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Reasons for Recent Large Increases in Commute Durations

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Commute durations in Minnesota increased by about two and a half minutes on average during the 1990s. Given earlier evidence suggesting that commute times remain fairly stable over time, this was a surprisingly large increase. The research described in this report was undertaken to try to identify reasons for this increase, and, specifically, for why it happened when and where it did.

Growth in commute durations does not appear to have been significantly driven by land use or economic factors. Commutes grew slower in the Twin Cities and other urban counties than in the rest of the state, despite congestion and land use changes in these areas. And overall there was little correlation between economic factors and the rate commute growth, especially outside the Twin Cities area.

Some of the increase seems to be due to a change in methodology in the 2000 census. Adjusting for this, the overall commute time increase in the 1990s (11%) was slightly larger than in the 1980s (7%) because in the 1980s travel speeds statewide increased slightly, offsetting longer distances to some degree. Because speeds statewide remained constant in the 1990s, all the increase in distance was reflected in longer travel times.</td></tr>
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Reasons for Recent Large Increases in Commute Durations

Final Report

Prepared by:

Gary Barnes

University of Minnesota
Hubert H. Humphrey Institute of Public Affairs

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395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

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Given the very large number of calculations that went into this research, it seems almost inevitable that there are probably mistakes in the final report. They are, of course, the sole responsibility of the author.

Executive Summary

Commute durations in Minnesota increased by about two and a half minutes on average during the 1990s. Given earlier evidence suggesting that commute times remain fairly stable over time, this was a surprisingly large increase. The research described in this report was undertaken to try to identify reasons for this increase, and, specifically, for why it happened when and where it did. That is, many underlying factors changed during the 1990s in terms of land use, economy, and so on, but these kinds of changes have been going on for decades, and there was no compelling evidence that the 1990s in particular were different in this regard. Furthermore, congestion and sprawl are typically offered as reasons for increasing commutes, but in the 1990s all counties saw increases, and the urbanized and "collar" counties of the state had among the smallest increases.

The research described in this report uses a number of different data sets and analytical techniques to understand why commute durations increased so much during the 1990s, and why they increased even in non-metro areas. The report is organized into a sequence of chapters that build on each other. The early chapters are focused more on simply documenting what happened, in order to be clear about the facts that need to be explained. Later chapters then explore different possible explanations, such as land use changes, lower speeds, and rising incomes. The answer ultimately is built upon a number of points developed in these chapters:

- Historically, commute times increased before 1990, although not as fast. The growth in commute durations since 1990 should thus be seen as an acceleration of an existing trend, rather than a complete departure from the past. In the 1980s commutes increased about one minute; in the 1990s the increase was about two and a half minutes. However, the median, or fiftieth percentile commute duration was essentially constant during the 1990s. The increase in the average appears to be due to a few trips becoming much longer, rather than a small increase for everyone. Since 2000, the rate of growth in commute times has reverted to the earlier pace of about one minute per decade.
- Land use and economic fortunes do not appear to have played a major role in rural Minnesota. While there were differences in population and job growth, wages grew at about the same rate everywhere, and changes in commute durations were not strongly correlated with these economic factors, especially outside of the Twin Cities area.
- In the Twin Cities area, changes in job locations actually tended to areas with shorter commutes, and the change in the geographic distribution of homes would have added only about twenty seconds to the overall average. Thus "sprawl" seems to have had a negligible impact.
- Looking at the location of destinations between 1980 and 2000, it appears in the state as a whole that the distance of the average commute increased about 10% in both decades. Implied speeds (shortest point-to-point distance divided by reported travel time) increased slightly in the 1980s and held steady in the 1990s.

- In the Twin Cities, two different analytical methods and data sets give the same result; that average commuting speeds decreased about 4%, and average trip distance increased about 4%, for a total roughly 8% increase in commute durations. Since land use changes alone had a very minor impact, most of the increase in distances here, as in the rest of the state, is due to people choosing more distant job locations, even though jobs as a whole were located at least as conveniently as before.
- At a given point in time, higher wages are strongly and almost linearly associated with longer average commute durations. Thus the growth of wages over time might tend to increase commute durations. Given wage growth, which was similar in both decades, this phenomenon would explain about one minute of growth in a decade. This explains essentially all the growth in the 1980s and since 2000, but less of the growth in the 1990s.
- The faster growth in the 1990s appears to be due in some part to a change in how commute durations were recorded in the 2000 census; using a similar methodology to 1990 would have reduced the average commute in Minnesota by 0.7 minutes.

When this adjusted figure is used, the growth in commute durations in the 1990s was about 11% statewide. In the Twin Cities area the adjusted increase was about 8%, and was about half due to longer distances and half to reduced speeds. Outside the Twin Cities, the adjusted increase was about 13%, and here larger growth in distances was slightly offset by a small increase in speed.

In the state overall, average speeds remained constant. Thus the overall commute time increase in the 1990s (11%) was slightly larger than in the 1980s (7%) because in the 1980s travel speeds statewide increased slightly, offsetting the longer distances to some degree. Because speeds remained constant in the 1990s, all the increase in distance was reflected in longer travel times.

The report is broken into a sequence of chapters addressing each of the above bullet points. Three appendices discuss first, the data sets used and their limitations, second, a division of the metropolitan area into zones that is used in some of the geographic analysis, and third, the total daily travel time in the Twin Cities and its relationship with commute durations.

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1 Introduction

Commute durations in Minnesota increased by about 2 ½ minutes on average during the 1990s (1). In the past overall daily travel times, and by extension, commuting times, have appeared to grow slowly, if at all in this region (2). Similar outcomes have been observed in other areas, and at least one researcher has postulated that people implicitly choose home and work locations in part to maintain a stable range of commute durations (3). Given this background, the increase in the 1990s was surprisingly large; even the census bureau notes the striking departure from past trends (4). The research described in this report was undertaken to try to identify reasons for this increase, and, specifically, for why it happened when and where it did.

There are many plausible explanations for why commutes would get longer in a given location, but none of them explains the two basic problems that this research is focused on. The first point is that the increase happened everywhere (in 258 of 258 counties in a three-state area), not just where certain conditions were met. The second is that the increase was so large in this one decade even though most of the apparent causes have been in place for a long time. The following points detail the inadequacy of the conventional explanations, and describe the general themes that this research addresses.

- Commutes increased by very large amounts in every single county in Minnesota (and every county in Iowa and Wisconsin as well), not just in urban areas. Thus the conventional explanations of congestion and urban sprawl have only limited explanatory power.
- The urbanized counties in Minnesota had relatively small increases compared with the rural parts of the state. Congestion and sprawl seem to have had a limited impact even in these places.
- While plausible explanations can be offered for increasing rural commute times, such as a declining farm economy and increasing job concentration in regional centers, these things have been going on for decades. Thus while they may explain part of the increase, they don’t explain why the increase was so large in this one decade.
- Explanations based on local conditions, and that vary from one location to another (job loss in one area, congestion in another), also aren’t consistent with the universal increase observed here. If certain conditions lead to longer commutes, then the opposite conditions should lead to shorter commutes (or at least lower growth rates), yet commutes grew substantially everywhere.

The research described in this report uses a number of different data sets and analytical techniques to understand why commute durations increased so much during the 1990s. Different techniques are used, and different explanations explored, for the Twin Cities area. The early chapters of the report are focused primarily on documenting what happened, in order to be clear about the facts that need to be explained. Later chapters explore different possible explanations, such as land use changes, lower speeds, and rising incomes. The overall sequence of the logic is the following:

- Documenting commute durations in three states over a 25-year span. This helps to establish how Minnesota in the 1990s fits into a broader perspective, both temporally and geographically.
- Examining the changes across Minnesota counties in the 1990s, and relating these to economic and demographic changes.
- Analyzing the impact of land use changes on commute durations in the Twin Cities area.
- Relating changes in commute durations to changes in speed and distance traveled, for both the Twin Cities and Minnesota as a whole.
- Analyzing the relationship between income and commute durations, and how much of the increase in commutes can be explained by rising incomes.

There are three appendices to the report. The first discusses the various data sets that were used, and the limitations of them that impacted the analyses in this research. The second appendix describes a simple geographic division of the Twin Cities metro area into large zones; this was used in some of the metro-based analysis. The final appendix is a related paper that documents how total daily travel time in the Twin Cities changed between 1990 and 2000, how this change breaks out between commuting and non-work travel, and how mode choice impacts total travel time and automobile travel time.

2 Historical Analysis, Three-State Area, 1980-2005

Although the primary question of this research was the large increase in commute durations in Minnesota between 1990 and 2000, it eventually came to seem that there might be value in expanding the scope to consider two other sources of information. First, how neighboring states compared: if commute times evolved in a different way in Iowa and Wisconsin, the differences might help provide some insight into what happened in Minnesota.

The second expansion was to look at what happened in the previous decade (5). The idea of going back to 1980 was to explicitly examine the assumption that commute times had been stable until the 1990s. The appearance of stability noted in past studies may have been due to a focus on metropolitan areas, where commutes might have grown more slowly because of transportation improvements and land use changes.

The intent of this chapter is simply to document what has happened; to establish a factual baseline that can serve as the subject of investigation in subsequent chapters. This is actually not a trivial problem due to apparent inconsistencies among the various data sources. However, a broad pattern does emerge, and one that is quite consistent across all three states.

Average commute times in all 3 states increased by around one minute during the 1980s. The corresponding increase was around 2.5 minutes during the 1990s. However, subsequent analysis by the census bureau indicates that some of this increase was due to a change in how very long commutes were recorded in the 2000 census (6).

In 1980 and 1990, the maximum recorded travel time was 99 minutes. This was done to save computer resources, as an additional digit would have substantially increased data storage and processing costs given the technology at the time. Thus any commute that was reported by the respondent as 100 minutes or more was recorded as 99, and mean commute values were calculated based on this. In 2000, computer resources were less constrained, and times could be recorded with three digits. In this census, the maximum recorded time was 200 minutes. An exercise by the census bureau to calculate mean commute times using the old standard of a maximum 99 minute commute showed that in the three states we study, the average would have dropped by 0.7 minutes in each state using the old method (6). The state averages reported in the table below use this adjustment to how the average changed using a constant methodology.

So while the increase in the 1990s was larger than in the 1980s, it was not that much larger, especially given that it was in fact starting from a historical baseline of increasing commute durations, rather than the constancy that earlier research had indicated (Tables 2.1a-2.1c).

Table 2.1a: History of Commuting in Minnesota

	1980	1990	2000	80-90	90-00
State average commute	17.9	19.1	21.2*	7%	11%
Average of county means	15.0	16.6	20.3	11%	22%
State median commute	n/a	18.2	16.0	n/a	-12%
Ave. of county medians	n/a	14.2	14.4	n/a	1%
Highest county	26.5	30.0	32.6	13%	9%
Lowest county	9.7	10.2	13.0	5%	27%

Table 2.1b: History of Commuting in Wisconsin

	1980	1990	2000	80-90	90-00
State average commute	17.1	18.3	20.1*	7%	10%
Average of county means	16.2	17.9	20.8	10%	16%
State median commute	n/a	17.0	15.7	n/a	-8%
Ave. of county medians	n/a	15.6	15.9	n/a	2%
Highest county	20.5	23.1	28.0	13%	21%
Lowest county	12.5	12.8	15.0	2%	17%

Table 2.1c: History of Commuting in Iowa

	1980	1990	2000	80-90	90-00
State average commute	15.4	16.2	17.8*	5%	10%
Average of county means	14.7	16.2	18.8	10%	16%
State median commute	n/a	14.8	15.2	n/a	3%
Ave. of county medians	n/a	13.7	13.6	n/a	-1%
Highest county	23.1	24.8	27.0	7%	9%
Lowest county	9.7	11.4	13.0	18%	14%

* 2000 averages adjusted for consistency with 1980 and 1990 coding practice; i.e., trips of 99+ minutes are coded as 99. This led to a reduction of 0.7 minutes in all three states, as calculated by the census bureau.

There are three points in Tables 2.1a-c that are particularly important to this analysis. First, while mean commute times did increase considerably during the 1990s, the increase during the 1980s was not trivial. This indicates that an upward drift in commute times may be the rule rather than the exception, and that the 1990s perhaps represented an acceleration of an existing trend rather than a complete departure from the past.

The second important point is that the median commute times hardly changed at all during the 1990s (median times were not reported in the 1980 census). This indicates that the increase in the average is coming from more and longer commutes at the high end of the range, rather than from an across-the-board increase. The 50% of people with the shortest commutes are not going any longer than they did in 1990, but the top 50% have a much higher average.

Finally, all three states saw similar patterns of commute growth: 5-7% during the 80s, and 10-11% in the 90s, despite very different baseline levels, degree of urbanization, and so on. The change, in other words, was not something specific to Minnesota.

A final step in documenting how commutes have changed over time is to examine what has happened since 2000. It is possible to do this using the American Community Survey (ACS), which is intended to replace the census long form (7). The ACS has asked census transportation-related questions on an annual basis since 2000. This data source is discussed in more depth in Appendix A.

Table 2.2: Commute durations since 2000

	Minnesota	Wisconsin	Iowa
2000 Census*	21.9	20.8	18.5
2000 ACS	21.7	20.1	17.7
2005 ACS	22.2	20.8	18.4

* For comparability with the other surveys in this table, 2000 census averages do not include suppression of long commutes to 100 minutes as was done in Table 1.

While the specific numbers vary, growth in commute durations is roughly in the range of half a minute for all three states during the 2000-2005 time frame. Expanded over a full decade, this would be about the same growth rate as was observed in the 1980s, and slightly slower than the 1990s.

One puzzle is the difference between the census and the ACS. In comparing the 2000 census to the 2005 ACS, it appears that there has been no growth in commute durations at all in the last five years. However, this appears to be because the ACS started in 2000 at a lower level than the census of that year. It is not clear why the two surveys would have a different average commute duration for the same year, and indeed a fairly substantial difference in two of the three states. Individuals at the census speculate that there may be differences in the sampling for the transportation-related questions, but there has been no formal research undertaken to address this question. However, given that there is such a difference the comparison of the 2005 ACS to the 2000 ACS seems like a better method for describing commute growth since 2000 (6).

