The rational locator reexamined: Are travel times still stable?

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Abstract. The rational locator hypothesis posits that individuals can, if they choose, maintain approximately steady journey-to-work travel times by adjusting their home and workplace. This hypothesis was coupled with the observation of long-term stability in drive alone journey-to-work times in metropolitan Washington (those times were unchanged from 1957 through 1968 to 1988). Despite the increase of average commuting distance and congestion, trip duration remained constant or even declined when controlling for travel purpose and travel mode because of shifting a share of traffic from slow urban routes to faster suburban routes. This observation has significance, as it is important to know for travel demand analysis if there is an underlying budget, or even a regularity, as this helps us determine whether our forecasts are reasonable. To re-test the underlying rationale for the hypothesis: that travel times are stable, intra-metropolitan comparisons of travel times are made using Washington DC data from 1968, 1988, and 1994, and Twin Cities data from 1990 and 2000. The results depend upon geography. For the larger Washington DC region, keeping the same geography shows little change in commute times, but using the larger 1994 area suggests an increase in commute times. However, the Twin Cities, starting from a much shorter commute time, shows a marked increase over the decade, using either the smaller or the larger geography. Despite the remarkable continuing observation of stability in drive alone commuting times in metropolitan Washington, we reject the theory of personal commuting budgets, as we find that not only are commuting times not generally stable over time at the intra-metropolitan area, but that commuting time clearly depends on metropolitan spatial structure.

1. Introduction

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

The rational locator hypothesis thus posits that individuals can, if they choose, maintain approximately steady journey-to-work travel times by adjusting their home and workplace. The hypothesis was inspired by the observation of long-term stability in journey-to-work times in metropolitan

Washington (those times were unchanged from 1957 through 1968 to 1988). Despite the increase of average commuting distance and congestion, trip duration remained constant or even declined when controlling for travel purpose and travel mode. Levinson and Kumar (1994) argue that this seeming paradox is due to a decreasing share of traffic using slow urban surface streets and a larger share using faster suburban routes. Even with increasing congestion on suburban roads, they remain faster than city streets. This increasing use of suburban routes results from increasing suburbanization of houses, workplaces, and other activities. The hypothesis that individuals and firms mutually locate to maintain travel times provides a mechanism to account for rising travel distances, rising congestion, but constant travel time or commuting time budgets. While the hypothesis was suggested by stable travel times, it also provides a mechanism to explain why commuting times might rise, but less slowly than the increase in commute distance and congestion would suggest.

We can identify three potential types of budgets. The first is the daily time budget of 1440 min. The second is a daily travel time budget, which has been posited by a number of researchers and is discussed in the following paragraph. Third is the possibility of a commuting time budget, discussed in the previous paragraph, which only relates to trips to and from work. Commuting time is, for workers, the dominant share of travel time, so these two notions are related, but not identical. In particular, commuting time can be seen as a more spatial phenomenon, since the area between home and work (and in a small radius around each) defines an individual's territory, and sets the area where other workday activities may conveniently take place. As transportation speeds have risen over the decades and centuries, the space enclosed by a given commuting time has increased. On the other hand, an overall travel time budget is largely a temporal phenomenon, which relates more to time available for travel and for doing other things.

The stability of overall daily travel time has been granted the status of "law" within parts of the transportation community (Hupkes 1982; Kölbl & Helbing 2003). Travel time budgets have been observed and posited as a basis for analyzing travel demand (e.g. Zahavi 1974; Zahavi & Ryan 1980; Zahavi & Talvittie 1980; Rossi 1997; Shafer 2000), been given an anthropological basis (Marchetti 1994), and disputed as being but one factor in a richer economic analysis (Prendergast & Williams 1981; Tanner 1981). However, Zahavi was not so naïve to think that the budget was rigid: "... time and money budgets are not constant, but they are functions of several variables. For instance, the travel time budget is related to travel speed (level of service) available to travelers and also to car ownership or household income and possibly to urban structure." (Zahavi & Talvitie 1980). Wee et al. (2002) find evidence against

such a budget. Mokhtarian and Chen (2003) reviews the literature on overall travel time budgets and finds it mixed.

