Do You Work From Home?

Studying the Travel Behavior of Telecommuters

A MURP **Professional Paper**

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I. INTRODUCTION

Telecommuting is defined as "work at home or in an office close to home". Telecommuting programs have increased substantially over the past years and have created flexible work options to employees. On the other hand, researchers and policy makers have been trying to study the impact of these telecommuting programs on travel behavior.

The desire to telecommute by employees has been increasing over the years. Telecommuting is has become an area of interest not only to employees but also to employers, transportation planners, communities, telecommunications industry, and others. Following the 1996 National Telecommuting Initiative Action Plan, government agencies are required to make telecommuting part of their overall strategy to improve services and working conditions.

Research has shown that telecommuting has individual benefits to employees. It decreases stress, allows flexible work timings, and increases free time. Telecommuting may have important benefits for working parents and single parent households. For example, they may value highly the timesavings that telecommuting provides (due to elimination of a commute trip) because it allows them to increase the limited time they spend with their children. Organizational benefits include improved work productivity of the employees. Transportation planners see telecommuting as a way to combat increasing congestion, increasing energy use, and declining air quality. Communities may see telecommuting as a potential economic development strategy. Telecommunications companies, computer and peripheral manufacturers, and software developers see telecommuting as a promising new market for their products.

There are also other issues that have to be considered to determine the feasibility of telecommuting. All types of work are not conducive to telecommuting. The nature of employment is an important factor in deciding whether one can work at home or not. Data input and computer programming are classic examples of 'telecommutable' jobs. Jobs that require physical presence are not 'telecommutable'. Also, all potential telecommuters cannot be provided the opportunity to telecommute. The employers should have the infrastructure to provide their employees the option to telecommute. The main factor that comes into play here is cost, because telecommuting may require the installation of high speed and sophisticated home-office equipment by the employer. However, with the increase in the number of telecommuters in the work force rising, many employers are considering telecommuting as a cost effective way to save office space, and improve employee productivity. In instances where the employers support the concept of telecommuting but are not able to pay for the establishment of a home office, the employees themselves are paying for the infrastructure so that they can telecommute.

It is interesting to study the travel patterns of telecommuters and how they differ from those of non-telecommuters. Due to their flexible work schedules, telecommuters do not seem to follow the regular travel patterns of non-telecommuters for their work trips. Not only work trips, household trips should also be compared to study the travel patterns of telecommuters. Also, the use of technology by telecommuters like emails, internet shopping and banking may differ from those of non-telecommuters. As a planner it is also interesting to study where telecommuters locate themselves in the context of an urban landscape. Telecommuting can permit geographic decentralization of residential developments. Telecommuters might move far away from the urban core to the suburbs because they need not bother about commuting every morning. This might also lead to the development of isolated "high-tech" suburbs far away from the urban core, that are basically "telecommuter" neighborhoods equipped with modern technology like high-speed internet access and telecommunications. On the other hand, the number of miles traveled might increase due to the increase in the distance between origins and destinations.

This paper is an effort to study these patterns of telecommuters and their impact on transportation and urban planning. To accomplish this, a literature review of previous research was conducted to gain a better understanding of the central issues, their success in answering the research questions and also their shortcomings. Data collected from two surveys was used in two separate analyses and studied. The first one was a survey conducted by the State and Local Policy Program, University of Minnesota in 1998. The second data set came from the Travel Behavior Inventory (TBI) Survey conducted by the Minnesota Department of Transportation in 2000. Details about these surveys are given later in the study.

II. LITERATURE REVIEW

The potential of telecommunications to mitigate urban traffic congestion and improve air quality through reducing the need to travel has in recent years captured the attention of public planners and policy-makers. The application of telecommuting offers particularly appeal since it addresses a number of other policy issues such as the ‘family-friendly’ workplace (Gordon, 1996a) and employment opportunities for mobility-limited sectors of the labor force (Hesse, 1995).