3 Minnesota Counties in the 1990s

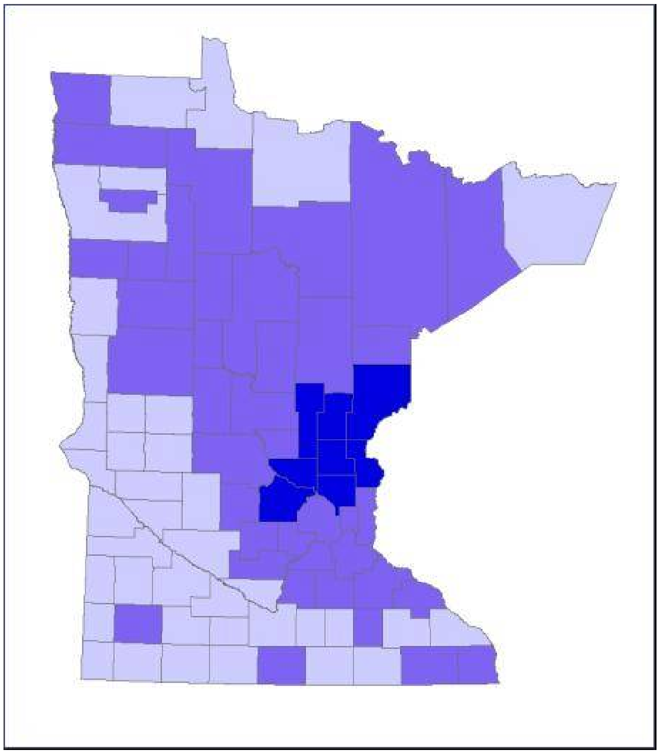
Every county in Minnesota experienced increased average commute durations in the 1990s. Commuting has typically been discussed in the context of urban areas, where traffic congestion and the spreading out of origins and destinations have typically been seen as the reasons behind longer commutes. However, it seems unlikely that these factors could have been of much importance in the roughly 85% of counties that do not have significant urban development. In fact, in terms of percent increase, the seven Twin Cities metropolitan counties were all among the bottom 12 in the state, with other urban counties in the same range. The “collar” counties of the Twin Cities have very long commutes, but did not have particularly big increases during the 1990s.

An intuitively plausible explanation for increases in rural commute times is that changing economic conditions force rural and small town residents to commute to more distant towns to find work. Over time jobs have tended to concentrate more in cities and larger towns, while smaller towns have often stagnated or become more residential in nature. Thus the rural increase could be due to commuting away from economically “losing” areas and toward those places with higher job growth rates. However, these kinds of economic changes have been going on for decades, so again it is not clear why there would have been such a large impact on commuting in this one decade.

This section examines the entire state at the level of counties, to try to understand first, why commutes in some counties increased much more than others, and second, why all counties increased by a considerable amount by historic standards. The general focus is on economic and demographic factors; that is, shifting patterns of jobs and population.

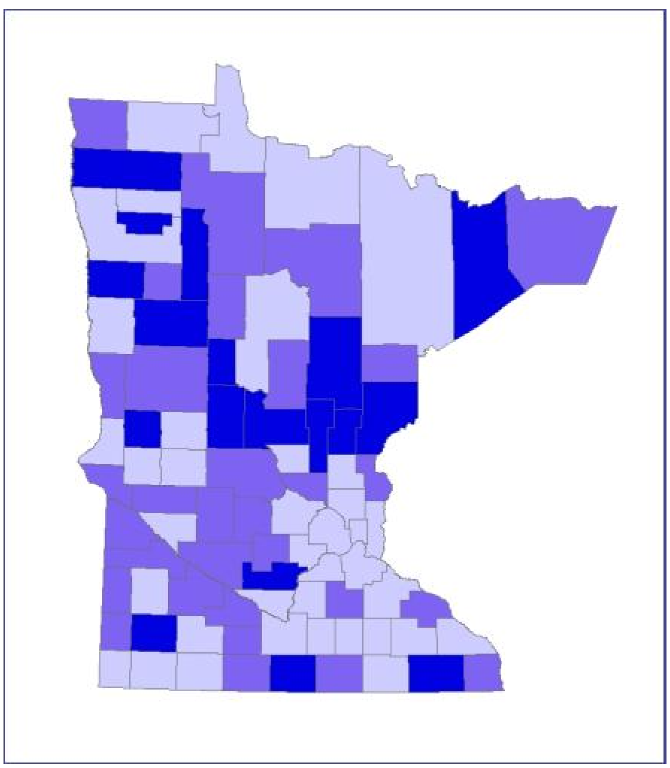
The longest commutes in the state are in the counties just north of the Twin Cities metro. These counties are more appealing scenically and recreationally than those in other directions that might be equally close to the center of the urban region, and have had the longest commutes in the state since at least 1980, when this was first measured. Mean commutes in these counties are in the range of 26 to 33 minutes. The shortest commutes are in southwestern Minnesota, and range from 13 to 19 minutes. The rest of the state, including all the Twin Cities metro counties and most of the counties in the northern part of the state, are in the range of 19-25 minutes (Figure 3.1).

The growth in commute times during the 1990s is more randomly distributed. Many of the biggest increases were in the “lake” counties 80 miles or more north of the Twin Cities area. Other counties with big increases were scattered seemingly randomly around the state, in many cases intermingled with counties with very small increases. Counties with small increases were concentrated in the Twin Cities metro and south of there, with others again scattered randomly around (Figure 3.2).



From lightest to darkest:
13.0-19.0 minutes
19.1-26.0 minutes
26.1-33.0 minutes

Figure 3.1: Mean commute durations in 2000



From lightest to darkest:
1.5-3.0 minutes
3.1-5.0 minutes
5.1-8.0 minutes

Figure 3.2: Increase in mean commute duration, 1990-2000

One plausible theory for explaining commute growth in rural areas is that increasing job concentration in regional centers forces long commutes, as jobs move away from smaller towns. One problem with this theory is the point noted above, that counties with big commute growth are juxtaposed with counties with small growth, even when the counties involved are equally distant from regional centers. If the problem were a declining farm economy and related changes, then it shouldn't have such a random impact. Also, even regional centers have increased commute times. However, if the increases were smaller in places with relatively rapid job growth, this would lend some support to this theory.

Table 3.1 shows the rate of growth in various economic measures relative to growth in commute times during the 1990s, for counties in Minnesota.

Table 3.1: Commute Durations and Economic Conditions

County Percentage Growth in:	Correlation with Growth in Mean Commute Duration	Correlation with Twin Cities metro counties excluded
Population	-0.43	-0.32
Resident Workers	-0.27	-0.20
Number of Local Jobs	-0.34	-0.25
Median House Price	0.10	0.08
Median Household Income	0.33	0.27
Average Wage for Local Jobs	-0.04	-0.02
Local Jobs per Local Worker	-0.22	-0.15

A correlation coefficient measures the extent to which relatively high levels of one variable occur in conjunction with relatively high values of another variable. The range is from negative one to one. A value of negative one means that high values of one variable are always associated with low values of the other, zero means high and low values of the two variables happen with no relationship at all, while positive one means that high values occur with high values.

So the first three lines of Table 3.1 indicate that rapidly growing counties tended to have relatively smaller increases in commute durations. This may make sense as these places have a lot of new opportunities that could provide shorter commutes for some residents. However, the relatively high correlation of low commute growth with high population growth seems odd. One would usually think that rapidly growing places are being settled by people with existing jobs elsewhere, thus high population growth should be associated with high, not low, growth in commute times. It could just be that this phenomenon is not captured at the level of an entire county, where population and jobs tend to grow at roughly the same rate.

Another consideration with regard to Table 3.1 is that the Twin Cities counties were among the fastest growing, and had among the lowest commute growth. If part of the point here is to understand commute growth in the rest of the state, there might be something to be learned by excluding the Twin Cities counties from this analysis. When these seven (out of 87 total) counties are excluded, all the correlations drop by about one third, so that for example, the correlation between commute growth and jobs per local worker drops from 0.22 to 0.15. Thus the impact of local economic conditions seems to be even less important in the rest of the state.

A more problematic result is that the two variables that intuitively should be the most important show rather small correlations with growth in commute durations. The growth in the wage rate for local jobs, which could be considered a measure of the attractiveness of local jobs, shows no correlation at all with growth in commute times. Similarly, growth in jobs per resident worker, which measures whether local opportunities are becoming more or less plentiful relative to the competition for them, shows a very low correlation with growth in commute times.

One problem with this approach is the simple statistical point that the sample sizes on which the average commute estimates are based can be quite small. About a quarter of all the counties have fewer than 5,000 commuters, which means that only 500 or so would have been sampled by the census. If 20 or 30 of these had very long commutes, this could substantially affect the average, and it would be impossible to know if this was a reflection of reality or just a sampling aberration. A way around this is to consider only the counties at the ends of the range, that is, those with the largest and smallest increases. Because the total range was quite large, this approach helps guarantee that the observed differences in commute durations are real and not just an artifact of sampling error (Table 3.2).

Table 3.2: Comparison of Lowest and Highest Ten Counties

County Percentage Growth in:	Lowest Ten Counties	Highest Ten Counties	State Average
Mean Commute Duration	10%	41%	23%
County Population	23%	-2%	8%
Resident Workers	28%	10%	19%
Number of Local Jobs	39%	15%	26%
Local Median House Price	88%	83%	95%
Local Median Household Income	51%	63%	60%
Average Wage for Local Jobs	48%	46%	47%
Local Jobs per Local Worker	9%	4%	6%

The 10 counties with the smallest commute time increases are not much different than the 10 with the largest, aside from the overall population and job growth rate. It seems significant that both housing prices and wages grew at about the same rate in both sets of counties, indicating that while rates of development may have differed, broader economic conditions were about the same in both areas. Similarly, the number of local jobs per local worker grew faster in the areas with smaller commute increases, but the difference was relatively small compared with the difference in commute growth. These results make it hard to build a convincing case around a theory of disappearing local opportunities forcing long commutes.

It is interesting to note the names of the ten counties with the smallest percent increases in commute durations; they include (not in order): Scott, Dakota, Anoka, Washington (Twin Cities suburbs), Hennepin and Ramsey (Twin Cities central), Isanti and Wright (Twin Cities exurbs), Olmsted (Rochester metro), and St. Louis (Duluth metro). The one remaining Twin Cities suburban county, Carver, ranks twelfth, just behind Sherburne, another Twin Cities exurban county. This indicates that the impact of congestion and urban sprawl may be less significant than is commonly believed.

A possible criticism of this approach is that it is too geographically narrow. Because people are not restricted to working in the county in which they live, the commuting patterns in a given county will not just depend on economic and demographic conditions in that county, but on conditions in surrounding counties as well, potentially to a very long distance away. While this is easy to grasp in principle, it is quite hard to come up with a robust way to operationalize this idea in a way that admits of quantitative analysis.

A simple example of the concept can be seen in the counties just north of the Twin Cities metro area. Wages in Isanti or Sherburne counties, for example, are not low compared to most places in Minnesota, and while there are relatively few jobs per worker, there are many other counties in the same range. So viewed in isolation these factors don't seem to explain much of the very long commute durations in these counties. However, wages in Hennepin County are substantially higher, and the differential is large enough relative to the distance to be traveled that a considerable number of residents of these counties choose to commute long distances into the metro region proper (and indeed probably had these jobs when they moved to these outlying areas in the first place).

Thus a given county may have changed in ways that would be expected to reduce commute times, such as an increasing job to worker ratio, but these changes could be trumped by conditions in some neighboring or even more distant county. In this context it is interesting to note that while the counties north of the Twin Cities had the longest commute times, they did not have particularly high growth in commute times during the 1990s. Isanti and Chisago counties have had the longest commutes in the state since at least 1980. The counties with really big commute time growth since 1980 are Pine and Kanabec, which are even farther north. This seems not a matter of suburban sprawl but of people commuting from their lake cabins.

Given the desirability of a larger geographic focus, another way of looking at this issue is to consider flows between counties. If the primary force is differentials in economic conditions, then cross-county flows should tend in certain directions and not in the reverse. In other words, if people are commuting from county A to county B to find better job conditions, or because housing is cheaper in county A, then there should not also be people commuting from county B back to county A, where presumably conditions are worse.

Generally, however, while the direction of commute flows tends toward regional centers, the trend is not that strong. For example, Washington County, on the east side of the Twin Cities metropolitan area, sends 60% of its resident workers to Hennepin, Ramsey, and Dakota Counties to the west. But, it also imports 25% of workers for its jobs from those same counties, and another 12% from other Minnesota counties to the north and south, which are also flows away from the center of the metro rather than toward it. Only 12% of its workers come from farther from the center of the metro area, in Wisconsin.

Compared to 1990, in 2000 almost all counties exported more of their resident workers to jobs in other counties, while simultaneously importing more workers from other counties to fill local jobs. And to a large degree, the imported workers are coming from exactly the same counties that the exported residents are traveling to (Table 3.3).

Table 3.3: Commuting Cross-Flows

	2000	1990	1980
Total resident workers	2,541,871	2,148,531	1,714,460
Destination in Minnesota	2,490,004	2,115,714	1,693,572
In home county	1,685,798	1,533,077	1,324,480
Out of county	804,206	582,637	369,092
Crossing flows	429,112	316,880	202,290
% Destination in Minnesota	98%	98%	99%
% In home county	68%	72%	78%
% Out of county	32%	28%	22%
% Crossing flows	53%	54%	55%

This table shows the growth in cross-county commuting since 1980. To some extent this probably reflects the growth of the Twin Cities area, where the extent of the built-up area means that a large fraction of the population and jobs are close to county lines. However, even many more rural counties show similar increases.

Another interesting point is the degree of “crossing flows.” Here this means the minimum of the flow in either direction between any two counties. For example, if ten people commute from A to B, and six commute from B to A, then twelve of the total commuters between these counties are crossing flows (six from A to B and six from B to A) while four are net one-directional traffic. Currently more than half of the total cross-county flow is offset by other commuters traveling in the opposite direction between the same two counties, and this has been the case since at least 1980. This indicates that while there may be more commuting to other counties, that the degree to which this flow is going in a single direction toward regional centers is no greater than it has been in the past.

