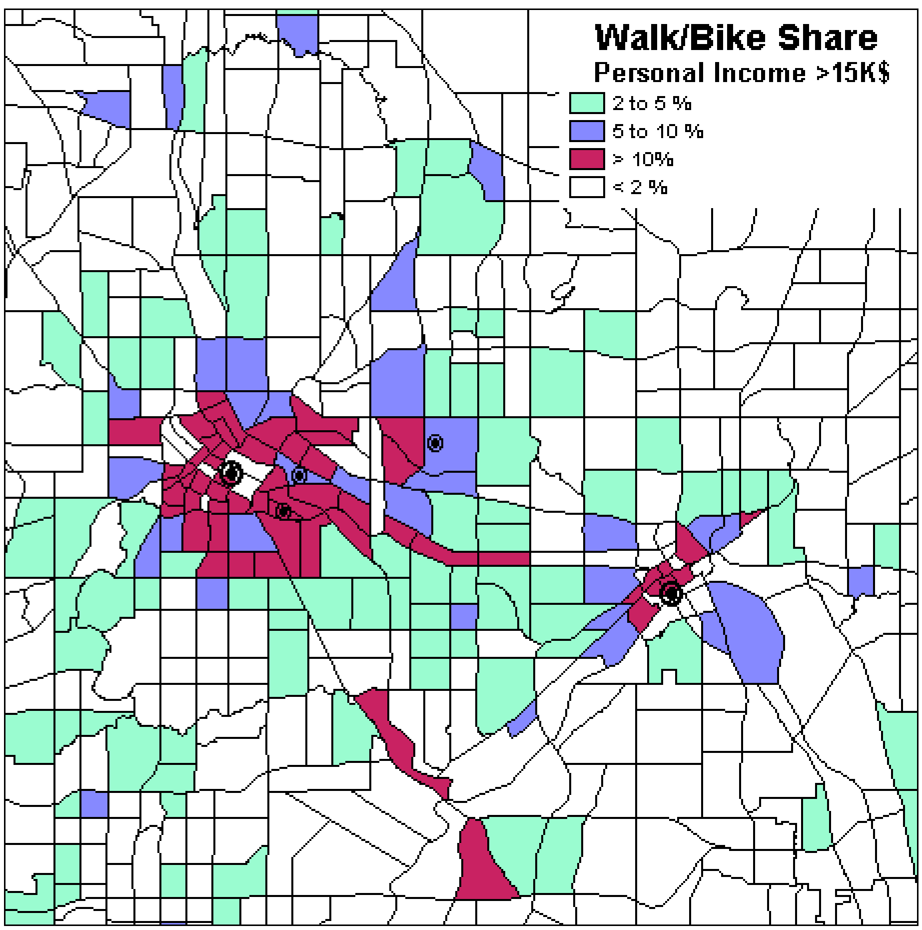
3.2.2 Walk and Bike

Mode shares for walking and biking exhibit similar patterns to those found in the transit mode (Table 4.7). That is, being low-income or working downtown appear to have a much larger impact than do residential land use patterns. For these modes, we have information only on the trip to work. Thus trips were divided into types based on income and, for central city residents, by whether the person worked downtown.

Table 4.7: Walk and bike shares, by location and household income

	<$25,000	>$25,000	Total
Central city/downtown	19.0%	7.6%	9.0%
Central city/non-downtown	6.7%	2.6%	3.4%
Central city total	9.7%	3.9%	4.8%
Near suburbs (<10 miles)	3.3%	1.2%	1.4%
Far suburbs (>10 miles)	1.6%	0.7%	0.7%

As with transit, being low-income and working downtown (including the University) contribute substantially to the mode share for walk and bike. For non-downtown workers, central city residents are more likely to walk and bike than are suburbanites, but the difference is not as large as might be expected, given the generally much better pedestrian infrastructure.



Map 4.3: Walk/bike share, work trips, personal income >$15,000

Areas with high walking and biking are concentrated around the downtowns (the two large dots) and the campuses of the University of Minnesota (the three small dots). The walk/bike share drops rapidly with distance from these areas. See reference maps in appendix.

The view of the central part of the region in Map 4.3 illustrates these two points. The two striking points about this map are the extent to which the areas with high walking and biking (for people with income above $15,000 per year) are concentrated around the downtowns (the two large dots) and the campuses of the University of Minnesota (the three smaller dots). There are only a handful of zones where walk/bike share exceeds 5% that are more than a mile from one of these attractors.