Over the past decade, a number of overviews of the impacts of telecommunications on travel have appeared both conceptual (Salomon, 1986; Mokhtarian, 1990) and empirical (Nilles, 1988; Mokhtarian, 1991; Mokhtarian *et al.,* 1995). Most of the empirical research has focused on telecommuting, probably because: it has been feasible for longer than most other ‘tele-applications’ (such as video conferencing or online-shopping); it has the appealing side benefits alluded to above; and the prospect of eliminating or reducing the peak-period commute trip is especially attractive. Although its share of total trips (but not miles) is declining, commuting still accounts for more trips (26 per cent in 1990) and miles traveled (32 per cent) than any other single purpose (Hu and Young, 1992). Also, it may well be the case that a higher proportion of commute trips than other types of trip will be amenable to substitution through telecommunications. Both factors combined mean that telecommuting probably has the highest potential for travel reduction of any of the tele-applications, which undoubtedly justifies a continued interest in the study of its adoption and impacts (Mokhtarian, 1998). Mokhtarian in this paper calculated the expected number of people who are in a period of active telecommuting at any given time using the following model:

$T = E \times A \times W \times C$

where, E = an average number of people employed within a certain time-frame; A = the proportion of workers who are able to telecommute; W = the proportion of those able to telecommute who want to; C = the proportion of those able and wanting to telecommute who choose to; and F = the average frequency of telecommuting; as expressed as a fraction of a five-day work week. The average number of people telecommuting on any given day, that is the expected number of telecommuting occasions, is estimated by:

$O = E \times A \times W \times C \times F = T \times F$

The numbers T and O illustrate the difference between the concepts of telecommuting *penetration* and *levels,* respectively, discussed in Handy and Mokhtarian (1995). Based on this model, the miles saved by telecommuting was 1% of total household vehicle trips, miles driven by telecommuters on telecommuting trips on telecommuting days was 0.7%, miles driven by telecommuters on non-telecommuting weekdays was 5.4%, miles driven by telecommuters on weekends and by non-telecommuters on all days was 92.9% in the base case (Mokhtarian, 1998).

In 1991, Caltrans conducted a statewide travel survey (Ochoa and Jones, 1983). Nearly 34,000 individuals provided travel information for a 24-hour period on a weekday. Respondents recorded trip data in a “memory jogger” format, later retrieved through telephone interviews. Each respondent was weighted appropriately to replicate the 1990 Census distributions in terms of household vehicle ownership, owner-renter status, and geographical location (Mokhtarian and Henderson, 1998). Conclusions from this study were that home-based business (HBB) workers had the highest average daily unlinked trip rate at

6.1 trips per day. However, much of the difference between HBB and NHB (non-home based workers) trip rates (5.3 per day) lied in a higher frequency of bicycle/walk trips in the former group. As expected, HBTs (home-based telecommuting workers) had the lowest total trip rate (5.2 per day), but in marked contrast to other studies, the rate is statistically equivalent to the rate of NHB workers. On the other hand, the difference in *drive-alone* trip rates to previous results, with HBTs and NHB workers are comparable to previous results, with HBTs making an average of 0.6 (18%) fewer drive alone trips per day.

However, it is found that telecommuters in their telecommuting make essentially the same number of total trips as conventional workers, compared with telecommuting-day decreases of up to two full trips per day in previous studies. Also, this study focused on travel behavior at the individual level for maximum comparability with earlier telecommuting studies, but as a regional travel demand-forecasting model typically done with the household as the unit of analysis, it would be of interest to take the same perspective with this sample. Future similar data collection efforts would be far more valuable if information on occupation and trip length were obtained. Further, collecting data across a multi-day period would permit a direct comparison of travel of home-based workdays versus other days (both within the two home-based groups and across all three groups).