Overall, the above evidence leads to the conclusion that economic conditions such as job and wage growth may explain some of why commutes increased more in some counties than in others. However, the flows are far from one directional, so the full explanation must include something besides job concentration. It is also the case that jobs have been concentrating in larger cities for decades, so this doesn't explain why commutes increased so much in this one decade. Changing economics might explain why commutes grew faster in some places than in others, but don't explain why the average county across the whole state increased by about two and a half minutes.

4 Commuting in the Twin Cities Area

This section focuses on changes in land use and commuting patterns in the Twin Cities area specifically. Generally commuting in urban areas is thought to be influenced by different factors that in rural places, and the greater amount of geographic detail available makes it possible to analyze these issues to some extent.

Increasing commute durations in urban areas are often thought to be caused by two primary factors. The impact of what could be called urban sprawl is that average commutes increase because people and jobs move from areas where commutes are short to places where they are long. Thus, even if commutes remain stable at each location, the gradual movement from short-commute locations to long-commute locations will pull the average up over time. The second common explanation is congestion, which is obviously just the possibility that a given point-to-point commute will take longer as traffic gets worse, and thus that commutes will take longer even if home and job locations don't change.

This chapter focuses on the first of these two explanations; that is, changes in home and job locations. Addressing the question of travel speeds requires a different methodology and data set, and is more enlightening in the context of travel speeds statewide, so this issue is tackled in a later chapter. A third possible explanation for longer commutes is that people are simply choosing to travel to more distant jobs, independent of any changes in where homes and jobs are located in general. While in theory it should be possible to address this question directly by comparing flows at the two times, in practice a large fraction of flows are suppressed due to confidentiality restrictions. Because of this, a direct comparison is impossible, and it is necessary to rely on indirect methods. Some of the information below is relevant to this question, and it will come up again in a later chapter on travel speeds.

4.1 Change in Commute Duration by Location

The first step in this analysis is simply documenting how commute durations changed in the region during the 1990s. A simple and intuitive way to do this is to compare commute durations for workers based on how far they live from the center of the region, defined here as the distance to the closer of the two downtowns (Table 4.1).

Table 4.1: Increase in Commute Durations by Distance from Downtown

Home location, distance from nearest downtown	1990 mean commute (minutes)	2000 mean commute (minutes)	Increase (minutes)	Percent increase
0-4 miles	17.9	19.5	1.6	10%
4-6 miles	18.0	19.7	1.7	9%
6-8 miles	18.1	20.2	2.0	11%
8-10 miles	18.6	20.6	1.9	11%
10-13 miles	19.4	21.2	1.7	9%
13-16 miles	21.1	22.4	1.3	7%
16-20 miles	22.1	23.8	1.6	8%
20-25 miles	23.1	25.5	2.4	10%
More than 25 miles	25.6	27.5	1.9	7%

A related way of dividing the region is to compare areas at different stages of development, as defined by the Metropolitan Council (Table 4.2).

Table 4.2: Increase in Commute Durations by Distance by Development Style

Development Pattern	1990	2000	Increase	Percent increase
Central City	18.1	19.8	1.7	9%
Developed Suburb	18.2	20.0	1.8	10%
Newly Developing Suburb	20.9	22.6	1.7	8%
Rural/Exurban	24.1	26.3	2.2	9%

A striking point about both of these tables is the consistency of the increase across the region. When looking at the distance of the home from the nearest downtown, with the exception of a single outlier at each end, every ring had an increase between 1.6 and 2.0 minutes; the percentage increase was between 7% and 11% everywhere. In looking at larger areas based on development styles, the percent increase ranged from 8% to 10%. Whatever was happening, was happening in almost exactly the same where everywhere, it seems. This could point to traffic congestion as the issue.

An even more detailed way of examining changes is to break the region into small, geographically focused units rather than rings, which include a variety of places that can be very far apart. Earlier studies by the author have used a set of 66 zones described in Appendix B, which correspond roughly to city boundaries, with some smaller cities and rural areas combined, and some larger cities broken into a number of zones.

A map of these zones becomes confusing due to the divergence of outcomes and the small size of some of the zones. A verbal description in this case is more helpful. As with counties, there is a range of outcomes, and random statistical error makes it risky to place too much weight on specific numbers. But again, it is interesting to compare the ten zones with the biggest commute time increases to the ten with the smallest, to see if any geographic pattern emerges; a large impact of congestion might cause increases to be concentrated in certain parts of the region.

The overall distribution of the 66 zones is that roughly one third are entirely inside the I-494/694 beltway, about one third are adjacent to the beltway, and about one third are entirely outside. Of the ten zones with the smallest commute time increases, four are inside the beltway, four adjacent, and two outside. Of the ten zones with the biggest increases, five are inside, two adjacent, and three outside.

The zones with the smallest increases included three southwestern suburban areas where congestion is among the most severe and sprawl is a major force. Zones with very large and very small increases are interspersed seemingly at random in the two central cities, and indeed throughout the entire region. This may be an artifact of small sample sizes to some extent, although these zones have fairly large populations. In any case, location and land use don't seem to have had a consistent effect. There is no place where there is a large area with increases that are consistently above or below the average.

Generally, outlying areas have longer commute times than more central areas. But this has always been the case. In examining the growth in commute times, as opposed to the level, there seems to be no relationship at all. The correlation between 1990 commute times and the amount of increase during the 1990s is just 0.10, or essentially none. Places with low starting times were just as likely to see large increases as places with high starting times. A map of changes confirms the lack of any clear relationship between location and level of increase.

4.2 Population and Job Movement Impact on Commute Durations

To analyze the impact of population and job movements requires three steps. The first is controlling for other reasons for increase; this is simply a matter of using the 1990 average commutes for each location. The point here is to negate the impact of congestion and other factors by imposing a constraint that the average commute length in each location did not change, and that the only thing that did change was whether people lived or worked in high commute or low commute locations. The second step is determining how the distribution of population and jobs changed over the period in question. We accomplish this by using a type of dissimilarity index, as described below. The third step is calculating the difference in commute durations between the places that are the net gainers and those that are the net decliners.

A dissimilarity index essentially compares two places or groups of people (or in this case, the same place at two points in time), by calculating the percentage of people in one place that would have to be moved to achieve the same geographic distribution as the other place. For example, if in 1990 there were 10 people in zone A and 10 in zone B, and in 2000 there were 15 in A and 25 in B, then to get back to the original distribution would require moving 5 people from B to A, or 12.5% of the total of 40 people. This gives a general sense of how much different the region really looks.

For Twin Cities commuters, the dissimilarity index of 2000 home locations compared to 1990 is 10.2%, comparing the two times at the geographic level of TAZs. That is, some TAZs grew faster than the regional average while others grew slower, but only about 10% of the population would have to be moved to get the geographic distribution to be the same as it was in 1990. This hints at the likelihood that the impact of population movements on commute durations will be limited, just because the vast majority of the population is in the same place as it was before.

A similar calculation for work locations indicates that about 21% of jobs would have to move to reach a similar geographic distribution to 1990. Some of this seems to be inaccuracies in where jobs were coded as being located; there were some cases where a zone would apparently lose a huge number of jobs, while a neighboring zone would gain an equivalent number. It could also be that in some cases tearing down an old office building and putting up a new one across the street may cause the appearance of a large number of jobs changing TAZs. Some of the change is also probably differences in growth rates; individual businesses grow and decline much more rapidly than households do. This doesn't necessarily mean that jobs are moving, but just that differences in the rates of growth can cause the geographic distribution to change over time.

One way to get a better picture of large-scale movements in population and jobs is to use a larger geographic area of analysis, such as the zones described in Appendix B. As these zones are of the size of a medium-sized suburb, small local movements will not show up but major differentials in growth rates across large areas will. In calculating dissimilarity using these larger areas, the population movement falls to 7% and the job movement drops dramatically to 8%, indicating that in fact a great deal of the apparent movement of jobs was at a small local level.

The final step in determining the impact of land use changes on commute durations is comparing the average commute durations between the areas that are the net gainers in population or jobs, to those that are the net decliners. This tells, for the 10% of commuters that are distributed differently from 1990, how much their commute went up as a result of their new location, compared to what it would have been if they had maintained the 1990 distribution. Similarly, for the 21% of jobs that are distributed differently, this tells how much longer the commutes into those jobs are because of their new location.

Using the terms "overpopulated" and "underpopulated" to refer to places that have, respectively, a higher and lower share of regional commuters in 2000 than 1990, the overpopulated zones had average commutes only three minutes longer than the underpopulated zones (22.7 compared to 19.8 minutes). This calculation uses 1990 commute times for both distributions, that is, it supposes that times stayed the same for people who are distributed in the original way. Using 2000 commute times doesn't change the results significantly, since commutes went up by about the same amount everywhere.

What this implies is that even if everyone who lives in “overpopulated” zones were forcibly moved to the original distribution, it would save only three minutes of commuting, for 10% of the commuters, or 0.3 minutes of the roughly two minute increase observed in the region as a whole. So it would appear that land use changes, at least on the residential side, actually had a fairly trivial impact on overall commute durations.

The situation is even more surprising on the job side. The TAZs that were “overpopulated” with jobs in 2000 had average incoming commute durations that were actually about 45 seconds shorter (21.0 to 21.7 minutes) than the zones that were underpopulated with jobs (relative to the original distribution). So the way in which jobs were relocated during the 1990s would have actually tended to make commutes shorter, although the small difference and the small number of jobs involved make this basically a wash. Again, using 2000 commute times didn’t change these results.

Doing these calculations using movements and average commutes at the larger zone, rather than TAZ level, does not give different results. For population changes, the average increase in commute duration is slightly longer, 3.5 to 4 minutes depending on whether 1990 or 2000 commute times are used. However, this larger increase only applies to the 7% that are distributed differently at the zonal level, so the net change is still 0.3 minutes or less. For work locations, the basic result that the 2000 distribution has a lower average commute than the 1990 distribution still holds in a zone-based analysis; again, using either 1990 or 2000 commute times.

So overall, it appears that the change in the geographic distribution of population and jobs was relatively small during the 1990s, by comparison with everything that was already in place, and that even the change that did occur would have had only a small impact on expected commute durations for the affected individuals. The fact that commute durations increased by about the same amount everywhere, despite jobs remaining equally if not more accessible, indicates that the increase must have come from either slower travel speeds, or people choosing to commute to more distant locations even though closer jobs were still as available as before. This issue is addressed in the next chapter.

5 Changes in Speed and Distance

Commute durations get longer over time because of some combination of two possible reasons; either the distances got longer or the speeds got slower. Any attempt to explain why durations got longer must consider the relative contribution of these two factors. This chapter uses two different methods and data sources to study this question in the context of both the entire state and the Twin Cities area specifically.

The available data does not make it possible to study speeds directly; speeds must be calculated as a residual of changes in distance and travel time. Travel times and flow sizes for trips between a variety of different areas were reported in the census in both 1990 and 2000. Using other data sources, it is possible to calculate either an approximate (for the entire state) or known network travel distance (for the Twin Cities area) for each of these area-to-area trips. The analysis below uses these information sources in two different ways to deduce changes in speed.

5.1 Speeds and Distance in Minnesota Counties

The simplest method for determining changes in speed would be to compare travel times between two points that are a known distance apart and see if the trip took more time or less. In practice this method is not as simple as it sounds because the reported travel times in a very large fraction of cases imply speeds that are unrealistically high or low. Even if the census commuting data is reasonably reliable on average, it is often not very reliable at the level of an individual commuter, which is what many point-to-point travel times are based on. However, there are ways around these problems, and the analysis of the Twin Cities area in the next section uses a variation on this approach.

However, in looking at the state as a whole, this method is not useable at all. The major problem is that origins and destinations are coded using different geographies, so that it becomes very hard to know the distance between the various origins and destinations, or even if the two are the same place. This is problematic because destinations that the census was unable to locate were apparently coded as being in the same geographic area as the home, leading sometimes to very large apparent increases in travel times for what should have been very short and reliable trips. (This issue arises again in the context of the Twin Cities analysis below.) Thus simply comparing common O-D pairs between the two censuses is not viable because many of the common pairs include these incorrectly coded destinations, giving the false appearance of dramatic increases in travel times.

Given these problems, it is more robust to use a more aggregate approach. In this approach, we calculate an overall average commute distance for all trips originating in a given county, and compare this with the mean reported travel time for that county. We further simplify the analysis by assuming that the general locations of homes and jobs are relatively constant over time, so that the average distance for a commuter traveling from county A to county B will be the same at one time as another. Obviously this is not going to be exactly right, especially in rapidly developing areas. However, the analysis here is not one of individual commuters, but of the average commuter. Even if a lot of new housing is built in a given area, it will usually be a small fraction of the amount of housing that was already there, so the location of the geographically average house (or job) will not change much within the span of a decade or two. The appropriateness of this assumption as a general rule is supported by the analysis of the Twin Cities area in the next section, in which the use of actual origin-destination patterns at each point in time gives almost exactly the same results as the simplified method used here.

This method assumes not only that the average commuting distance between any two counties is the same over time, but that the average distance for commutes that stay within a single county is also the same over time. Given this, it follows that the only way commute distances can increase is if more people commute to more distant counties. As will be seen in the analysis that follows, this assumption is not as implausible as it may appear on casual observation.

The LEHD data (discussed in the appendix) gives a very geographically detailed breakout (to the census block level) of the location of workers and jobs in the state (8). This combined with geographic coordinates of each census block, makes it possible to calculate the geographically average location of where workers live in each county, and where jobs are. We then use a grid distance between the two centroids to determine the average distance between housing in county A and jobs in county B for all the counties in the state.

We have county-to-county commuting flows going back to 1980. Given this, it is possible to determine the increase in distance implied by changes in these flows in each of two different decades. We calculate a state average distance by weighting the average distance for each county by the number of commuters in that county. The average speed then is the state average distance divided by the state average travel time, including the 0.7 minute downward adjustment to correct for the different 2000 methodology, as discussed in chapter 2. Table 5.1 shows the results.