The second striking point about this map is the rapidity with which the walk/bike share drops from more than ten percent to less than two, as the distance from the major attractors increases. This further supports the point that, as with transit, it is the characteristics of the destination more than the home neighborhood that lead to high alternate mode use. Population density does not drop off nearly as rapidly as the rate of walking does, nor does the quality of sidewalks.

Another point that bears further emphasis is that walking and biking are very much modes used by low-income people. In the census data, people with personal income less than $15,000 per year make (in both cities and suburbs) more than 70% of the total walk and bike to work trips, despite constituting at most 40% of the population (in the cities, and less than this in the suburbs). Much of this no doubt is teenagers and college students working part-time jobs, but the general point still holds – people who can afford not to walk generally don't. (And more generally, don't even work within walking distance of their home.)

Table 4.7 is not directly comparable with the similar one for transit (Table 4.4). This table includes only work trips (because that is all the data available), while the transit table included all trips. The transit share of work trips is undoubtedly higher than is its share of total trips. However, this is hard to determine exactly because many trips to work apparently were not recorded as such in the TBI data. (Only 75% of workers report making a trip to work on the day they were surveyed.) This does not affect the conclusions drawn here, since they were based on the relative, not the absolute sizes of transit shares in different locations.

However, despite problems of comparability, it is clear from these data that overall, and especially for non-downtown work trips, walking and biking are of the same order of importance as transit. This suggests that a greater focus on encouraging these non-motorized modes, and on providing safe access to them, could conceivably pay substantial dividends in reducing local rush hour congestion.

3.2.3 Carpool

The final "alternate" mode studied here is carpooling. The number of people who get to work by riding as a passenger in a car is considerably larger than the number who use transit, on a region-wide basis. Given this, it seems worth putting some effort into understanding carpool behavior, in case there are policy ideas that could be exploited.

Auto occupancy rates (the number of people per car) have an interesting history. The numbers below are taken from the 1990 Travel Behavior Inventory Summary Report (Table 4.8). (Note that there are other types of trips in addition to those shown here; "All trips" is not the average of work and shopping.)

Table 4.8: Auto occupancy, 1949 to 1990

	Work trips	Shopping trips	All trips
1949	1.12	1.67	1.55
1958	1.12	1.79	1.57
1970	1.19	1.48	1.50
1990	1.08	1.31	1.29

Overall occupancy declined precipitously between 1970 and 1990 after holding steady for the 20 years preceding that; hopes of regaining earlier behaviors might have driven some of the desire for dedicated carpool lanes. But surprisingly, occupancy rates for work trips, despite a small upward blip in 1970, have never been particularly higher than they are now.

The large decline in occupancy rates since 1970 is due to decreases in occupancy for shopping and other types of trips. This in turn stems to a large extent from two sources. First, through 1970 there were substantial numbers of adults (elderly and women) who could not drive or were discouraged from doing so. These adults provided a "captive audience" for non-driving modes, including carpooling (and walking and transit). Second, the post-war baby boom generated a large number of children, most of whom were still at home, riding as passengers with their parents (and raising non-work trip occupancy rates) through 1970, but driving their own cars as adults (and with fewer children as passengers) by 1990.

Unfortunately, we do not have data on mode choice by age groups for time periods before 1990, so it is impossible to calculate directly how much of the observed change is due to demographic shifts and how much to actual changes in behavior on the part of individuals. It is interesting, nonetheless, that children account for more than half of all trips as auto passengers (10,000 of 18,500 such trips in the TBI data). And given that children are only 23% of the regional population now, compared with 33% in 1970, it seems likely that this demographic change might be responsible for a substantial part of the recent decline in overall auto occupancy.

A final point of interest is how much of the "carpooling" observed in the data is actually made up of members of different households, who might be influenced by incentives, as opposed to members of the same household, who presumably would likely travel together anyway. It is possible to determine this: when two members of the same household make a trip from the same origin to the same destination, at the same time, one as a "driver with passenger" and one as a "passenger," then they can be safely assumed to be traveling together. Looking at only adults, 64% of trips as "passenger" were made with a member of the same household. It could be objected that this is including shopping and other trips, and that work trips would be more likely to include actual two-household "carpooling." But restricting the time period to morning rush hour (which presumably eliminates most recreational trips) does not change the rate at all. A substantial majority of "carpooling," even for work trips, is made up of members of the same household.