In a study of center-based telecommuting, for example (Balepur et al., 1998), it was found that although telecommuters traveled 65% fewer vehicle-miles on a telecommuting day than on a conventional commuting day, when travel on each day type was weighed by the frequency of occurrence of each type of day, the overall reduction in weekday vehicle travel for telecommuters was only 17% of their non-telecommuting baseline.

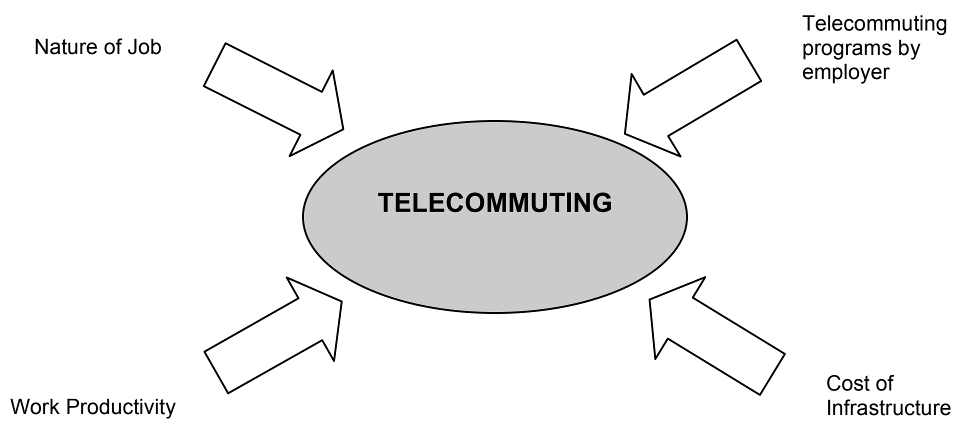
Empirical research has found that, on workdays, both numbers of vehicles trips and vehicle miles of travel are significantly lower for telecommuting that for similar workers who do not telecommute (Helling and Mokhtarian, 2001). These reductions are due to eliminating commute trips. Telecommuters significantly reduced both number of personal trips vehicle trips (27 per cent reduction) and vehicle miles traveled (VMTs) (77 per cent reduction) on telecommuting days compared with days before they telecommuted (Koenig et al., 1996). The trips that telecommuters do make on telecommuting days tend to be more closely clustered around the home than those they make on non-telecommuting workdays (Saxena and Mokhtarian, 1997).

Many of these studies have studied whether telecommuting increases or decreases the number of miles traveled. But, there are many other factors that affect telecommuting and the decision of people to do so. The most important thing is to look at travel data at the household level instead at the individual level. Also trip linking information is very helpful in predicting the travel patterns of telecommuters. Following are the various factors affecting telecommuting:

Decision to Telecommute

The decision to telecommute is affected by the fact whether the employer provides telecommuting options to his employees. The next issue is whether the nature of the job is conducive to telecommuting. The next issue is what the organizational constraints are if an employee wants to telecommute. Several employers offer telecommuting to eligible employees on a waiting list method. They approve or grant only a certain number of telecommuting applications each fiscal year. While some employers pay for the infrastructural costs for a home office, some do not. In this case, employees have to make sure that they are properly equipped with high-speed internet access, faster computers and dedicated home office spaces in order to be productive in their work.

Figure 1. Factors affecting telecommuting at organizational level.



Telecommuting and Technology

During the 1990s the world saw a rapid increase in the use of technology. Use of mobile telephones, electronic mail (e-mail), the Internet, and electronically enabled commerce (e-commerce) has become widespread. This widespread use of technology has altered the manner in which we do business or work.

Telecommuting may not have been possible if there was not such an increase in technology use. *Teleprocesses* are all of the new work techniques and arrangements of organizations and individuals that voice, data and video telecommunications allow (Niles, 1996). Such processes include *telework*, which affects the locations of workers in ways that may go beyond telecommuting. Telecommuting is just a fraction of telework.