Table 5.1: Commute Distance, Time, and Speed, 1980-2000

	1980	1990	2000	1980-1990	1990-2000
Average distance	8.1	8.9	9.9	10.0%	10.8%
Mean travel time	17.9	19.1	21.2	6.7%	11.0%
Implied average speed	27.2	28.1	28.0	3.1%	-0.0%

The very simple and intuitive result here is that average commute distances in the state increased by about 10% in both decades, a fact that is explained perhaps by higher incomes and increased job specialization. Longer commutes tend to be at higher average speeds, since relatively more time is on highways rather than low-speed streets. Thus in the 1980s higher speeds meant that average commute durations only increased about 7%. This trend toward higher speeds continued in the 1990s in most of Minnesota. However, in the Twin Cities area speeds actually declined slightly, as discussed in the next section. These diverging trends in travel speeds canceled each other out, so that average speeds statewide remained unchanged in the 1990s. Because speeds did not improve, all of the increase in distance was reflected in longer travel times, so that commute durations increased by a larger amount in the 1990s than in the 1980s.

5.2 Speed and Distance in the Twin Cities

Because of the greater amount of data and geographic detail available in the Twin Cities area, it was possible to calculate commute distances using actual origins and destinations rather than the simple geographic approximations used in the rest of the state. It was also possible to calculate distances between origins and destinations using actual network distances rather than a formula based on centroid coordinates.

However, the problems with small sample sizes and unreliable travel times were still an issue. The solution to this problem was to round the distance between each origin and destination to the nearest mile, then calculate the average reported travel time for all origin-destination pairs of a given number of miles separation, in each of the two time periods. So for example, we would extract all the origin-destination pairs that are six miles apart, and calculate weighted average travel times between them for 1990 and 2000 based on the reported flows at each time.

A criticism of this approach might be that the origin-destination pairs of a given distance might not be the same in the two time periods, so comparing the average travel times might not be appropriate. However, restricting the method to just those pairs that appear in both time periods does not change the results overall, and including all the data reduces the variability in the results considerably. Pairs that appear in one census but not the other typically have very small flows, so even if one pair replaces another with a different travel time, the impact on the weighted average is small. Also, there are so many pairs at each distance that there seems to be no particular bias in how the pairs change.

The results of this calculation of travel speeds based on aggregating all origin-destination pairs at each distance are shown in Figure 5.1. The consistency of the results is striking. Excluding the very low distances and a handful of outliers, the increase in travel time is about 4-6% at every distance up to 30 miles. This includes 98% of all commuters in the region. This implies that a 20 minute commute in 1990 would take 21 minutes in 2000, while a 30 minute commute would go up to 31.5. Given the overall increase in commute durations of about 11% in the region, this implies that distances also increased by 5-6%.

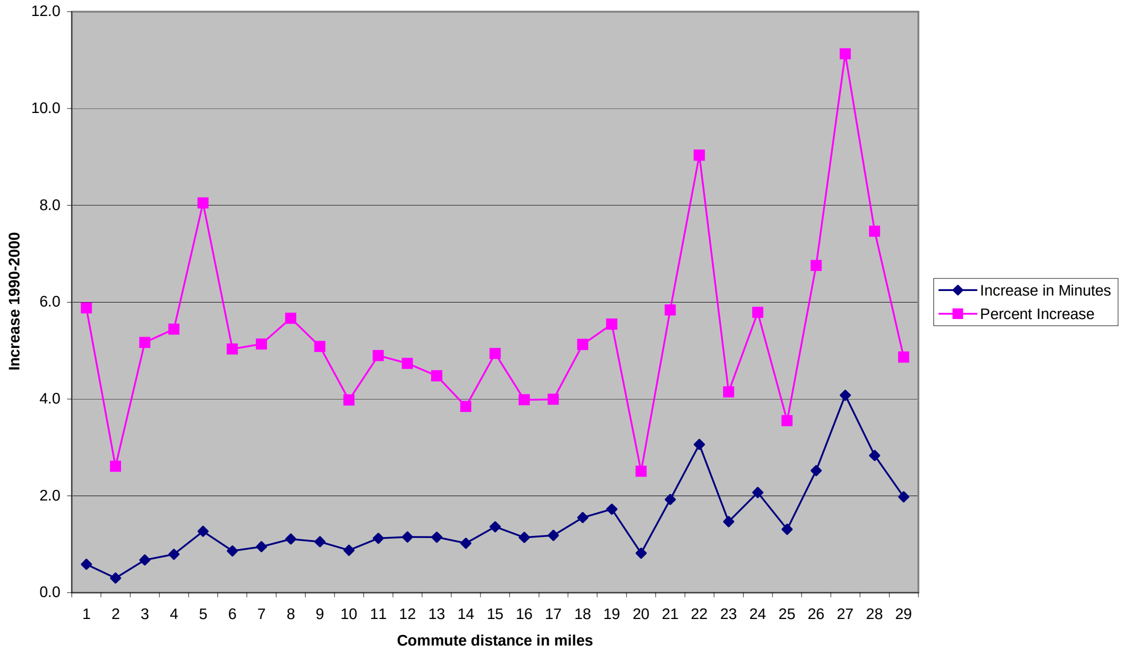


Figure 5.1: Change in commute durations in the Twin Cities, 1990-2000

The widely publicized congestion ratings put out by the Texas Transportation Institute (9) rated the Twin Cities as having 43 annual hours of delay per peak period traveler, up from 22 in 1990, but this seems overstated given these results. The TTI figure implies about 50 minutes per week or 10 minutes per day, or 5 minutes per commute, compared to about half this in 1990. This would imply that the average commuter is spending an extra 2 ½ minutes per commute because of congestion, compared to 1990. Average commute durations did go up about two minutes, which seems roughly consistent with this, but half of this appears to be due to longer distances; the travel time for a constant distance only increased about one minute or a little more on average. The increases calculated here imply about an extra 10 minutes per week for the average commuter due to congestion, rather than the extra 25 minutes implied by TTI.

It is interesting to compare these results with the methodology used to calculate distances and speeds at the state level, which used very simplified methods for determining both home and work locations, and distances between counties. When the seven counties of the Twin Cities area are extracted from that analysis, they are found to have experienced about a 5% increase in distance and a 4% decline in speeds, almost an exact match for the more detailed calculation based on actual distances and origin-destination patterns. The effect of miscoded destinations observed in the statewide analysis is probably smaller in the Twin Cities area because the true destinations are probably still within the metro area, rather than long distances away as is more likely to be the case in rural counties.

6 Wages and Commute Durations

This chapter examines a possible explanation for at least part of the ongoing rise in commute durations over time, that is, that increasing wages induce (and are induced by) longer commutes. Certainly it is true that both wages and commute durations have risen over time; however, this proves nothing, as almost all economic and demographic variables tend to get larger. This chapter attempts to establish a relationship in other ways. The first is a simple theoretic discussion of why there should be a relationship. The second is an empirical observation of such a relationship at a point in time, and a demonstration that the evolution of this relationship over time would be broadly consistent with the growth in commute distances between 1980 and 2005.

The theoretical model for a relationship between wages and commute durations is perhaps somewhat obvious. The simplest point is that higher wages make longer commutes more affordable and worthwhile; most people would be more likely to consider a long commute for a $20/hour job than for a $10/hour job, or for a four hour per day job. However, empirically it turns out there are measurable and consistent differences in average commute durations even between very small changes in wage rates, so it seems unlikely that this can be the entire explanation. It is easy to understand why people would behave differently for 20 dollars per hour rather than 10, but the empirical fact that there is a difference between $20.50 and $20 is not as easy to grasp.

A second element of the explanation goes in the opposite direction. This is that the longer commute might be driving the growth in income to some extent. If a person is offered a job with a longer commute, then the decision to take the job will probably to some extent depend on that job offering higher pay. The association with higher pay is not true in the opposite direction; a person might accept either higher or lower pay if the commute is shorter. Thus in many cases, increases in income and in commute duration are inextricably linked at the individual level.

A final explanation has to do with increasing specialization in the economy, both over time and across different wage categories. At the bottom end of the pay scale, low skill labor pays about the same everywhere and requires about the same skills everywhere; there is little reason to commute long distances to such a job if one is available locally. But at the other end, high skill jobs, while they may not be rare in the aggregate, could be quite rare at the level of the skills of a particular individual. As such, the pool of possible jobs may be few and far between, and the differentials in pay from one job to another could be quite large, depending on the specific needs of the company and the skills of the individual. Thus, on average, such a person would be more likely to have reason to commute farther than someone with less specialized skills.

The ideas provide a plausible explanation for why higher wages would be associated with longer commutes at a point in time. The evolution of this relationship as time passes is somewhat less clear. Wage growth over time can perhaps be best understood by considering the two extreme cases. At one extreme, no one ever changes jobs and all wage growth is simply raises. In this case, commute durations don't change, and over time the wage associated with a given commute time will go up, or conversely, the commute associated with a given wage will go down. At the other extreme, no one ever gets a raise, and incomes only rise when people change jobs. In this case, it might be more reasonable to suppose that the commute associated with a given wage will remain constant, and that the overall average commute will increase as people switch from lower-paying, shorter-commute jobs to higher-paying, longer-commute jobs.

While in the short term the first case is probably valid, in the longer term, such as we are examining here, the second case may be more reasonable. Certainly people tend to stay in a given job or house for some years, thus they will be earning more money while their commute doesn't get longer. But when they do change job or home location, they may at that point jump up to a higher commute time that is commensurate with their current earnings, for the reasons cited above. Wages grow for other reasons besides job and home location changes, but these changes are the decision points that determine commute durations, so the motivations at that decision point are the key.

These ideas taken together imply that not only is it reasonable to assume that higher wages would be associated with longer commutes at a point in time, but that increasing wages at the individual level would tend to be associated with longer commutes over the passage of time. The remainder of this chapter examines the empirical relationship between wages and commute durations in 1990 and 2000, and the implications for how commutes would have been expected to change over time given these relationships.

This analysis uses the Public Use Micro Sample (PUMS) data for the 1990 census and the American Community Survey (ACS) of 2000-2004. The PUMS data are the actual responses to the census questions for individuals, but with identifying information removed (10). This is an improvement over the Census Transportation Planning Package (CTPP) standard cross-tabs, in that it is possible to break income down into much finer gradients, and to calculate actual average commute durations for particular income levels. Having individual responses also makes it possible to control for the effect of possible confounding variables, such as education level, age, or urban location.

The methodology was to start with the individual's wage income (which is reported separately from other income sources), and round it to the nearest $1,000. The reported 1990 earnings were first converted into 2000 dollars by multiplying by 1.3, to account for the effects of price inflation. I then calculated the average commute duration for all people who reported a given (rounded) income level. The final step was to use regression analysis to determine a relationship between income and commute duration. I did this for Minnesota, Iowa, and Wisconsin, for both the 1990 and 2000-2004 time periods. Within Minnesota, I was able to break out the Twin Cities separately in the 1990 data.

There is one important caveat to note about this analysis. That is, that while the reported commute time is for the current job, the reported wages are the total for the previous year. There are two implications to this. First, the reported wages may not be from the job from which the commute duration is being reported. Second, the reporting of total earnings means that this variable is really representing some unknown combination of hourly wages and hours worked last year. So the analysis here is not measuring the relationship between a person's current rate of pay and their commute length, but rather the between their commute length and some measure of their longer-term relationship with the job market. Given this rather inexact comparison, the consistency of the results is even more intriguing.

One simplification that was made to the data was to condense everyone earning more than $50,000 into a single data point. The primary reason for this was that beyond this level, the sample size for each $1,000 increment became so small that the commute calculations became dominated by random noise. A secondary reason was that the average commute duration tended to level off at this point, so not much information was lost in the condensation. Finally, the earnings below this level included 80-90% or more of the wage earners in all three states, so again, relatively little information was lost by condensing these remaining data points.

The general result is that while there is variation across states, the overall relationship between earnings and average commute durations is strikingly consistent even down to the lowest income levels (Figure 6.1).

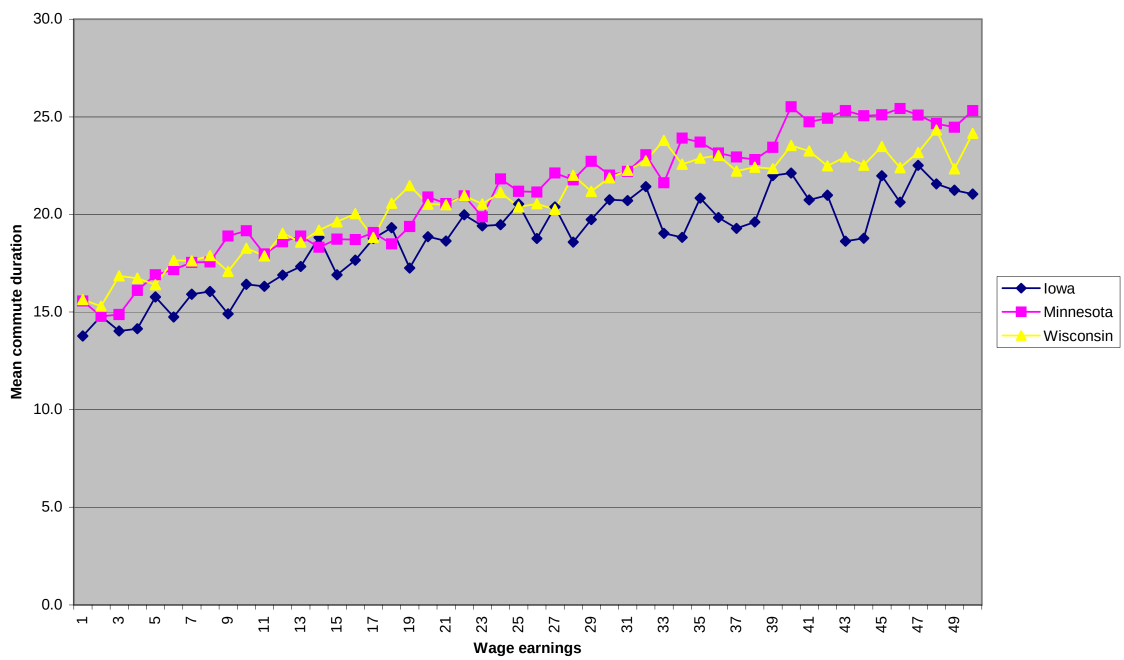


Figure 6.1: Wage earnings and commute durations in 2000

In 1990 the graph has basically the same shape, but is shifted down by a couple of minutes. That is, for a given amount of income, people were willing to commute 1.5-2 minutes longer in 2000 than in 1990 (Figure 6.2).