The related theory of commuting tolerances implies that individuals who find, that over time, their commute has crept beyond their tolerance due to factors like congestion, will readjust their travel and location choices to make their commute tolerable. Unlike a budget however, a tolerance does not imply that commuters will spend a fixed amount of time, rather that the total amount traveling will be under some level. This has been suggested at least since Getis (1969), and has been reconsidered by van Ommeren et al. (1997). Collectively, the empirical results suggest a tolerance zone in the range of a 30–45 min separation between workplace and home. To achieve a tolerable commute, individuals may relocate their home or workplace. If individuals are concerned about the duration of commute, those who recently moved or changed jobs should have a shorter than average commute. Levinson (1997) examined the relationship between the separation of home and workplace and commute time, and found that those who recently moved had a commute duration that was similar to those who had not recently moved, neither higher nor lower, suggesting people are on average maintaining their commute when relocating. Clark et al. (2003) review the literature on job search and its relationship to the commute, especially long commutes.

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

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

However, the 2000 Census also shows that journey-to-work times have risen since 1990 for most metropolitan areas, seemingly contradicting the commuting or travel time budget observations (Pisarski 2002). In part, this may be an artifact of metropolitan areas extending more broadly in space, thereby including more exurbanites in the analysis (increasing the sample of those with

Figure 1. Vehicle-km traveled (VKT) vs. Lane-km growth in the Twin Cities.

a known preference for or tolerance of long commutes). Part may be due to changing preferences for travel time (people increasing their tolerance for long commutes). And part may be due to congestion rising faster than individuals can adapt by relocating (changing homes or jobs requires a significant transaction cost). Congestion within nearly every metropolitan area continues to worsen both in severity and duration (TTI 2001).

This paper conducts two intra-metropolitan analyses to better understand the responses of individuals to changing travel environments: a statistical analysis of the 1968, 1987–1988, and 1994 metropolitan Washington DC Household Travel Surveys, and the 1990 and 2000 Travel Behavior Inventories from the Twin Cities of Minneapolis and Saint Paul, Minnesota. We use these two cities because of the author’s familiarity, and because of previous literature analyzing questions about travel time budgets in earlier years using these two cases (e.g. Zahavi & Ryan 1980; Levinson & Kumar 1994; Barnes & Davis 1999). Washington DC is a classic monocentric city which developed a number of suburban activity centers; the Twin Cities is a bit more complex in that it has always been bi-centric, though has also seen the emergence of significant suburban employment over the past three decades. This allows us to study the trend of commuting times and to understand the daily allocation of time among different activities, stratifying individuals by work status, gender, mode used, and metropolitan location.

2. Data

We consider within city changes over time. The data used include 1968, 1988, and 1994 household travel surveys in the metropolitan region of Washington DC and 1990 and 2000 home interview surveys of the Twin Cities metropolitan

area. The data collection methodologies for these two regions are largely the same: a weekday was assigned to each of the randomly selected households and information on the demographic, socioeconomic, and trip making characteristics of the residents was gathered (Metropolitan Washington Council of Governments 1997). The 1968 survey used in-person interviews, 1987–88 was mail-out, mail-back, and 1994 was a computer aided telephone interview (CATI). For the Twin Cities, the 1990 and 2000 surveys were mailed out, and the day after the travel day, interviewers called the participating households to obtain and record the travel information for each household member, and enter it into the computer. Each dataset contains a household file, a person file, and a trip file. The household file records vehicle ownership, household size, and household income; the person file records gender, age, and work status; the trip file includes the locations and purposes of the origin and destination of each trip, transportation mode, vehicle occupancy, departure time, and arrival time (thus giving the travel time directly, and allowing us to compute the activity duration).

The 1988 survey of Washington DC consists of a sample of 8000 households and 55,000 trips; the 1994 data involved 5000 households making over 40,000 trips. The 1990 home interview survey in the Twin Cities area was based on 9700 households and 98,000 trips; the 2000 survey includes 6200 households and 58,000 trips.

