Operational Evidence of Changing Travel Patterns: A Case Study

BY DAVID M. LEVINSON AND AJAY KUMAR

An understanding of travel patterns is of key interest to transportation planners, researchers, engineers and policy analysts. The concern with the environment and traffic congestion and the focus on the balance between available supply and the resulting demand in view of the scarcity of fiscal resources has strengthened the need to better monitor travel behavior. This research uses traffic count data collected between 1976 and 1985 in Montgomery County, Maryland, a suburb of Washington, D.C., to shed fresh light on changes in patterns of traffic. To the authors' knowledge, no attempt has been made to analyze traffic count data to corroborate changing travel patterns.

A number of travel patterns have been identified in earlier analysis of person- or household-based travel surveys.[1-5] These relate to changes in directionality, purpose, mode and time of trips. These surveys have the advantage of being able to track an person's reported travel behavior and relate this behavior to demographic and geographic characteristics. However, surveys are limited in their dependence upon individual recall of travel behavior. A serious self-reporting bias exists in any survey and is evident to most analysts of travel data. Moreover, special effort and expense is required to conduct household travel surveys, thus they are conducted infrequently, often less than once a decade.

Traffic counts, which directly measure volumes, are a more accurate measure of traffic patterns on specific facilities than could be obtained from any household travel survey. Measurement of roadway and intersection traffic volumes is an established field of traffic engineering utilized for several purposes, including signal design, highway engineering and measuring congestion. Traffic counts are routinely and frequently collected by most transportation departments. The relative usefulness of the data, however, is limited because of its inability to relate vehicles to specific trips. It is, however, possible to analyze direction of traffic, quantify traffic volumes during specific time periods and compare morning with afternoon traffic volumes.

Based on survey findings that a predominant share of vehicular traffic during the morning peak period is for work trips as compared with the afternoon peak, which also accommodates a large number of nonwork trips, it is possible to comment on the nature of nonwork travel from traffic counts.

This analysis concludes that there has been a faster increase in lateral (suburban-suburban) travel as compared to radial (suburb-city) and reverse radial (city-suburb) trips; that vehicular traffic volumes are greater in the afternoon peak than the morning; and that the peak is spreading. An interesting conclusion relates to a more pronounced directionality in radial as compared with lateral trips. This suggests that better use is made of existing roadway facilities by suburb-to-suburb travel than by the traditional suburb-to-central city trips. Nonwork trips emerge as the more elastic trips, shifting out of the peak with an increase in congestion.

Data

Intersection traffic counts taken from 1976 to 1985 form the data set used in this analysis. These counts, collected for the Montgomery County Department of Transportation, taken at intersections throughout the county, measure turning volumes in half-hour intervals for the 7–9 a.m. and 4–6 p.m. periods. Aggregation of turning volumes into link volumes was made before analysis. Periodic recounting provides time series data on the directionality and peaking of traffic flow. The data was entered into an electronic database by the Montgomery County Planning Department (MCPD) in half-hour intervals.

An intersection count of a typical four-leg intersections results in eight link traffic counts. In this analysis, 468 directional links scattered throughout the county are studied. Figure 1 shows the intersections in Montgomery County where these counts were taken. These links had multiple counts taken in the period from 1974 to 1986. Data on each link was not collected every year. Missing years were interpolated from available data to provide an estimated count for each year in the period from 1976 to 1985.

Montgomery County Trends

Montgomery County is a large suburban jurisdiction located directly to the northwest of Washington, D.C., with an area of just more than 500 square miles. During the time period from 1976 to 1985 there has been a large growth in population and employment, accompanied by a small growth in transportation supply.

Table 1 shows the change in important statistics for this period, derived from data used as part of the Montgomery County General Plan Refinement.[6] A 22 percent increase in the number of households and a 7 percent increase in population are accompanied by a 12 percent decline in average household size. At-place employment increased by 20 percent in the county, indicating a significant decentralization of jobs in the region from the Washington core to suburban activity centers. In addition, the proportion of the population aged 15 to 75 in the labor force increased from 60 percent to 77 percent, indicating additional female labor force participation, deferral of retirement and more part-time, teenaged workers.

Rising income because of the increased number of workers is associated with an increase in vehicle registrations (including passenger cars, vans and pick-up trucks) of 41 percent and in vehicles per household from 1.94 to 2.24. However highway capacity did not increase to accommodate this increase in demand factors, the number of lane miles of state roads (representing the most important roads in the county, including freeways, major highways and many principal arterials) increased by only 2 percent. Estimates of total annual vehicle miles of travel on Montgomery County roads increased by 35 percent from 2.6 billion to 3.5 billion.