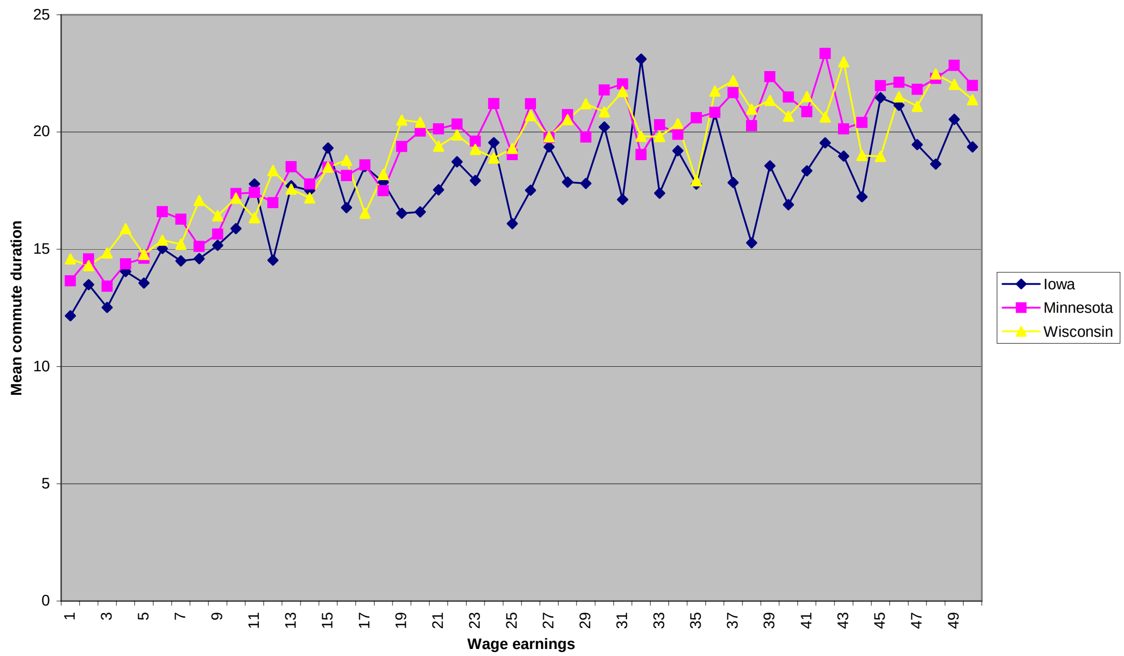


Figure 6.2: Wage earnings and commute durations in 1990 (expressed in $2000)

In all three states and in both time periods, there is about an eight to nine minute difference between the average commute duration at the lowest and highest income levels. This is not simply a matter of an accidental correlation with some other variable such as age or education. The range of variation across both of these variables is only a couple of minutes, and is not systematic; that is, the highest commute times occur at middle ranges of age and education, although earnings are higher at the upper ends.

Another possible explanation for commutes rising with income is that both variables are higher in urban areas. Given this, it could be that the higher incomes include a higher percentage of longer urban commutes, explaining why they would have a higher average commute than the lower incomes. However, this turns out not to be the case. When the Twin Cities area is broken out separately, both it and the rest of Minnesota still have commutes rising with income, although at different levels. Interestingly, the curves for Minnesota outside the Twin Cities and for the state of Iowa are almost identical (Figure 6.3).

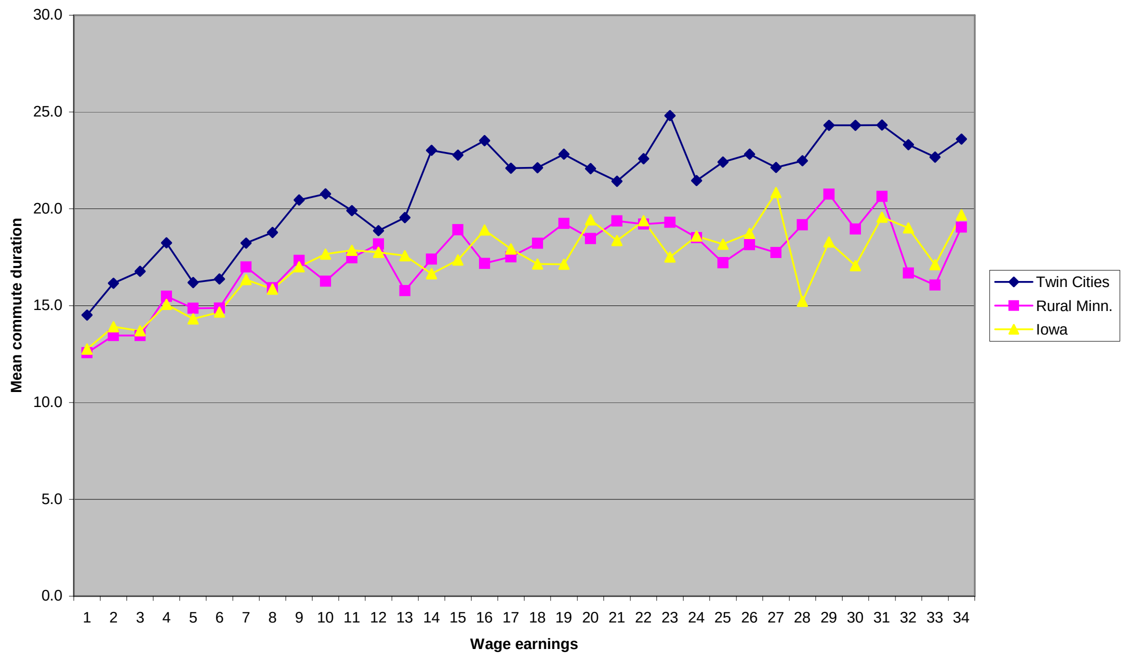


Figure 6.3: Wages and commuting in urban and rural areas

The general objective of this analysis was to try to understand impact that rising incomes would have had on commute level, given this finding that people on average commute farther when they earn more money, and that real incomes rise over time. While this explanation does appear to be consistent with some of the observed increase, there is still a good deal that is left unexplained. The most basic point in this regard is that real incomes in these states rose only slightly faster in the 90s than in the 80s, yet commute durations grew considerably faster.

Perhaps a minute of increase in each state could be explained by higher incomes; more people are in the higher income categories with longer average commutes, bringing the overall average up. However, an equal if not more significant force can be seen by comparing the 1990 and 2000 graphs. For all three states the line as a whole seems to have shifted up by 1.5 to 2 minutes; that is, even for people at the same income level, the average commute is longer in 2000. Thus there may be something besides simple income growth that is causing commutes to be longer. However, it is possible that some of this may simply be due to differing methodologies between the different surveys; for example the recording of long commutes discussed in chapter 2, or differences in demographic and geographic sampling.

7 Conclusion: The Future of Commute Durations

Ultimately, a number of different points are important in understanding the large increase in commute durations in Minnesota during the 1990s.

First, the increase during the 1990s may have not been as large as it appears, because of changes in how long commutes were recorded. Examination of other data shows that commutes also increased during the 1980s, and have continued to increase since 2000, although in both cases at a slower rate than in the 1990s. A substantial part of the large growth in the 1990s seems to have been due to a change in how long commutes were accounted for; calculating 2000 commutes using a similar methodology to 1980 and 1990 gives the result that travel time growth was about 7% during the 1980s and 11% during the 1990s. The increase in the 1990s appears to have been an acceleration of an existing trend rather than a complete departure from past behaviors.

A broader geographic and temporal perspective shows that the increase was not unique to Minnesota; neighboring states showed very similar patterns. Thus the increase in Minnesota was not driven by some unique local situation, such as the growth of the Twin Cities or urban residents purchasing remote second homes (although these factors likely played a role in some specific locations).

A plausible hypothesis is that commute changes were due to differences in economic conditions, such as faster wage growth, lower unemployment, or lower gas prices. But the 1980s and 1990s were basically similar in terms of these factors. Indeed, gas prices declined even more during the 1980s than during the 1990s. Looking at the 1990s in isolation, changes in economic conditions were only slightly correlated with changes in commute durations.

In the Twin Cities it is reasonable to think that land use changes might have led to some increase in average commute duration. A traditional explanation of increasing commutes is that people move from central locations to new suburban homes that are far from job opportunities, leading to much longer commutes for those individuals. However, about 90% of the Twin Cities population in 2000 was geographically distributed in the same way as in 1990. Of the 10% that were distributed differently, the average commute in the new locations was only about 3 minutes longer than the locations that were left behind. Thus this explains only about 0.3 minutes of the overall 2.2-minute increase in the metro area. And part of this was offset by the movement of jobs, which actually tended to go to areas with shorter average incoming commute times.

In examining traffic congestion as an explanation of longer commutes in the Twin Cities, two different methods, using different data, both indicate that travel speeds declined by about 4% during the 1990s. This is about half of the overall increase in commute durations. The other half is due to longer distances. Perhaps a quarter of this other half was caused by new residential development in outlying areas, but the remaining three quarters seems to have been the result of people choosing to commute to more distant jobs, even though jobs as a whole were at least as conveniently located as before.

In the remainder of Minnesota outside of the Twin Cities, essentially all of the increase in commute durations appears to have been due to longer distances. The increase in distances appears to have been almost entirely caused by a greater number of commuters traveling long distances out of their home counties. This result is supported both by direct calculation of commute distances, and by the fact that median, or fiftieth percentile commutes, did not increase at all during the 1990s. Since in most cases intra-county commutes would be shorter than out-of-county, and the fiftieth percentile did not change, this indicates that intra-county commutes generally did not get much longer.

Overall, commuting distances statewide appear to have increased about 10% in both the 1980s and 1990s. Longer distance travel is generally at higher speeds, since more of the time is spent at high speeds rather than on slower local streets. In the 1980s the longer distances were partially offset by higher speeds, so that the overall time increase was about 7%. In the 1990s average speeds outside of the Twin Cities metro continued to improve with longer distances, but inside the metro speeds actually declined because of congestion. The two effects cancelled, so that average speeds statewide remained unchanged in the 1990s. Thus all of the increase in distances was reflected in higher travel times, explaining the larger travel time increase in this decade.

Mean commute durations increase directly with wage income; that is, people who make more money, commute farther on average. While the precise form of this relationship varies slightly from place to place and from time to time, the relationship as a whole is fairly robust. Over time, economic growth leads to higher average wage rates. This would, in itself, be expected to add about one minute per decade to the mean commute duration in a given location; given the sensitivity of commute durations to income, and the rate of income growth over time. This is consistent with the growth in commute durations observed in the 1980s, and since 2000. It could also be consistent with the larger growth in the 1990s given that speeds did not improve during this time.

There may be some value in considering how commuting choices evolve over time. It may be important to remember that commuting patterns at a point in time are not a perfect reflection of conditions at that time, but are rather a reflection of how people have responded to a set of conditions over a long period of time. An individual's commute can only increase when that person changes jobs or home location (in the absence of a change in driving conditions, which probably was not an issue in most of this three-state area). That is, even if conditions such as low gas prices might make many people willing to consider longer commutes, that interest can only manifest itself when a home or job change is made, perhaps once every few years.

Even then, the possibility that a person might be willing to consider a longer commute doesn't mean that the commute actually will get longer. Sometimes the new job will actually be closer than the old one, and people moving to new homes on the edge might already have jobs on the edge, and thus be reducing their commute duration. So even given economic conditions that are conducive to longer commutes, commutes will only change gradually over a long subsequent period. The 1990s might have just been a period when this long slow trend accelerated slightly.

Only a few people would have had to change to create the apparently large change in commute patterns. Assume that 0.5% of the commuting population changes commutes in a way that adds 40 minutes to the average for that group. This small fraction with the big change would then single-handedly add 0.2 minutes to the overall mean each year. If this happened for five years, one full minute would be added to the mean, which would explain nearly all the remaining increase that is not explained by rising incomes.

It is natural then to wonder what might have happened in the 1990s that could have created such a temporary acceleration. One good candidate is the unemployment rate. A low unemployment rate would typically be associated with a large number of job openings and likely with a relatively rapid rate of turnover as people seek better opportunities out of the many that are available. If job changes are one of the two ways that commute times can increase, then an economic environment in which there are a lot of job changes would have more opportunities for commute times to increase at the individual level, and this would tend to cause the overall average to rise faster.

The second half of the 1990s featured some of the lowest gas prices relative to income ever observed, as well as some of the lowest unemployment rates ever recorded. Good job availability means not only that there may be more opportunities at long distances, but also that there is less risk in trying the long commute: If it doesn’t work out it is easy to find another job that is closer. This unusual combination of plentiful job opportunities and a low monetary cost of commuting may have induced a number of people to switch to longer commutes, that otherwise might not have done so for many years, if ever. Since 2000, both gas prices and unemployment rates have remained relatively low by historical standards, but the moderate increase in both factors at once may have changed the preferences of just enough people to stabilize commuting patterns.

Will commute durations continue to grow? Almost certainly, although the rate of growth seems hard to predict. Certainly we seem far from any kind of psychological boundary in this region. There are many metropolitan areas where the average commute for the entire region is near or even in excess of 30 minutes, which indicates that people in general are willing to tolerate much longer commutes than we are experiencing here at the moment. Even locally, all the people who are willing to commute long distances from collar counties are not yet doing so, as evidenced by continued housing construction in those areas. Income growth and longer distances should continue to add about one minute per decade to the average commute duration. Whether the increase is even faster than this may depend on other factors such as job availability and the cost of commuting, especially the cost of gasoline.

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Appendix A

Data Sources and Issues

Appendix A: Data Sources and Issues

Census 1980-2000

While it appears to be possible to download 1980 census data in electronic form, it is in a fairly raw state. This may be a viable option for applications that require a large amount of data, justifying the necessary investment in processing the data. However, for this research only a small amount was needed, related to commute times and some supporting information for counties in three states. Thus the necessary data was simply copied and entered by hand, from printed census documents in the University of Minnesota library.