Without sufficient technology, telecommuting may not be possible or might not be allow productive work environment. For example, Fiber-to-the-Home (FTTH) is providing faster internet speeds and other telecommunications right into the residences in neighborhoods. These neighborhoods are technology savvy and allow their residents to participate in telecommuting programs. This technology is not only used for telework, but also for online shopping and commerce.

Telecommuting and Travel

Travel patterns of telecommuters can be studied by broadening the scope of the study instead of a single application. The issue whether telecommunications replaces travel or generates it was based on the nature of the studies conducted. To synthesize these results, researchers have pointed out that the *substitution* effect is more like likely to be short-term and direct and to occur within the boundaries of the process being studied, whereas the *complementary* effect is more likely to be long-term and indirect and to occur outside the scope of the studied process. It is difficult to assess the complementary effect quantitatively.

It cannot be concluded that telecommuting decreases the number of miles traveled. Various factors come into play, for example, telecommuters might be located further away from their workplace than non-telecommuters. Also, the number of days in week that a person telecommutes is also a factor. If, for example, a telecommuter, telecommutes only two days a week, and lives further away from his workplace when compared with his fellow non-telecommuter, the total commuting miles traveled may turn out to be the same. The total number of household trips may be studied to see if the telecommuter households travel less when compared to non-telecommuter households.

III. 1998 SLPP SURVEY

Survey Method

As a first attempt to study the travel pattern of telecommuters, data from a survey conducted by the State and Local Policy Program, University of Minnesota was studied and analyzed. This data was collected from a survey administered in 1998 to a cross section of respondents in two large organizations in the Twin Cities Metro Area (Fingerhut Companies and Hennepin County Government Agencies), each representing a different sector of the economy. Fingerhut Companies initiated a formal telecommuting program in 1996. During the time of the survey, approximately 200 employees were involved in formal telecommuting agreements. Also, formal telecommuting was restricted to only two departments. Every member of both departments, including the 200 telecommuters, was invited to participate in the survey. Altogether, 276 (170 non-telecommuters, 106 telecommuters) of the 550 surveys were returned providing a response rate of 50%.

Hennepin County government initiated a formal policy supporting telecommuting in 1995. At the time of the survey, 293 public sector respondents were officially identified at telecommuters. Even though both companies had some percentage of informal telecommuters, only officially designated telecommuters were invited to participate in this survey. A control group of 507 non-telecommuters were also asked to participate. Of the 800 mailed surveys, 520 were returned, providing a response rate of 65%. Of these, 293 were telecommuters.

Participant Profile

In both the groups, most participants were Caucasian (public 87%, private 97%) and were between the ages of 35 and 54 (public 72%, private 69%). However, public participants were primarily female (77%), while private organization participants had an equal distribution between men (53%) and women (47%). Some of the other participant profiles are given below:

Variable	Public	Private
Marital Status	63%	68%
Have Children	56%	60%
Hold Graduate Degree	30%	8%
Have Associate or Technical Degree	31%	15%
Annual Income $20,000 - $50,000	39%	63%
Annual Income $50,000 - $80,000	41%	21%

Results on Travel Behavior

In the survey, 74% of the respondents reported that they drove alone to work. This was consistent with the both the 1990 Census findings for Minnesota and a Mn/DOT survey of the Twin Cities area. 17% of the respondents reported that they carpooled (census 11%), while 11% choose to bus to and from work (census 16%). Only 4% of respondents reported full time (5 days per week use of either carpool or bus).

Of the 797 surveyed, 43% engaged in telecommuting, while 57% did not. Most of the telecommuters worked from home, only 5% traveled to a remote work center. In an average week over half of (55%) of participants claimed to telecommute 3 to 4 days, 38% 1 to 2 days, while only 7% engaged in full-time or five days in the average week. 38% of the sample engaged in telecommuting for a period of less than 1 year, 39% from 1 to 2 years and 23% indicated length of participation longer than 2 years (SLPP, 2000).