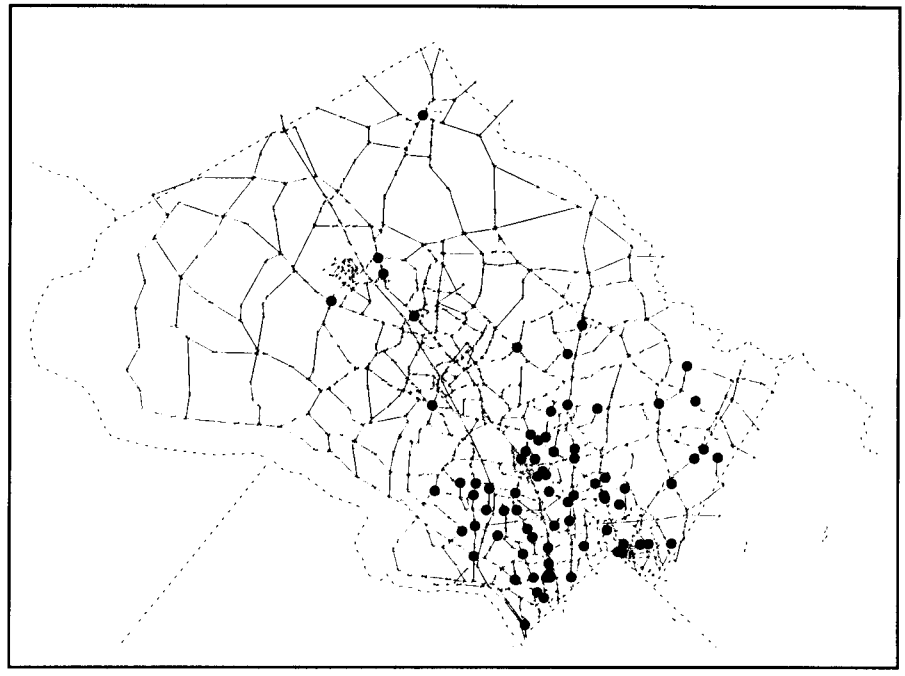

Figure 1. Montgomery County road network and sites of traffic counts.

Table 1. Montgomery County Trends

	1976	*1985*	*Change (%)*
Households	193600	236000	22%
Population	585000	628000	7%
Average Household Size	3.02	2.66	-12%
Employment	274000	330000	20%
Vehicle Registrations	374827	527742	41%
Vehicles per Household	1.94	2.24	16%
Labor Force Participation	60%	77%	28%
Lane Miles of State Roads	1098	1122	2%
Annual Vehicle Miles Traveled ('000)	2586275	3490378	35%

Source: Montgomery County Planning Department

Volume Trends

The objective of this study is to throw fresh light on the direction and volume of changes in trip patterns based on traffic counts. Because of the geographical location of Montgomery County relative to the regional center in downtown Washington, radial commutes involve more travel on north-south than on east-west corridors. An exception to the general trend is that some suburban-to-suburban commutes might also involve predominantly north-south movement, particular considering the corridor arrangement of Montgomery County's major employment centers along Interstate 270. In general though, east-west movements can be considered as largely composed of suburban-to-suburban trips, while suburban-to-urban core trips are a predominantly north-south movement.

Decentralization of employment from regional central business districts to suburban activity centers is a long-term trend in metropolitan Washington and nationwide.[7-11] Thus, more suburb-to-suburb movements would be expected. Table 2 shows that lateral east-west movements have a faster growth rate (27 percent) than radial north-south in the morning peak (18 percent), but reveals that radial movements are still increasing more in absolute terms. Table 3 shows the same information for the peak half hour, with nearly identical growth rates. Radial movements started from a much larger base, and it can be anticipated that if the rates of growth remain stable, that even in

Table 2. Morning and Afternoon Peak-Period Average Traffic Volumes, by Direction

Traffic Direction	1976 AM	1976 PM	1985 AM	1985 PM	% Change AM	% Change PM
Northbound (S-N)	1024	2073	1184	2405	16%	16%
Southbound (N-S)	1983	1337	2374	1583	20%	18%
Eastbound (W-E)	1037	1280	1314	1488	27%	16%
Westbound (E-W)	1017	1177	1289	1495	27%	27%

Note: Morning peak period is from 7-9 a.m.
Afternoon peak period is from 4-6 p.m.