The situation is better in 1990 and 2000. Not only are the data easily accessible on the internet, but transportation-related information is broken out into a separate package (the Census Transportation Planning Package – CTPP) with standardized tables of results. The CTPP is divided into three parts. The first gives results based on the home location of the respondents. This would give, for example, average commute durations for the residents of a given area. Part 2 gives results based on the job location, so for example could be used to calculate the transit share for all the people who work in downtown Minneapolis. Part 3 gives information on specific point-to-point trips, for example, the travel time or mode split between a particular home and work location.

While the part 3 data is in principle the most interesting, in practice it is the hardest to work with. The biggest issue is sample size. While there may be 1,000 workers residing in a given Traffic Analysis Zone (TAZ), they may work in 50 or 100 different TAZs, so any given point-to-point flow is generally very small. Thus the sample for a given flow may consist of literally a single individual, which means that the reported data is really a description of that person rather than the broader situation. Because of confidentiality concerns arising from this, in 2000 these very small flows are not reported at all. This makes comparisons of flows between 1990 and 2000 hard to do.

There are other issues that must be addressed in using the census data. A fairly simple one of these is that in 1990, commute durations were "capped" at 100 minutes; meaning that if a person reported a commute longer than this, they were recorded as 100 minutes. In 2000 the cap was raised to 200 minutes, thus the average in 2000 is being calculated from a slightly different set of rules in terms of how the data are reported. While there are relatively few commutes longer than 100 minutes, they can have a disproportionate impact on the sample mean since they are so much higher. In this report I used PUMS data (described below) to calculate the impact of suppressing longer commutes to be 100 minutes; the difference was in the range of a third to half a minute.

A larger problem with the data was that in 2000 unreported destinations (or just those that the census was unable to map) seemed to be coded as being in the same area as the home. One impact of this was that trips that were coded as beginning and ending in the same TAZ or MCD would have implausibly long reported travel times, because they were really including trips that went elsewhere but for which the destination was not known. This impacted the results all the way up to the county level, where there were sometimes very large increases in travel times for intra-county trips even though the reported flows didn't change much. The chapter in the report on distance and speed addresses this issue in more depth.

There were apparently no commute-related questions in 1970, so it was not possible to extend the analysis back even farther.

American Community Survey (ACS)

This survey is conducted annually by the census bureau and is meant to replace the census long form, where the transportation-related questions have been asked in the past. The idea of the ACS is to survey a smaller sample on an annual basis, and aggregate the responses over time. Given geographic units are only reported as a sufficient sample size is accumulated; over a full ten year span the sample size would be equal to or greater than would have been obtained through the traditional long form method. One benefit of this is that new information is available on an annual basis for large areas such as states or high-population counties. A downside is that for smaller areas, the reported figures will be an agglomeration of several years data, rather than a snapshot of a point in time. In this report I only use this data to track commute durations since 2000 for states and large counties in Minnesota.

One issue with this data is that it seems to give different answers than the census long form. For commute durations, for example, the 2000 ACS gave averages for the three states examined in this report that were 0.2 to 0.8 minutes lower than the census averages, which were ostensibly describing the same places at the same time. Thus in comparing the 2005 ACS to the 2000 census, it appears that commutes did not increase at all in those five years, but comparing the 2005 ACS to the 2000 ACS, there was a clear half minute or more increase. It is not clear why the answers would not be the same since they are supposed to be equivalent surveys.

Public Use Microdata Sample (PUMS)

This data set is the actual survey responses from the ACS, with identifying information removed. So again, there is no geographic detail lower than the state, except that metropolitan areas are separated. However, having individual responses makes it possible to analyze specific relationships that may not be reported in the census summary tables. In this report, I look at the relationship between wage incomes and commute duration. The high level of reported detail makes it possible to break out wage income from other non-work sources, and to control for correlated factors such as age and education.

Longitudinal Employer-Household Dynamics (LEHD)

This data set comes from a partnership of the census bureau with the labor departments of a number of states, including Minnesota. The census bureau works with the IRS and other sources to track where individuals live. The state labor departments collect data on where people work, as part of their unemployment insurance programs. The LEHD program combines these two data sources to create extremely detailed maps matching home and work locations. For example, it is possible to pick a census tract, or an even smaller area, and map the job locations of all the workers who live in that census tract.

These data are only available for 2002-3 at this time. So this analysis doesn't address the changes that took place during the 1990s, but it does provide considerably enhanced detail on what commute patterns look like now. An important benefit of this is that the detailed coverage makes it possible to analyze long-distance commutes in great detail. Very long commutes tend to be small flows; that is, only one or perhaps a few people will make the trip between a specific origin and destination that are far apart. Since the 2000 census sampled only about 10% of the public with regard to commuting, many of these trips would have been missed entirely. And because of confidentiality restrictions on reporting, most of the rest would not have been reported except perhaps at the county level.

The LEHD data, by contrast, is based on all workers and jobs, so everything is captured. It also uses more advanced techniques to ensure confidentiality while reporting even very small flows. This makes it possible to analyze the exact destinations of long-distance commutes and how patterns might vary across locations.

There are some problems with these data. Perhaps the most significant is that the home locations is based on the previous year (from a tax return, for example) while the work location is based on the current year (unemployment insurance payments). So in a few cases people might have moved in between, leading to inaccurate representations of flows. This data set also doesn't pick up self-employed people who don't pay unemployment insurance, but this is a relatively small part of the total.

A bigger problem is that the work location is coded to where the payroll comes from, which may not be where the person actually works. The Minnesota unemployment insurance office has gone to some lengths to reduce this problem by coding workers to specific establishments in cases where a company has a number of different locations (like a fast food restaurant). However, the problem still seems to occur, and to cause some results that are hard to interpret.

The most common problem is a small rural county that seems to be sending a large number of workers to a larger city 200 miles away. This seems almost certain to be a situation where people work in a branch facility of a company that is headquartered in the distant city, so that the true commute is a few miles rather than 200. One way of seeing this is noting that closer counties are not sending equivalent numbers of workers to the same city. Another is that in most of these cases, the number of workers is dozens of times higher than the number reported with that flow in any previous census.

Another issue with coding work location at the main office is that it does not capture the true work location of people such as construction workers, who work at specific job sites. However, in these cases the work location is highly variable from one time to another anyway, so simply using the office location seems no worse than any other option. A countervailing benefit of this approach, compared with the census method of asking where the person worked last week, is that the true permanent job location is captured, rather than a short business trip or temporary assignment. This eliminates the common problem in the census in which people report working in a location that is hundreds or even thousands of miles from where they live.

Twin Cities Travel Behavior Inventory (TBI)

This survey is done approximately every ten years by the Metropolitan Council for purposes of calibrating the local traffic forecasting model. It differs from the other data sources described here in that it covers all trips made over the course of a day, not just commuting trips. As such, it can provide a useful complement in terms of understanding how travel times changed for non-work travel, compared with changes in work travel times. This issue is addressed in the second appendix of this report. This analysis makes use of the TBI data from 1990 and 2001.

Appendix B

Twin Cities Zones

Appendix B: Twin Cities Zones

As part of an earlier research project, the author created a division of the Twin Cities metropolitan area (seven counties) into 66 zones, defined in terms of traffic analysis zones (TAZs). These are generally based on city boundaries, with some smaller cities and rural areas combined, and some larger cities broken into a number of zones based on land use and neighborhood differences, and natural boundaries. Minneapolis is divided into twelve zones, Saint Paul into seven zones, and Bloomington and Brooklyn Park are each divided into two zones. The average population of each zone is 35,000, although some zones, such as the downtowns and the airport have many jobs but very few residents. Within the TCMA, 20 of the zones are in the central cities of Minneapolis and St. Paul, 38 are suburban, and 8 are mostly rural.

Figure B.1 below shows the zones on a map. Figure B.2 is the same map, but with the central part of the region expanded for greater readability.

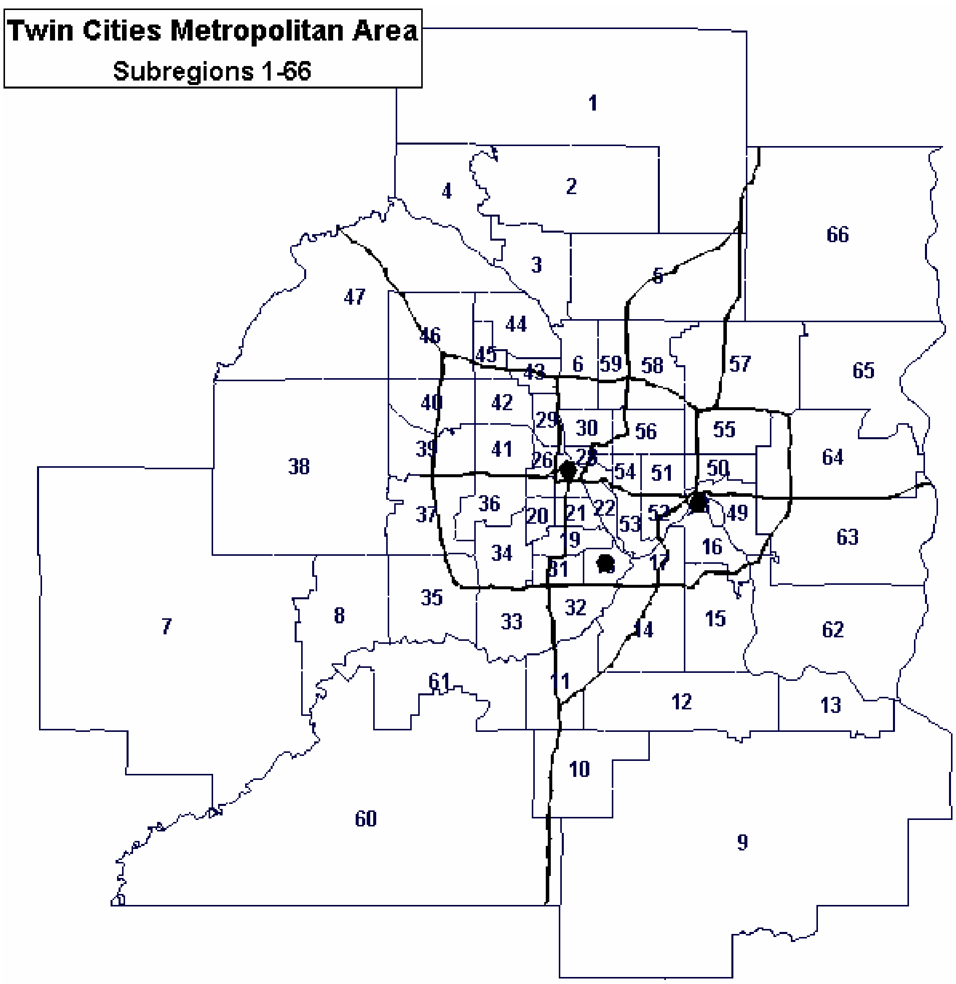


Figure B.1: The 66 Zones Contained in the Twin Cities Metropolitan Area

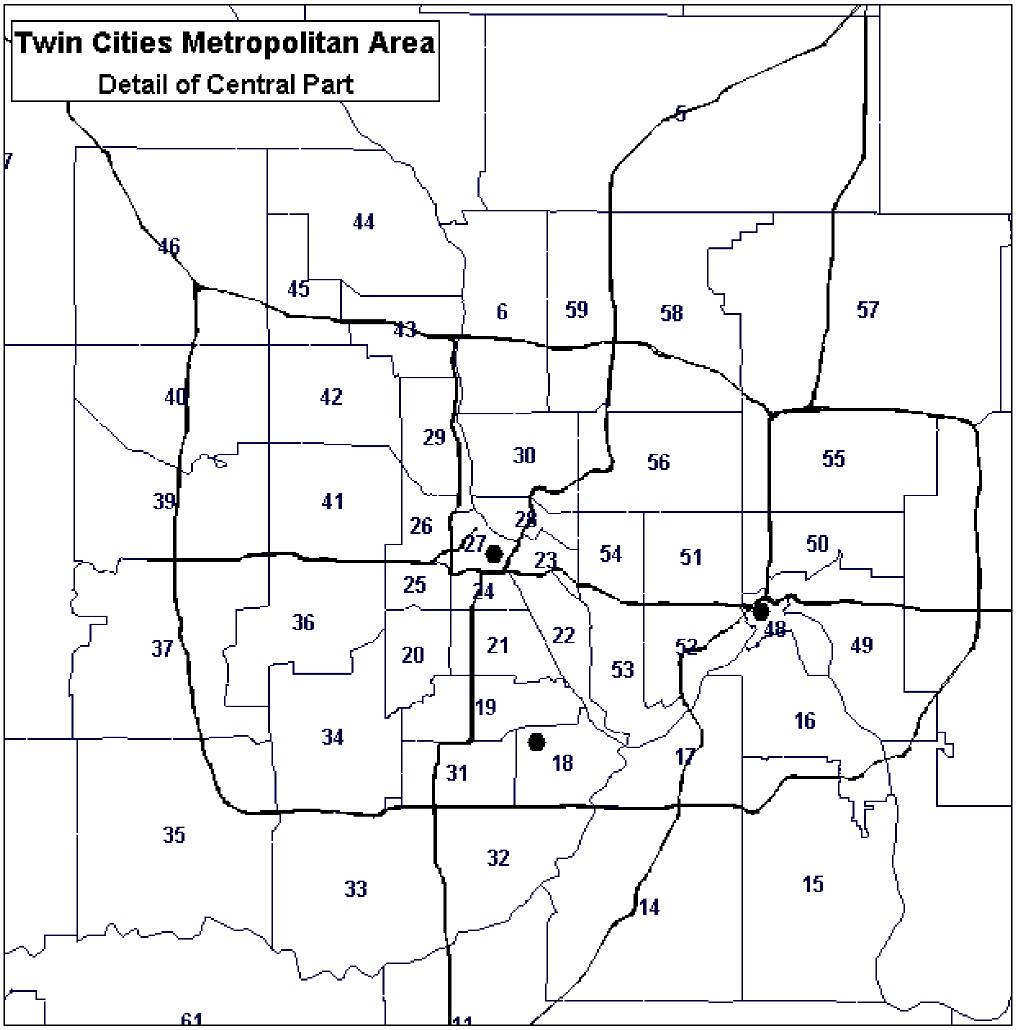


Figure B.2: The Zones in the Central Part of the Twin Cities Metropolitan Area

Appendix C

Commuting and Total Daily Travel Time

Appendix C: Commuting and Total Daily Travel Time

This appendix contains a short paper written as part of this project. Because it addresses total daily travel rather than commuting specifically, the findings it contains ultimately did not contribute to the main line of argument about commute durations, thus it was omitted from the main body of the report. It is included here as a non-central, but closely related topic.