Further details about the travel behavior of telecommuters and non-telecommuters are given in the table below:

Travel Variable	Non-Telecommuters (N = 447)	Telecommuters (N = 339)
Days Travel to Work/Week		
Mean	4.70	2.88
Median	5.00	2.50
Miles from Home to Work		
Mean	16.00	25.92
Median	12.00	17.00
Time to Travel to Work (mins)		
Mean	31.01	39.56
Median	25.00	35.00
No. of days telecommute/week		
Mean		2.66
Median		2.50

From the table it is clear that on an average, telecommuters lived further away from their actual place of work when compared to non-telecommuters. Due to this telecommuters on an average had greater travel times than non-telecommuters.

Model Development and Analysis

The number of miles traveled per week depends on the number of days people travel to work per week. While non-telecommuters are likely to travel all five days of the week, telecommuters travel three days on an average to work per week. Therefore, the fact that whether people telecommute or not should impact the number of days traveled to work per week. Also, if telecommuters travel more number of days to work, the number of miles traveled should increase. To arrive at the number of days traveled to work per week by the respondents, a model was developed using whether the respondent telecommutes or not and miles traveled to work per day as the predictors. The results of the model developed are given below:

$D = 4.671 - (1.555 \times T) + (0.002 \times M)$

Where, *D* = number of days traveled to work per week, *T* = whether respondent telecommutes or not, and *M* = Miles traveled from home to work per day. The R square of the model is 0.133 tells us that the model is not significant in predicting the relationship between the dependent and independent variables. We can see that the telecommuting has a negative impact on the number of days traveled to work per week and that on an average there is an increase of 0.002 miles when a respondent travels to work. This increase is not significant enough to prove that telecommuting decreases the number of miles traveled. The table below gives the some other details of the regression model:

Model	Unstandardized Coefficients B	Standardized Coefficients	T statistic	Significance
Constant	4.671		41.657	.000
Does R Telecommute	-1.555	-0.368	-10.395	.000
Miles to Work	0.002	0.018	0.498	.618

Dependent Variable: Days travel to work per week.
R Square = 0.133
Adjusted R Square = 0.131

The failure of this model to predict the travel pattern of telecommuters can be attributed to the limitations of the data. The survey collected information on only work trips. To study whether telecommuting decreases the total number of miles traveled, the model should include the household trips as well as trip chaining information. Also, the data set lacks information on other factors like access to information technology and telecommunications. The next analysis was conducted on the data from the Travel Behavior Inventory Survey collected by the Metropolitan Council, Minneapolis.

IV. 2000 Travel Behavior Inventory (TBI)

Study Purpose

The Travel Behavior Inventory (TBI) is a comprehensive travel survey of the Minneapolis-St. Paul metropolitan area and first available since 1970. The TBI documents when, why and how Twin Cities residents and businesses use the region's highways and public transit. This data has been used to refine and update the region's computerized travel forecasting models and provides a factual basis for decisions about highway and transit improvements.

The Metropolitan Council, Minnesota Department of Transportation, Regional Transit Board and Transportation Advisory Board were the lead agencies for the TBI and principal users of the study.

Survey Method

The TBI used the following coordinated surveys in the year 2000 to gain a comprehensive overview of travel:

- Home Interview
- Traffic Counts
- Vehicle Classification
- External O-D Survey
- Highway Speeds

The Home Interview Survey is the centerpiece of TBI; almost 10,000 randomly selected households kept a travel diary for one day between April and September 2000. The 2000