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

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

The jurisdictions of metropolitan Washington DC for which data were collected in 1988 include the District of Columbia; Montgomery and Prince George's counties in Maryland; Arlington, Fairfax, Loudoun, and Prince William counties in Virginia; and the cities of Alexandria, Falls Church and Fairfax in Virginia. In 1994, the area was expanded to include Calvert, Charles, and Frederick counties in Maryland; Fauquier and Stafford counties in Virginia; and Manassas City and Manassas Park City in Virginia. Similarly, the metropolitan Twin Cities data for 2000 were collected on a larger geographic

area than the 1990 data. In 1990, seven counties were used: Hennepin, Ramsey, Dakota, Anoka, Washington, Scott, and Carver, while in 2000, this number expands to 20 (adding Chisago, Goodhue, Isanti, Le Sueur, McLeod, Mille Lacs, Rice, Sherburne, Sibley, Wright, Pierce, Polk and St. Croix). To examine changes in travel times, the results of the more recent survey are used while both controlling for geographic area and using the larger survey area (no control).

Figure 2 shows the breakdown of the gender and work status for adults (age 18–65) in Washington and Twin Cities surveys. For Washington, the sample size of 1994 is slightly smaller than that of 1988, and the percentage of each category shows little variation. The overall employment rate for women increased from 78 to 82%, while the male labor force participation rate remained at 86%. In the Twin Cities, the overall employment rate for women increased from 73 to 83%, and for men it increased from 90 to 92%.

3. Activity duration

Activity duration is the time spent at an activity, which shows how the 1440 min in a day are allocated to different activities for different groups of people. The duration of each activity is calculated from a travel diary by subtracting the arrival time from the departure time of the next trip. To estimate the duration of the last (or first) activity, assume that the person will make the first trip on the

Figure 2. Sample distribution. Note: Excluding work-at-home.

following day at the same time as that of the previous day. The duration of the last activity is obtained by adding 1440 min to the departure time of the first trip and then subtracting the arrival time of the last trip.

Mean activity duration for the Washington metropolitan region is summarized in Table 1, for the Twin Cities area in Table 2. In both tables, the parameter is classified by the work and gender status for each activity. An examination of median (rather than mean) values gave the same implications, also activity frequencies were calculated, but these tables are not shown for reasons of space.

Table 1 shows that workers and non-workers, males and females spent less time at home in the Washington area. The reduction for male workers is 38 min and for female workers it is 31 min. The male working time apparently increased by 27 min in 1994, for female workers it increased by 29 min. The amount of time

Table 1.

Activity	Year	Work outside home				Non-workers			
		Male		Female		Male		Female	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Home	1968	786	143	831	135	1120	229	1225	164
	1988	799	150	826	153	1143	196	1165	187
	1994	761	131	795	129	1093	219	1155	190
	1994(full)	760	133	797	132	1104	219	1158	194
Work	1968	515	143	487	116	0		0	
	1988	472	173	447	165	0		0	
	1994	499	145	476	133	0		0	
	1994(full)	498	149	473	133	0		0	
Work-related	1968	0		0		0		0	
	1988	0		0		0		0	
	1994	20	72	10	49	0		0	
	1994(full)	21	75	10	48	0		0	
Shop	1968	7	24	10	32	27	62	52	77
	1988	10	41	13	41	31	62	50	90
	1994	8	28	13	28	33	75	47	77
	1994(full)	8	27	13	28	34	75	47	76
Other	1968	44	100	29	76	217	214	101	143
	1988	61	118	62	112	187	187	140	156
	1994	47	78	47	75	220	204	154	165
	1994(full)	46	77	48	76	207	197	149	163
Travel	1968	88	51	82	48	76	58	62	50
	1988	99	63	92	61	80	64	85	73
	1994	104	57	99	56	93	69	85	67
	1994(full)	108	60	100	57	95	73	86	72

Note: **Bold Italics** indicates 1988 baseline, or cells not statistically different from 1988 using a two-tailed *t*-test at 95% confidence level. Normal font indicates cells are statistically different.