Daily Travel Time Variability in the Twin Cities, 1990-2001

Gary Barnes
Stephanie Erickson

Abstract

This paper describes a study of daily personal travel time in the Minneapolis-St. Paul, Minnesota metropolitan area and how and why it changed between 1990 and 2001. This has two major components. The first is the relationship between commute and non-commute travel time. The second is the relationship between mode choice, total daily travel time, and automobile travel time. Both of these are analyzed in terms of how they vary geographically within the region as well as how they changed during the decade.

The study is based on the Twin Cities Travel Behavior Inventory (TBI), which included about 10,000 households in 1990 and about 5,000 in 2001. These large samples make it possible to study geographic variations within the region. This is supplemented with information on commute durations from the Census Transportation Planning Package.

Average Twin Cities one-way commute durations increased by about two minutes during the 1990s, while total daily travel time increased by about five minutes for workers and two minutes for non-workers. This supports an earlier finding that variations in total daily travel time within the region were primarily due to differences in average commute durations rather than non-work travel. The findings here also support the theory that time spent in non-auto modes reduces the amount of time spent in auto travel, although the reduction is not one-for-one.

Introduction

Understanding the likely sizes of, and reasons for, variations in total daily travel time is important for formulating effective transportation and land use policy. If increased speeds from highway improvements, or reduced distances from mixed-development land use policies, simply free time for people to make more or longer trips, then the efficacy of these policies at reducing congestion might be limited. A similar limitation would arise if trips that are shifted to non-auto modes by transit- or pedestrian-friendly development were replaced by additional auto trips. Being able to make these kinds of predictions is a matter of distinguishing between two competing views of how people make travel decisions.

While popular discussion tends to view individual trips in isolation, so that eliminating or reducing the length of a trip will always lead to a reduction in total travel, it is not clear that travelers actually constrain themselves in this way. Zahavi (1979, 1980a, 1980b) was among the first to promote the idea of a daily travel time budget; that is, the notion that travelers in the aggregate will tend to spend a certain amount of time traveling each day regardless of conditions. This is a very different way of thinking about travel, since it implies that eliminating or reducing the time needed for a trip will usually just induce the traveler to make additional trips, or travel to more distant destinations.

Zahavi initially made this point in the context of the Minneapolis-St. Paul, Minnesota (Twin Cities) and Washington, D.C. metropolitan areas, for the years roughly between 1955 and 1970. He noted that both of these regions experienced considerable population growth during this time, and more significantly, the construction of freeways that led to a very substantial increase in average travel speeds. However, in both cities the response to this increase in speeds was not to spend less time traveling, but rather to build new housing on the previously less accessible edge of the region, so that overall average daily travel times remained basically unchanged while vehicle miles traveled increased dramatically.

Barnes and Davis (2001) replicated Zahavi’s analysis using 1990 data, and found that average daily travel times were still basically unchanged, despite the continuing increase in the built-up area of the Twin Cities and significant decreases in residential and employment density. Their focus was on the effect of land use on travel behavior, and they found that the travel time budget was also useful for understanding this relationship. Residents of areas with better access to destinations tended to travel to a larger range of destinations rather than reducing their total daily travel time; while residents of access-poor outlying suburbs reduced their destination set.

This paper describes a study of daily personal travel time in the Twin Cities metropolitan area and how and why it changed between 1990 and 2001. This is essentially an update of the Barnes and Davis study, but focused specifically on two major components. The first is the relationship between commute and non-commute travel time. The second is the relationship between mode choice, total daily travel time, and automobile travel time. Both of these are analyzed in terms of how they vary geographically within the region as well as how they changed during the decade.

Following Zahavi, there have been a number of studies of travel time over the last 25 years; many of these are summarized in Mohktarian and Chen (2003). Some of this literature focuses on establishing the characteristics of travel time patterns in different places or situations. The notion of a psychological budget for travel implies that there should be a fairly limited range of behaviors across different locations, and establishing the size of this range is important for the credibility of the concept. Another approach to the issue is studying the reasons why daily travel times vary across locations. One aspect of this is socio-economic considerations. Another, and the more interesting possibility, is policy decisions related to travel, such as land use and transportation infrastructure investments.

This paper uses elements of both approaches, aimed specifically at better understanding the impact of land use and mode choice on daily travel time. The two approaches between them address three main questions. First, how much does total daily travel time vary across locations and time? Second, are differences in total daily travel time due primarily to the commute trip, to personal travel, or to a combination of the two? Finally, to what degree does alternate mode use shift travel time away from auto travel?

These three questions are derived in large part from claims made by the “smart growth” movement (Calthorpe, 1993); which promotes the development of dense, mixed-use, alternate-mode-friendly neighborhoods. The argument behind this from a transportation perspective parallels the three questions of this paper: that people will not have to spend as much time traveling because destinations will be closer; that in particular they will be able to minimize personal travel since it will be possible to meet most of these needs in the neighborhood, and finally that the focus on non-auto modes will reduce the amount of auto travel even more than total travel.

Methodology

This study is based on the Twin Cities Travel Behavior Inventory (TBI), which is a large travel-diary-based survey conducted roughly every ten years by the metropolitan planning organization. It included about 10,000 households in 1990 and about 4,000 in 2001. These large samples make it possible to study geographic variations within the region. This is supplemented with information on commute durations from the Census Transportation Planning Package.

In order to use an equivalent methodology with Barnes and Davis’ 1990 analysis, the 2001 TBI was filtered in a number of ways. The first was to exclude any traveler who did not travel entirely within the seven-county metropolitan area. The primary reason for this is because a few very long vacation trips can seriously compromise the effort to understand ordinary metropolitan travel. Another adjustment was the exclusion of within-metro trips of greater than 120 minutes; there were a small number of these in both years. Because of the physical size of the metropolitan area, it seemed probable that these implausibly long trip durations were due to diary or coding errors.

Finally, travelers under the age of 18 were excluded. Barnes and Davis argue that children do not make their own travel decisions in most cases, therefore from a theoretical standpoint it is inappropriate to include them in an attempt to understand travel preferences. Additionally, they found that children’s travel behavior is quite different empirically from that of adults, thus average travel times in areas with greater numbers of children may differ substantially from those with less children, even if travel behavior of adults in these areas is similar.

For purposes of comparing average daily travel times to 1990, we further restrict the data to include only those adults who traveled exclusively by automobile, either as driver or passenger. This was not much of a restriction, as it included about 90% of the adult travelers in each data set. The purpose was to keep the underlying sample as similar as possible between the two years. We also examine the set of all travelers by all modes in 2001 and how mode choice behavior varies within the region. However, we do not compare non-auto travel directly to 1990, because the sample is too small and because the data sets are not completely comparable in this regard.

After creating equivalent data sets, there were about 14,500 adult travelers in 1990 and about 5,500 in 2001. The much smaller sample in 2001 unfortunately makes it difficult to do the kind of detailed geographic analyses that Barnes and Davis did. To understand geographic variations within the region, we use a simple set of nine rings, based on the distance of a traffic analysis zone (TAZ) from the nearest downtown (Minneapolis or St. Paul). Empirically, this is a reasonable if somewhat coarse proxy for population density and access to job opportunities, which are the land use features that are most often thought to impact travel behavior.

Having created equivalent sets of travelers for the two data sets, we calculated a number of travel time descriptors. For those that traveled only by auto, we simply added their total daily travel time, and averaged these by ring for workers and non-workers. For workers, we divided their total time into commute travel and personal travel by using the mean drive-alone auto commute time from the census for the TAZ where they were residents. This number, multiplied by two, was the daily commute time, and the remainder of total daily travel was non-commute.

We used the census commute times rather than the respondents' own reported commute times because trip chaining and possibly careless reporting of trip purposes made it hard (in both years) to determine the actual time spent driving to work. If someone drives 15 minutes toward work, stops to get coffee, then drives three more minutes to their job, only the last three minutes would show up as a "to work" trip in the TBI. The census, by contrast, asks specifically about the entire trip from home to work as a unit, so we felt that this was a more reliable indicator of the time needed for this activity. The fact that some people may use their commute as an opportunity to complete personal errands is part of the phenomenon of travel time management that we are trying to study here.

For those that traveled by non-auto modes, we just calculated total daily travel times and split these out by mode, and by ring. We did not divide the times into commute and personal in this case because it was not clear what the appropriate commute time would be. As noted above, it was generally not viable to use the respondents' own reported commute times, and there was no mode-specific time from the census data that corresponded in the same clear way that drive-alone did for auto-only travelers.

Results

From a perspective of how land use policy might influence travel choices, there are three major questions whose answers would inform the debate. First, how much does total daily travel time vary either across locations or time? This addresses whether improved accessibility in general is likely to have much influence over how much time people spend traveling. Second, are differences in total daily travel time due primarily to the commute trip, to personal travel, or to a combination of the two? This can help to focus on what aspects of land use development might have the most impact (Levinson and Kumar, 1994, Boarnet and Sarmiento, 1990). Finally, to what degree does alternate mode use shift travel time away from auto travel? This addresses the question of the likely magnitude of the benefits that can be gained by this tactic (Pivo, 1994, Boarnet and Crane, 2001).

The first and second of these questions are addressed here by an analysis of total daily travel time for auto-only travelers in 1990 and 2001, and how these times vary geographically within the region. The first is addressed again, along with the third, in the subsequent analysis of geographic variations in mode choice and daily travel time in 2001.

Travel Time and Commuting, 1990-2001

Between 1990 and 2001, the average total daily travel time for auto-only travelers went from 74.1 to 79.2 for workers and from 70.6 to 72.7 for non-workers. From the census, the regional mean drive alone commute time, weighted by the home locations of the TBI sample distribution, increased from 20.1 to 22.3. Multiplied by a two-way trip, this would account for 80% or more of the total travel time increase for workers.

Breaking the sample down into rings of varying distances from the nearest downtown makes it possible to observe, at least at a crude level, relationships between commute and personal travel. Barnes and Davis (2001) had found that there was no systematic intra-regional variation in personal travel time, that is, travel by non-workers or non-commute travel by workers. To the extent that there was non-random variation across the region in total daily travel times, it was due almost entirely to variations in average commute durations. Barnes (2001) came to a similar conclusion in a study of the 31 largest U.S. cities.

Generally speaking, commute durations increase fairly steadily with increasing (home) distance from the center of the region. For non-workers, there is little relationship between home location and total daily travel time, and for workers there is an inverse relationship between commute durations and non-commute travel time. While 1990 and 2001 show similar trends, the substitution between commute and personal travel for workers seemed to be amplified during the 1990s (Figures 1 and 2).

Figure 1: Total Daily Travel Times, 1990

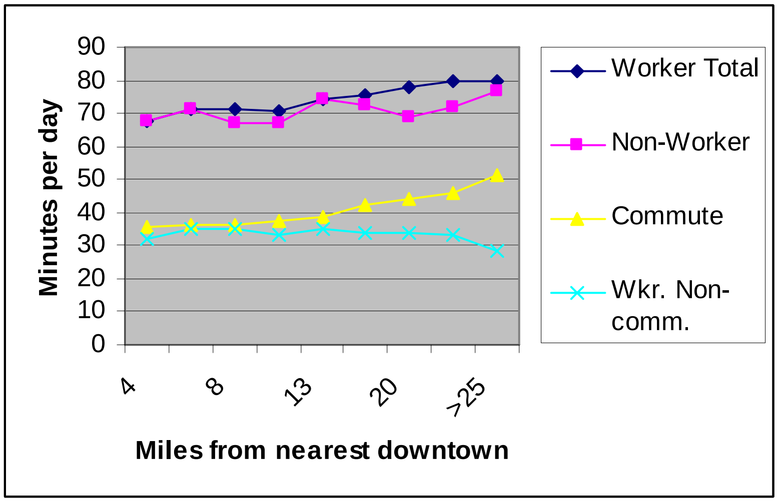
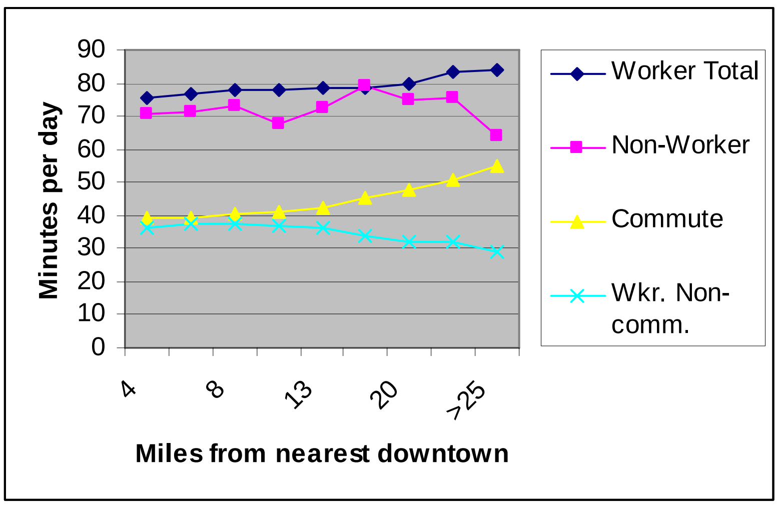


Figure 2: Total Daily Travel Times, 2001



The fluctuations in the non-worker travel times are probably due in large part to the relatively small samples of this type of traveler. The very last ring, in particular, seems sensitive to sampling aberrations, as it was much higher than any other ring in 1990 and much lower in 2001.