Table 3. Morning and Afternoon Peak Half-Hour Average Traffic Volumes, by Direction

Traffic Direction	1976 AM	1976 PM	1985 AM	1985 PM	% Change AM	% Change PM
Northbound (S-N)	324	599	366	677	16%	16%
Southbound (N-S)	596	393	694	446	20%	18%
Eastbound (W-E)	315	468	393	419	27%	16%
Westbound (E-w)	313	349	387	432	27%	27%

Note: Peak half hour is defined for each link separately as the 30-minute interval of highest traffic volume.

Table 4. Ratio of Peak Half Hour to Peak-Period Average Traffic Volumes, by Direction

Traffic Direction	1976 Am	1976 Pm	1985 Am	1985 PM
Northbound (S-N)	0.32	0.29	0.31	0.28
Southbound (N-S)	0.30	0.29	0.29	0.28
Eastbound (W-E)	0.30	0.37	0.30	0.28
Westbound (E-W)	0.31	0.30	0.30	0.29

absolute terms, lateral movements will be increasing faster in the near term. The trend towards an increase in lateral trips as compared with radial trips has been reported in earlier research.[12] The corroboration of that hypothesis using traffic counts provides the opportunity to closely monitor this trend on a yearly basis to provide for additional facilities and to alleviate specific bottlenecks.

Spreading of the Peak

Transportation theory suggests that several behavioral responses to congestion can occur, including changes in route, mode, retail destination, workplace, household location, activity sequence and departure time.[13] Changes in route and departure time are the least drastic and shorter term responses. The choice of route often is constrained by the number of feasible and practical routes available between two points. Change in departure time is constrained by schedules, in particular the time at which arrival and departure from work are specified. However, some people are more flexible than others. In the aggregate, it would be expected that as the peak half-hour or peak hour becomes more congested, some people with flexibility will change their time of departure.

The traffic count data bears this out, with a small change in the proportion of peak-period volume, which occurs in the peak half hour. Table 4 shows the ratio of traffic volumes during the peak half hour to peak period for 1976 and 1985. If volumes were uniform, it would be expected that 25 percent of peak-period (two-hour) traffic would occur in the peak half hour. In the observed data, for the larger radial movements, the actual proportion declined on average 2 percent to 3 percent. Furthermore, many trips that in 1976 were made in the peak period might have been pushed out of the peak period entirely, a phenomenon that could not be measured with this data. This fact might explain why total annual all-day vehicle miles of travel, shown in Table 1, increased by 35 percent, while peak-period travel increased between 16 percent and 27 percent.

Reverse Commuting

There is interest in reverse commuting as a means to relieve traffic congestion by using currently underused transportation capacity in the off-peak direction. Table 2 shows that on radial routes the morning peak period became more directional in the 1976 to 1985 period, with peak direction southbound travel increasing faster than off-peak northbound travel. However, Table 2 also shows that the afternoon became less directional, with off-peak southbound travel increasing faster than peak northbound travel. This indicates a declining share of reverse commuting. The morning imbalance demonstrates work and school based nondiscretionary travel is more peaked than afternoon trips, which are more often linked to retail destinations and are thus less directional. With little growth in housing in the metropolitan core, reverse radial commuting is unlikely to increase significantly.

Discretionary and Nondiscretionary Travel

The next issue of interest to transportation professionals relates to changes in purpose of travel. Nondiscretionary trips are characterized by specific destination and arrival time requirements. Work trips or school trips typically are nondiscretionary trips. Similarly, trips made to pick up or drop off a passenger, such as a child at day care, would also be characterized as

nondiscretionary. Discretionary travel is more flexible on either destination or departure time. In this artricle, discretionary travel is used synonomously with nonwork travel. Shopping at a regional mall or eating dinner out can be considered discretionary travel. Recent research comparing the United States Nationwide Personal Transportation Survey between 1983 and 1990 reported a significant increase in discretionary travel.[1]

Direct attribution of trip purpose to a traffic count can only be made at select locations, such as shopping center driveways. However, discretion of travel or the ability to make a trip at some other time, is of high interest. Some inferences can be made using the following assumptions. According to a local household travel survey about 80 percent of travel during the morning peak period is classified as nondiscretionary, usually home to work or home to school trips, perhaps with intermediary stops for dropping off or picking up of passengers.[14] The afternoon peak period has more discretionary travel, such as shopping or visiting, which are not generally fixed in time, constituting about 50 percent of all trips.

The difference between the morning and afternoon periods in terms of volume therefore can be ascribed to a large extent to the discretionary trips that occur in the afternoon and not in the morning. Trips to shopping and recreational centers are more likely to be made on the return trip from work. More caveats on the use of this data include the fact that many trips that are one-way in the morning from home to work or school, might return home before or after the two-hour afternoon peak period for which traffic counts were collected. This is mitigated in part by trips leaving home before or after the two-hour morning peak period and returning in the afternoon peak period.