Table 2. Mean activity duration per day (in min) for 1990 and 2000, Twin Cities metropolitan area, adults 18–65.

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

Note: **Bold Italics** indicates 1990 baseline, or cells not statistically different from 1990 using a two-tailed *t*-test at 95% confidence level (indicates $t < 1.96$). Normal font indicates cells are statistically different.

spent at home declined by about the same as the amount of time increased at work. Simply put, workers work more at the expense of lost leisure time.

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

The Twin Cities data show similar patterns but different magnitudes. As shown in Table 2, workers in this area worked more in 2000 than in 1990, but not as much as those in the Washington region. The increase in this decade for both men and women was approximately 10 min. As in Washington, people spent less time at home. For non-workers, the time is reduced by 50 min.

In Washington, the time spent at travel increased for all groups of people, and so did the number of trips. For the same geographic area, the travel time for all people increased from 93 to 98 min, a 5% increase; while for the whole survey area in 1994, the number is 100 min. In the Twin Cities the time spent at travel rose from 84 min to 90 min when controlled for the same geographic area. When the analysis moves to the larger area, the travel time remains the same.

4. Travel duration

The interesting finding of a rise in overall travel time needs to be elaborated upon. In order to study the change of travel times, trips are stratified by purpose and mode. For Washington DC data, the seven purposes are: home-to-work, work-to-home, home-to-other, other-to-home, work-to-other, other-to-work, and other-to-other. The travel modes are auto-1, auto-2, auto-3, and transit, which are defined above. The purposes for Twin Cities that are considered are work and other trips (both home-based) and the modes are cars and buses.

As noted earlier, previous studies showed that the auto drive-alone commuting times remained constant between 1968 and 1988 in the Washington metropolitan region. Table 3 summarizes the average travel time in peak period and sample size for the metropolitan region by mode and by purpose for 1988 and 1994. Results with control and no control for the geographic area are compared.

Home-to-work and work-to-home commutes are longer than trips for other purposes. As shown in Figure 3, the travel time for these two purposes has remained constant over the six year for the drive-alone mode (auto 1). The average time for home-to-work trips stayed at 29.6 min and for work-to-home trips, it remained at slightly over 33 min. However, for the modes with higher occupancy, the travel time for these two purposes increased. (Examining medians rather than means gives the same basic conclusion).

Figure 3 also compares the commute time with and without control for geographic area. As expected, all the trips using the larger geography took a longer time. For the Twin Cities, as summarized in Table 4 and Figure 3, the average travel time of home-based work trips for drive-alone commuters increased from 22.6 min in 1990 to 27.2 min in 2000. For the other purposes, travel times show the same pattern as the home-based work trips. Furthermore,

Table 3. Average travel time (in min) for the metropolitan Washington region by mode and by purpose (a.m. and p.m. peak period).

Mode	Year	Purpose						
		Home to Work	Work to home	Home to other	Other to home	Work to other	Other to work	Other to Other
Auto-1	1988	29.6	33.4	17.8	21.6	26.4	23.8	17.7
	1994 (7co)	29.6	33.3	16	16.5	25.9	21.4	14.3
	1994 (full)	30.5	35.2	17.2	17	26.8	22.2	15.5
Auto-2	1988	31.6	35.7	16.8	19.3	23.6	29.5	16.6
	1994 (7co)	33.8	40.4	17.1	16.7	31.7	25.3	16.8
	1994 (full)	33.7	42.5	17.3	16.9	30.4	24.7	17
Auto-3	1988	37.8	43.1	18.8	19.2	29.8	28.9	18.6
	1994 (7co)	41.7	45.7	20.1	17.3	42.7	36.5	16.5
	1994 (full)	41.8	48.6	19.2	17.9	41.3	39.2	17.6
Transit	1988	43.2	49.6	35.8	37.5	38.4	31.5	34.7
	1994 (7co)	47	54.5	57.8	44	47.1	43.7	55.4
	1994 (full)	47.4	55.3	58.5	44	48.5	46.1	55.6

Note: **Bold Italics** indicates 1988 baseline, or cells not statistically different from 1988 using a two-tailed t -test at 95% confidence level (indicates $t < 1.96$). Normal font indicates cells are statistically different.

travel times increase by about the same amount using either the same geographic area for 2000 or the larger geographic area.