While the lines in general retained similar shapes between the two surveys, they did shift upward somewhat. A comparison of the percentage increase by ring and travel type between 1990 and 2001 helps to bring the changes into focus (Table 1). The averages in the last row are weighted by the distribution of the 2001 sample.

Table 1: Percent Increase in Total Daily Travel Time, 1990-2001

Ring distance from nearest downtown	Worker total	Non-worker total	Worker commute	Worker non-commute
0-4 miles	12%	4%	10%	14%
4-6 miles	8%	0%	9%	7%
6-8 miles	9%	9%	11%	8%
8-10 miles	11%	1%	11%	11%
10-13 miles	6%	-3%	9%	3%
13-16 miles	4%	9%	7%	1%
16-20 miles	2%	9%	8%	-5%
20-25 miles	4%	5%	10%	-4%
More than 25 miles	5%	-17%	7%	3%
Weighted average	6.5%	3.0%	9.0%	3.3%

The increases for non-workers and for non-commute travel by workers both were about 3%. Commute times showed a much larger increase. An interesting point is that while commute times rose by about the same amount across the region, in the outer areas workers on average held their non-work travel at or below 1990 levels, while in the more central parts workers had an increase in non-work travel that was similar to their commute increase. Overall this had the effect of achieving some degree of equalization in total daily travel times across the region. In 1990 the range between the inner- and outermost rings for workers was from about 68 to 80 minutes; in 2001 it was about 76 to 84.

In terms of land use policy, it does not appear, at least for auto travelers, that there is much advantage in terms of time savings to being in a denser, more central location. The innermost ring has a job density that is three times higher than the second ring, and population density that is 50% higher, with even larger differences for outer rings. But total daily travel time for residents of this ring is not much lower, and in fact the differences seem to be getting smaller rather than larger over time. This is not due to residents traveling elsewhere due to economic decline in the central part of the region; the two central cities actually gained population during this period for the first time in several decades.

Another point of interest is that the primary source of differences, both geographically and temporally, is commute durations. Travel by non-workers shows hardly any systematic variation either geographically or temporally. Workers even appear to actually reduce their personal travel as their commutes get longer. This to some extent refutes the argument that dense, mixed-use development is needed so that people can complete their personal errands in a reasonable amount of time. Instead, people appear to figure out how to do this on their own when the occasion demands. In low-density suburbs personal destinations are typically much farther from the home, but people apparently change their travel patterns to compensate for this; by combining trips, by doing errands on the trip to or from work when little marginal driving is required, or simply by making trips less often.

It is worth noting for background purposes that average commute times rose substantially throughout the state of Minnesota, and throughout the entire U.S., during the

1990s. The increase in the Twin Cities was actually less than in the rest of the state; of 87 Minnesota counties, the seven metro-area counties were all in the bottom 12 in the percentage increase in commute durations. Thus, while increased sprawl and substantially increased congestion levels would seem to be the obvious explanations for the increases in commute times, it is hard to accept this at face value given the even larger increases in the rest of the state, where neither of these factors were issues.

The congestion studies issued annually by the Texas Transportation Institute (2005) have been used to argue the economic benefits of policies and investments to reduce the level of congestion in the Twin Cities. They indicate that extra driving time due to congestion increased from about 22 hours a year per driver in 1990 to about 42 in 2001, nearly a doubling in the congestion level. This extra 20 hours would equate to about 24 minutes per week, or about five minutes per day. This is in fact almost exactly the size of the increase in total daily travel for workers in the 1990s.

However, the universal nature of the increasing commute times during the 1990s points to a more general cause; possibly a so-far-unidentified change in the underlying benefit-cost structure for commute travel. While Twin Cities commuters may in fact be spending an extra five minutes a day sitting in congestion, it seems very likely that in the absence of congestion they would still be spending that extra five minutes anyway, given that commuters everywhere else in the state are doing this.

It is important to eventually establish the reasons for the observed increases in Twin Cities commute durations because the policy implications depend on this. If they are due to congestion, then reducing congestion might reduce travel times and fuel consumption, as the TTI studies imply. If, however, they are due to some underlying shift in preferences or benefit-cost calculations, then the time and fuel saved by reducing congestion would just be spent traveling to more distant jobs rather than sitting in traffic.

Travel Time and Mode Choice

Although the much higher density of the central part of the Twin Cities region does not lead to much reduced daily travel times for those that travel exclusively by auto, one of the primary selling points of higher density is its facilitation of the use of non-auto modes. A case could be made that restricting the analysis to those that travel exclusively by auto is biasing the results in that these may be the highest-travel residents of dense areas. Those that work and shop locally as in the "smart growth" model would be left out and their beneficial effects on the transportation system overlooked by this method.

A competing, and also plausible theory, asserts that exactly the opposite effect would be expected. People may view walking and biking primarily as recreation rather than transportation. So they may just make all the car trips they would have made anyway, leading to an increase in their total daily travel, and a minimal if any reduction in their auto travel.

This section addresses this concern by examining total travel time by all modes as it varies by geographic location within the region. There are two issues here. One is the effect on total daily travel. This is a function of the prevalence of alternate mode use among the population and the amount of it that is done. The second issue is the degree to which alternate mode use substitutes for auto use.

This section uses just the 2001 data. The 1990 data did not include walking and biking, which are at least half of the alternate mode use, making comparisons difficult. Comparisons are also problematic because of the small sample sizes of people who used alternate modes. The census indicates that mode shares for commuting remained fairly constant during the 1990s, and this combined with the relative rarity of alternate mode use hints that changes in total travel time were probably primarily driven by changes in auto travel time.

The sample of non-workers who used non-auto modes was quite small, especially at the level of individual rings, so the tables in this section just give information about workers. Non-workers are discussed in the text in cases where reasonable conclusions can be drawn. Throughout this section, we refer to travelers who use modes other than auto by the shorthand descriptor "mixed-mode," even though some of them may in fact use only a single mode.

The first question of interest is how the total daily travel time of mixed-mode travelers compares with those who use autos exclusively (Table 2).

Table 2: Total Daily Travel Time by Mode Type, 2001

Ring distance from nearest downtown	Total, all travelers	Car-only	Mixed mode	Mixed mode %
0-4 miles	79.7	75.7	85.9	39%
4-6 miles	82.1	77.0	99.9	22%
6-8 miles	80.0	77.8	92.0	16%
8-10 miles	79.5	78.1	107.1	12%
10-13 miles	80.1	78.7	93.6	13%
13-16 miles	80.1	78.8	91.7	11%
16-20 miles	82.3	79.7	107.4	9%
20-25 miles	85.4	83.1	108.3	9%
More than 25 miles	87.3	83.9	103.7	6%

Across the region, those that use non-auto modes spend more total time traveling each day. Including the additional, mixed-mode travelers brings the overall average travel time up, not down, and this is true even in the dense central parts of the region. Access to non-auto modes does not, on average at least, have the effect of allowing people to reduce the amount of time they spend traveling.

The fraction who used mixed modes by ring was almost identical for workers and non-workers. That is, the use of alternate modes is not solely a matter of workers using transit to get to their jobs, but does seem to reflect a broader system of opportunity or preferences in a given location, which both workers and non-workers utilize to much the same degree. There was a difference in the specific modes used; non-workers were relatively more likely to use transit in the inner rings, and to walk or bike in the outer rings.

Although total average travel goes up when non-auto modes are included, this could still be associated with a net reduction in auto travel, since much of the additional time is in other modes. Examining specifically the subset of mixed-mode travelers shows that they do have considerably reduced auto use on average (Table 3). The times in the last three columns do not add to the total because of the presence of a few other minor modes.

Table 3: Mixed-mode Travelers' Time by Mode

Ring distance from nearest downtown	Total daily travel time	Auto time	Walk and bike time	Transit time
0-4 miles	85.9	36.0	29.0	19.3
4-6 miles	99.9	52.4	26.6	19.6
6-8 miles	92.0	42.2	23.3	25.6
8-10 miles	107.1	63.4	18.6	16.5
10-13 miles	93.6	58.5	16.4	16.8
13-16 miles	91.7	60.5	14.4	10.9
16-20 miles	107.4	63.6	15.7	26.2
20-25 miles	108.3	57.2	16.3	29.1
More than 25 miles	103.7	74.3	17.0	10.9

A follow-on question is the size of the reduction in auto travel implied by the auto time for mixed-mode travelers compared to that for auto-only travelers, and how this compares to the amount of non-auto time (Table 4).

Table 4: Alternate Mode Use and Reduction in Auto Time

Ring distance from nearest downtown	Auto-only travelers	Mixed-mode auto time	Implied reduction for mixed-mode	Non-auto time for mixed-mode
0-4 miles	75.7	36.0	39.6	49.9
4-6 miles	77.0	52.4	24.6	47.5
6-8 miles	77.8	42.2	35.6	49.8
8-10 miles	78.1	63.4	14.7	43.6
10-13 miles	78.7	58.5	20.2	35.1
13-16 miles	78.8	60.5	18.3	31.2
16-20 miles	79.7	63.6	16.1	43.8
20-25 miles	83.1	57.2	25.9	51.2
More than 25 miles	83.9	74.3	9.6	29.4

There appears from this table to be a general relationship in that those rings with larger non-auto times tend to have larger implied reductions in auto travel. However, the relationship is not perfect, and in every ring the amount of non-auto time is larger than the implied reduction in auto time, implying that there is not a one-for-one tradeoff. Overall, calculating averages weighted by the number of non-auto travelers in each ring indicates an average reduction of 28 minutes in auto travel time, and an increase of 45 minutes in non-auto time. This is a little better than 2 to 1, or that every two minutes in non-auto reduces auto time by one minute.

Another way of looking at this is to run a simple linear regression on this small data set, regressing the implied auto time reduction on the amount of non-auto time. The results of this indicate that the average mixed mode user spends 13 minutes more per day as a baseline (although this is not statistically significant) and spends 0.84 minutes less driving for every minute spent in non-auto modes. The adjusted R-squared of this regression is 0.45. This implies nearly a one-for-one reduction, but some of the "extra" 13 minutes will be auto time as well, so the net reduction is smaller than this.

The final calculation in this analysis is the total amount of auto and non-auto travel time for all travelers, including both auto-only and mixed-mode. This is the ultimate measure of how much difference mode choice makes to overall travel reduction (Table 5).

Table 5: Average Time by Mode for All Travelers

Ring distance from nearest downtown	Total time per traveler	Total auto time per traveler	Non-auto time per traveler
0-4 miles	79.7	60.1	19.6
4-6 miles	82.1	71.5	10.6
6-8 miles	80.0	72.2	7.8
8-10 miles	79.5	74.3	5.2
10-13 miles	80.1	75.6	4.5
13-16 miles	80.1	76.7	3.4
16-20 miles	82.3	78.3	4.0
20-25 miles	85.4	81.0	4.4
More than 25 miles	87.3	85.5	1.8

While the difference between the inner- and outermost rings is only about eight minutes in total daily travel time, it is nearly 25 minutes for auto travel time per traveler. This is due to the large fraction of mixed-mode travelers in the inner ring (nearly 40%) and the substantial reduction in auto travel that they generate (nearly 40 minutes in this ring). While the effect of alternate mode use appears to be much greater in this table, this is in part because different influences are being combined here; the differences include both mode-induced variations, and variations across the ring in the time spent by auto-only travelers.

While the relative constancy of total daily travel time across the region does lend some support for the notion that implicit travel time budgets might limit the impact of land use policies on travel in general, this table does support to some degree the idea that mode shifts can have a significant impact on the amount of auto travel, even if not on travel in general. A 25-minute per day difference in auto travel is certainly significant enough to merit further attention, and while recreating inner-city land uses in the exurbs may not be viable, even the difference between the inner two rings is ten minutes per day. The possibility exists that people may have chosen their home location in order to facilitate their mode preferences, and thus that the same land uses somewhere else may not have the same impact; further study to establish the extent of this would be useful. Overall, though, these results indicate that mode-shifting may represent an effective strategy for reducing regional auto travel, at least within a limited range.

Conclusions

These results provide support for a flexible version of a travel time budget hypothesis, as well as mixed support for the claimed travel benefits of smart growth. Clearly total daily travel times increased between 1990 and 2001, so a strict travel time budget in which preferences are fixed and people respond completely to changes in travel conditions cannot apply. However, such a strict interpretation seems implausible anyway; a more interesting approach lies in understanding the underlying factors that influence the degree of elasticity in daily travel times.

A finding that supports the travel time budget concept, as it did in 1990, is that total daily travel time varies only about 10% across the Twin Cities region, despite very significant differences in both local and regional accessibility to work and personal destinations. This indicates that geographically at least, people adjust their behaviors to reflect the benefits and costs of the available opportunities. This to some extent refutes the smart growth notion that having more opportunities close to home should lead to a noticeable reduction in total travel.

Geographical analysis in 1990 indicated that intra-regional variations in total daily travel time were mostly due to differences in commute durations. This seems to be the case temporally as well. There was a small (3%) increase in total travel time by non-workers, and a similar increase in non-commute time by workers. Commute times increased about 10% across the region and this was responsible for about 80% of the total increase in travel times for workers.

While the increase in commute times is roughly the same as the regional increase in congestion delays as reported by TTI, similar commute time increases occurred throughout the state during the 1990s. Thus it is not clear whether the increase in the Twin Cities represented a failure to adjust to increasing congestion levels, or from a shift in underlying preferences that happened universally. Travel time budget theory would not rule out the possibility of changing preferences, but it would generally imply that people should respond to congestion by reducing travel time in some other way, in the same sense that they adjusted to freeway-induced speed increases in the 1960s by increasing trip distances.

Finally, the presence of meaningful choices in terms of non-auto travel modes does appear to have a clear if somewhat limited impact on the amount of auto travel that people engage in. People who use other modes tend to spend more total time traveling than those that just use autos; every two minutes of another mode tends to reduce auto travel by about one minute. In the aggregate this can amount to a reduction of ten minutes a day or more when comparing adjacent areas with differing degrees of alternate-mode facilitation. This is not insignificant, but does point to the need to be cautious in predicting the benefits of mode-substitution policies. They will likely be half of what would be indicated by a simple assumption that trips are fixed and that any auto trip that disappears will not be replaced.

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