Table 5 shows the difference between morning and afternoon peak period traffic volumes for 1976 and 1985. The difference between morning and afternoon peak and off-peak directional flow is expected to reflect the change in discretionary travel during the afternoon period. Northbound traffic during the afternoon period represents peak-direction flow as the Washington D.C. core is the region's largest employment concentration during this period, workers commuting from work in Washington to home in Montgomery County are traveling northbound. In the lateral direction the pattern is less clear; however, employment centers in the western part of Montgomery County are numerous, suggesting that traffic in the eastbound direction during the afternoon peak would represent the peak direction.

Two points can be made from this table: As expected, afternoon trips are always greater than the morning trips in the reverse direction, largely explained by the additional travel for discretionary purposes in the afternoon; and more interesting, between the years 1976 and 1985, a higher discretionary traffic growth in the peak period is observed along the direction with lower traffic volumes. The converse of this observation also appears to hold: Traffic for discretionary purposes in the direction with higher volumes in fact exhibits a smaller traffic growth rate.

Table 5. Difference Between Morning and Afternoon Peak-Period Average Traffic Volumes, by Direction

Traffic Direction	*1976*	*1985*	*% Change*
Radial Peak	90	31	-66%
Radial Off-Peak	313	399	27%
Lateral Off-Peak	140	181	29%
Lateral Peak	263	199	-24%

Peak-direction traffic during the morning period is represented by southbound traffic, while during the afternoon the peak direction is represented by northbound traffic. In the lateral direction, westbound traffic in the morning and eastbound traffic in the afternoon represent the peak direction. The first row in Table 5 gives the difference between southbound traffic during the morning and northbound

traffic in the afternoon for 1976 and 1985. Northbound traffic during the afternoon peak period was greater than southbound traffic during the morning period by 90 vehicles in 1976. In 1985, the difference declined to 31 vehicles, indicating that the discretionary travel purposes are the most elastic with respect to congestion (or an increase in traffic). Discretionary trips are the first to be pushed out to shoulder hours.

The second row in Table 5 gives the growth in "reverse radial" traffic, radial traffic in the off-peak direction. Discretionary traffic grows to fill the available roadway capacity if congestion is not perceived as a constraint. There is no direct evidence on the level of congestion in each direction, but the fact that off-peak direction volumes are on average about 60 percent of peak-direction volumes would suggest availability of road capacity in the off-peak direction given the large symmetry of the road network. A change of similar nature is observed for lower traffic volumes in the eastbound direction in the morning, though volumes in each direction are much more balanced laterally than radially. The elasticity of discretionary trips gives credence to the argument extended by Gordon et al.[2] that road congestion pricing would help to dislodge the growing number of peak nonwork trips.

Conclusion

This analysis reviewed traffic count data to identify changing travel patterns. Peak volumes on suburban links are increasing faster than population. The number of suburb-suburb trips, as measured by volumes on lateral links, is increasing faster than radial, suburb-to-central city trips. In the off-peak directions with underutilized transportation capacity, discretionary travel is increasing as a share of trips, but in the congested peak directions, discretionary travel is declining in the peak period. This suggests that the growing congestion in the past decade largely can be attributed to a growth in nondiscretionary travel during the peak period, although volume increases in peak and off-peak directions are a result of both rising work and nonwork travel.

Comparing the peak half hour to the two-hour peak shows a small amount of peak spreading within the peak. Afternoon trips are less directional than the morning, indicating more afternoon discretionary travel, which is expected. Over time, radial trips have become more directional, while lateral trips are becoming less so. This indicates that lateral, suburb-to-suburb trips are making better use of the available road network than are the more traditional radial trips.

Acknowledgments

The authors would like to thank the Montgomery County Planning Department for providing the data for this analysis. The views expressed herein are those of the authors and do not necessarily represent those of the Montgomery County Planning Department. In addition, the authors would like to thank Michael Replogle of the Environmental Defense Fund, Bob Winick of Comsis Corp. and Peter Gordon of the University of Southern California for their comments on earlier drafts of this work.

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David M. Levinson has been a transportation planner with M-NCPPC since 1989. He received a B.S.C.E. from the Georgia Institute of Technology and an M.C.E. from the University of Maryland. He is an Associate Member of ITE.

Ajay Kumar, Ph.D., has been employed by the Maryland-National Capital Park and Planning Commission (M-NCPPC) since 1989. He holds a B.Sc. and M.Sc. in physics from the University of Delhi, India, and Ph.D. in urban and regional planning from the University of Southern California, Los Angeles.