We compare intra-county work trips to try to control for origin and destination location. This is shown in Figure 4. Perhaps, work trips are taking longer due to people traveling farther. This seems not to be the case in the Twin Cities. Greater shares of trips were intra-county in 2000 than 1990. Moreover, every intra-county pair had higher travel times in 2000 than 1990. While it is possible to make a longer trip while remaining within the same county, we suspect the dominant factor is rising congestion – travel speeds dropping faster than people can relocate to manage their commutes. It is also possible people are indifferent to small changes in commute times below a threshold (tolerance theory) (say the 30 min or so Washington DC has), and so strong preferences have yet to kick in.

5. Summary and conclusions

It was previously observed in metropolitan Washington DC, over the same geographic area, the average commuting times remain stable between 1968 and

Figure 3. Change in travel time.

Table 4. Average travel time (in min) for the metropolitan Twin Cities region by mode and by purpose (a.m. and p.m. peak period).

Mode	Year	Work	Other (Home-based)
Auto-1	1990	22.6	14.8
	2000 (7co)	27.2	17.6
	2000 (full)	27.0	17.8
Auto-2	1990	23.1	14.7
	2000 (7co)	24.6	16.4
	2000 (full)	25.5	16.4
Auto-3	1990	24.2	14.9
	2000 (7co)	23.8	15.7
	2000 (full)	28.6	16.5
Bus	1990	32.9	29.2
	2000 (7co)	42.0	33.7
	2000 (full)	42.0	33.2

Note: **Bold Italics** indicates 1990 baseline, or cells not statistically different from 1990 using a two-tailed *t*-test at 95% confidence level (indicates $t < 1.96$).

1988 despite the increase in commuting distance and congestion. (And the numbers are the same as found in Whyte (1957).) Fixing the area for 1994 to be consistent with the area from 1988 shows commuting times that are statistically equal (though higher) (and for drive-alone commuters, identical). Nevertheless, considering the new larger metropolitan area, the commuting times in 1994

Figure 4. Twin Cities intra-county drive-alone home-based work trip travel time (min).

show a 10% increase over 1988. Overall, time spent traveling rose as well (by 5 min in the same area, 7 min in the larger area), thus continuing a trend from 1968 (time spent traveling between 1968 and 1988 increased from 72–95 min).

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

What do these results imply for metropolitan transportation planning? One could suppose that there is a travel time tolerance. So long as commuters are well under the tolerance, they will not necessarily make decisions to maintain or reduce commuting duration. But when the tolerance is reached, unwillingness to travel more may dominate other considerations. However, to call this a budget may overstate the case; some people will make long trips while opportunities are there, and others will not; it is simply a matter of individual preferences. People will be willing to travel farther in areas with more opportunities (large cities), but as cities grow in size, the amount of extended travel exhibits diminishing marginal returns. Imposing a simple budget on metropolitan models is wrong, although incorporating real, congested travel

times in travel demand (trip distribution, mode choice) modeling (ensuring an equilibrium between supply and demand) still seems warranted.

These findings do raise interesting questions concerning geographical analyses of this type. Clearly expanding the region increases commuting times, as exurbanites (who have fewer nearby job opportunities) have longer commutes than those who live closer in (who have many nearby opportunities). There may be some off-setting effects, commuter rail or Metro in the DC region and HOV in both regions increase the speed for some commuters in specific corridors, but cannot fully compensate for the increasing distance traveled. To the extent that the recent rise in commuting times is associated with simply increasing the area considered “metropolitan”, it is a statistical artifact. But when times increase within the same geographical boundaries because of congestion, or a willingness to spend a greater time traveling to achieve other objectives (e.g. a larger house), we have a more severe problem. As most metropolitan areas are growing faster in space than in population, that may indicate an increasing willingness to trade-off time for space, or an inability to rationally relocate to compensate for rapidly rising congestion.

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