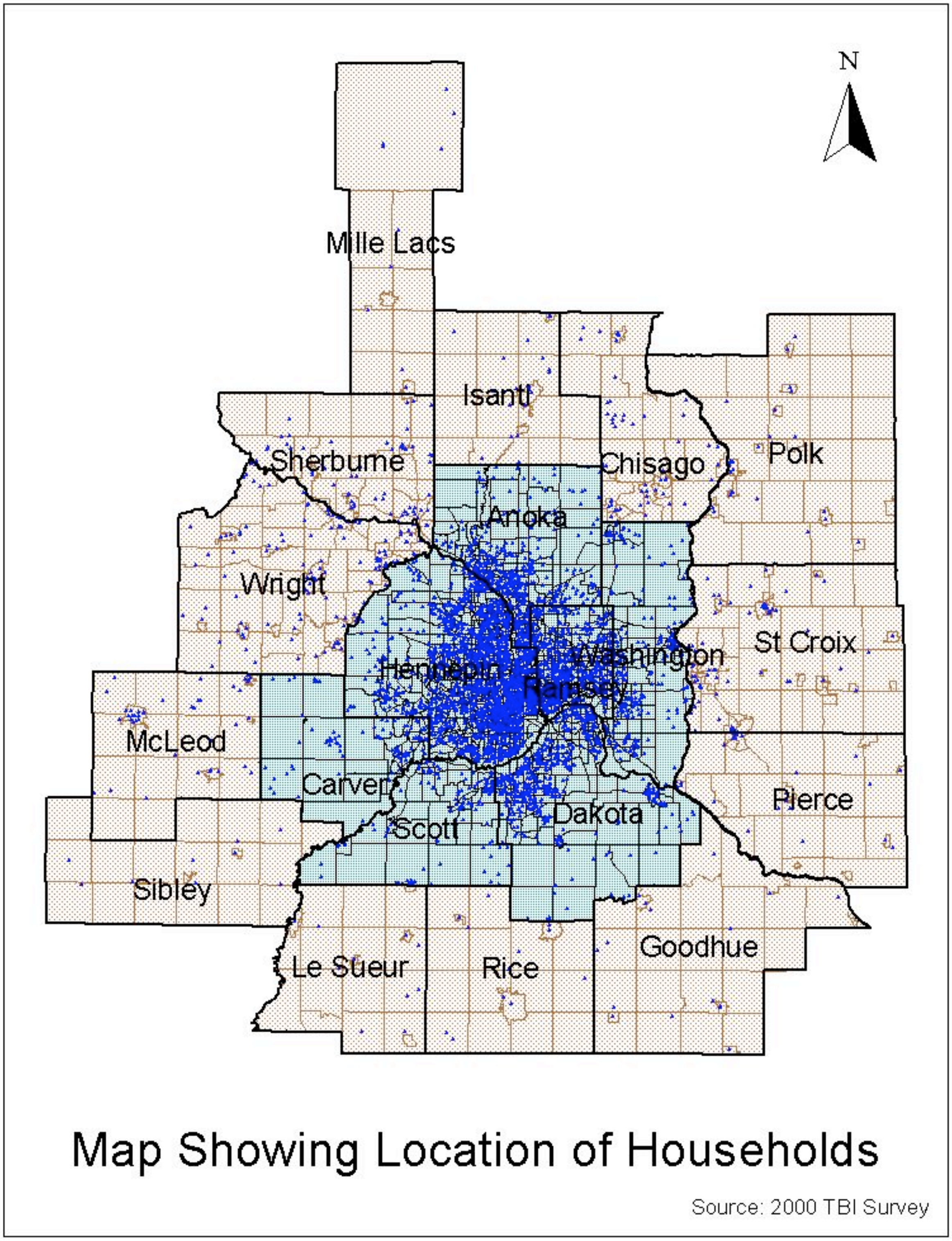
TBI survey got a response from 6,219 households located in the seven core counties (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington) and thirteen ring counties (Chisago, Goodhue, Isanti, LeSueur, McLeod, Mille Lacs, Rice, Sherbourne, Sibley and Wright in Minnesota and Pierce, Polk and St Croix in Wisconsin). These households provided 24-hour travel logs for all household members five years and above. The household surveys have information on telecommuting and this can be analyzed with household information and trip information. Figure 2 shows a map of the location of the households.

The TBI data categorized each household by a sample number. Each participant in every household was categorized by a person number. For example, household 457632 has two participants – person 1 and person 2. The household survey was categorized into *three* parts. The "household" section included information on household size, number of participants in the household, household income, number of household vehicles, household location, and the day the household took the survey. The household section also included information on the technology used like dedicated phone lines, phone lines dedicated to fax or modem, equipment in home like computers, modem, fax machines, and printers.

The "person" section included information at an individual level like age, level of education, employment, telecommuting, and number of trips.

The "trip" section included details of each trip made by an individual participant. Each person gave information about the origin, destination locations of their trips, duration, persons in the household who were on the trip, travel mode. The trip section also provided information on walk and bike trips. The trip section did not record the number of miles traveled on each trip.

Figure 2.


N
Mille Lacs
Isanti
Sherburne
Chisago
Polk
Anoka
Wright
St Croix
Washington
Hennepin
Ramsey
McLeod
Carver
Pierce
Scott
Dakota
Sibley
Goodhue
Le Sueur
Rice
Map Showing Location of Households
Source: 2000 TBI Survey

Preliminary Analysis

Out of these household participants, there were 1850 telecommuters. Non-telecommuters from the household participants were used as a control group. Non-telecommuters were selected from households different than those of telecommuters to give a better estimate of differences in travel patterns of telecommuter and non-telecommuter households.

The first step was to combine the "person" data with the "household" data. This gave information about the various differences in telecommuter and non-telecommuter households.

Variable	Telecommuters	Non -Telecommuters
Age		
Mean	42.63	40.74
Median	42.00	41.00
Gender		
Males	52.9%	50%
Females	47.1%	50%
Household Size		
Mean	2.68	2.57
Median	3.00	2.00
Household Income		
Less than $45,000	11.87%	26.6%
More than $45,000	88.13%	73.4%
Total Household Vehicles		
Mean	2.03	2.02
Median	2.00	2.00
Number of Household Phone Lines		
Mean	1.73	1.27
Median	1.00	1.00
Std Dev	4.599	2.618
Dedicated Phone Lines for Fax/Modem		
Yes	67.37%	55.9%
No	32.48%	43.6%

The following table gives information about employment and telecommuting policies:

Variable	Telecommuters	Non-Telecommuters
Number of Paying Jobs		
1 Job	90%	91.8%
2 Jobs	8.3%	7.5%
3 Jobs	1.7%	0.7%
Employer has Formal Telecommuting Policy		
Yes	27.19%	
No	63.51%	
Don't know	9.3%	
Telecommute Days		
Almost Everyday	29.83%	
Once a Week (1-3 times)	28.38%	
Once a Month or more	25.89%	
A few times a year or more	13.46%	
Once a year	2.43%	

The next step was to combine the trip data with the person data. This gave information on the differences in travel patterns of telecommuters and non-telecommuters. Straight line distances were calculated from the XY coordinates of origin and destinations. The following table shows the travel patterns of telecommuters on an individual basis:

Variable	Telecommuters	Non-Telecommuters
Mode to Work		
Drive Alone	69.2%	81.0%
Shared Ride (2 person carpool)	3.5%	6.2%
Shared Ride (3+ person carpool)	0.8%	0.7%
Vanpool	0.2%	0.2%
Transit – walk access	1.1%	1.4%
Transit – home access	1.8%	2.1%
Walk	3.4%	1.6%
Bike	1.0%	1.0%
Work at home	15.6%	1.2%
Total Number of Trips		
Mean	2.89	2.73
Median	3.00	3.00
Total Number of Miles		
Mean	28.12	25.10
Median	18.41	15.12

The following table shows the county household location of telecommuters and non-telecommuters:

County	Telecommuters %	Non-Telecommuters %
Anoka (Core)	7.7	9.8
Carver (Core)	1.6	1.8
Dakota (Core)	11.7	10.9
Hennepin (Core)	45.8	37.7
Ramsey (Core)	11.8	11.5
Scott (Core)	3.5	2.5
Washington (Core)	4.3	4.7
Chisago	1.1	1.5
Goodhue	1.8	2.4
Isanti	0.3	0.5
Le Sueur	0.6	1.1
Mcleod	1.2	2.0
Mille Lacs	0.6	1.0
Rice	1.2	1.7
Sherbourne	1.1	2.0
Sibley	0.4	0.6
Wright	2.3	3.2
Pierce (Wisconsin)	0.4	0.8
Polk (Wisconsin)	0.9	2.3
St Croix (Wisconsin)	1.7	2.1

Trip data was aggregated on basis of households and combined with the person data to give information on travel differences of telecommuters and non-telecommuters on a household basis.

Variable	Telecommuters	Non-Telecommuters
Total Number of Household Trips		
Mean	4.50	4.17
Median	4.00	4.00
Total Number of Household Miles		
Mean	64.97	57.68
Median	42.71	35.36

It can be seen from the above tables that telecommuters have the same number of trips both at the individual and household level. It is surprising that telecommuters have greater number of miles traveled than non-telecommuters both at the individual level as well as the household level.

Modeling process

The modeling process used was similar to the one used in the previous analysis. The number of miles traveled is based on many variables. Whether a person telecommutes or not is expected to affect the number of household miles. In the same way, the increase in the total number of household trips household size and number of household vehicles is expected to increase the number of household miles traveled. Based on this assumption, a model was built using Household Miles as the dependent variable, and the other variables as the Independent Variable. This model was developed at a household level instead of treating telecommuters and non-telecommuters on an individual basis. Thus instead of using Individual Number of trips, Household Trips have been used to predict the Household Miles. The same method has been followed for the other variables as well.

$$HM = (1.198 \times T) + (17.474 \times NT) + (2.233 \times HS) + (11.464 \times HV) - 44.091$$

Where, HM= total number of household miles traveled, T = whether person telecommutes or not, NT = number of household trips, HS = household size, HV = number of household vehicles. Further details about the model are given below:

Model	Unstandardized Coefficients B	Standardized Coefficients	T statistic	Significance
Constant	-44.091		-12.997	0
Does R Telecommute	1.198	0.006	0.525	0
No. of Household Trips	17.474	0.312	24.310	0
Household Size	2.233	0.026	1.905	0.057
No. of Household Vehicles	11.464	0.093	7.626	0

Dependent Variable: Total Household Miles
R Square = 0.137
R Square Adjusted = 0.136
F Stat = 301.162

The R square of 0.137 is not large enough for the model to be significant. Thus the model is not good in predicting the relationship between the dependent and independent variables. The F stat level at 301.162 is greater the F critical level and the P value is greater than 0.001. This extremely large P value provides strong evidence that the null hypothesis cannot be rejected and suggests that not all variables are good in predicting the number of household miles traveled.

V. CONCLUSION

With the increase in technology use, rate of telecommuting is increasing day by day. It is certainly very difficult to predict the travel patterns of telecommuter without proper data or information. Data from surveys collected keeping telecommuting in mind are the most preferable data sets to study the travel patterns and technology use of telecommuters. Location data of trip origins and destinations should be calculated based on the road network instead of straight-line distances. GPS (Global Positioning System) Units are an effective way to get the trip details of participants instead of travel diaries or logs. These units eliminate the error in the calculation of trip distances and duration.

The travel patterns of telecommuters are difficult to predict from surveys that have been conducted as a statewide travel survey. These surveys will be able to provide basic information on trips and technology use, but to get a detailed perspective of telecommuters, surveys designed exclusively for this purpose should be conducted. Thus, with improved data collection, the impact of telecommuting and telecommunications on travel patterns and urban form as a whole can be studied much more efficiently.

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