

# UC Berkeley

## Earlier Faculty Research

### Title

Analyzing the preference for non-exclusive forms of telecommuting: Modeling and policy implications

### Permalink

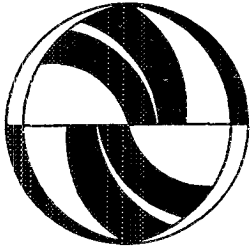
<https://escholarship.org/uc/item/7200521q>

### Authors

Bagley, Michael N.  
Mokhtarian, Patricia L.

### Publication Date

1997



**Analyzing the Preference for Non-Exclusive  
Forms of Telecommuting: Modeling and  
Policy Implications**

Michael N. Bagley  
Patricia L. Mokhtarian

Reprint  
UCTC No. 370

**The University of California  
Transportation Center**  
University of California  
Berkeley, CA 94720

**The University of California  
Transportation Center**

The University of California Transportation Center (UCTC) is one of ten regional units mandated by Congress and established in Fall 1988 to support research, education, and training in surface transportation. The UC Center serves federal Region IX and is supported by matching grants from the U.S. Department of Transportation, the California Department of Transportation (Caltrans), and the University.

Based on the Berkeley Campus, UCTC draws upon existing capabilities and resources of the Institutes of Transportation Studies at Berkeley, Davis, Irvine, and Los Angeles; the Institute of Urban and Regional Development at Berkeley; and several academic departments at the Berkeley, Davis, Irvine, and Los Angeles campuses. Faculty and students on other University of California campuses may participate in

Center activities. Researchers at other universities within the region also have opportunities to collaborate with UC faculty on selected studies.

UCTC's educational and research programs are focused on strategic planning for improving metropolitan accessibility, with emphasis on the special conditions in Region IX. Particular attention is directed to strategies for using transportation as an instrument of economic development, while also accommodating to the region's persistent expansion and while maintaining and enhancing the quality of life there.

The Center distributes reports on its research in working papers, monographs, and in reprints of published articles. It also publishes *Access*, a magazine presenting summaries of selected studies. For a list of publications in print, write to the address below.



**University of California  
Transportation Center**

108 Naval Architecture Building  
Berkeley, California 94720  
Tel: 510/643-7378  
FAX: 510/643-5456

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation.

**Analyzing the Preference for Non-Exclusive Forms of  
Telecommuting: Modeling and Policy Implications**

Michael N. Bagley  
Patricia L. Mokhtarian

Department of Civil and Environmental Engineering  
University of California  
Davis, CA 95616

Reprinted from  
*Transportation*  
vol. 24, pp. 203-226 (1997)

UCTC No. 370

The University of California Transportation Center  
University of California at Berkeley

## Analyzing the preference for non-exclusive forms of telecommuting: Modeling and policy implications

MICHAEL N. BAGLEY & PATRICIA L. MOKHTARIAN\*

*Department of Civil and Environmental Engineering and Institute of Transportation Studies,  
University of California, Davis 95616 USA (\*corresponding author)*

**Key words:** home-based telecommuting, preference model, telecommuting center

**Abstract.** This study examines three models of the individual's preference for home- and center-based telecommuting. Issues concerning the estimation of discrete models when the alternatives are non-exclusive are discussed. Two binary logit models are presented, one on the preference to telecommute from a center versus not telecommuting from a center (adjusted  $\rho^2 = 0.24$ ), and the other on the preference to telecommute from a center over telecommuting from home (adjusted  $\rho^2 = 0.64$ ). A nested logit model is also estimated on the following four alternatives: preferring not to telecommute, preferring either form of telecommuting, preferring to telecommute from home, and preferring to telecommute from a center (adjusted  $\rho^2 = 0.35$ ).

The results of the models illustrated the importance of attitudinal measures in measuring an individual's preference to telecommute. Oblique factor scores representing workplace interaction, stress, workaholism, internal control, and commute stress were statistically significant in some or all of the models. Other explanatory variables which were found to be consistently significant were education, job suitability, and age. Most respondents preferred either to telecommute from home or were indifferent between either form of telecommuting, which raises the question as to whether there really is a sizeable market niche to be filled by telecommuting centers, and hence whether they may make a significant contribution to transportation demand reduction.

### 1. Introduction

Continuing advances in telecommunications and information technologies and their applications have the potential to generate profound changes in the economic and social structure of society. One application enjoying growing interest from public planners and policy-makers, due its potential to mitigate urban traffic congestion and reduce vehicle emissions, is the telecommuting work option. Telecommuting may be defined as using telecommunications technology to work at home or at a location close to home, instead of commuting to a conventional work place at the conventional time. There are two main forms of telecommuting: home-based and center-based. Home-based telecommuting is by far the more common form of the two, and has been practiced and studied for many years. On the other hand, experimentation with center-based telecommuting is growing (Bagley et al. 1994; Mokhtarian

et al. 1996) since it is hypothesized to reduce many of the disadvantages associated with telecommuting from home.

Researchers have identified a number of potential advantages for an employee of telecommuting from a center versus home, which include providing a boundary between home and work, and allowing greater opportunities for social and professional interaction (Healy 1968). In addition, telecommuting from a center has advantages for employers, such as permitting several employees to share equipment and offering a more professional image than working from home (Mokhtarian 1991).

Recent studies have developed causal models of the decision to telecommute (Bernardino et al. 1993; Bernardino & Ben-Akiva 1994; Mahmassani et al. 1993; Mannering & Mokhtarian 1995; Mokhtarian & Salomon 1994; 1996a; 1996b; 1997; Stanek & Mokhtarian forthcoming; Sullivan et al. 1993; Yen & Mahmassani 1994). These researchers, with the exception of Stanek and Mokhtarian, have focused their modeling efforts on the decision to telecommute from home. Consequently, little is known about individuals who prefer telecommuting from a center. However, the decision to telecommute from a center may be influenced by different variables, or by the same variables with different weights. Hence, models of the preference and choice of telecommuting from a center as well as from home are needed to develop more accurate forecasts of telecommuting adoption. Those forecasts, in turn, will provide input into models of the differing transportation and air quality impacts of home- and center-based telecommuting.

This paper presents three causal models focusing on the desire or preference to telecommute from a center. All three models were based on a conceptual model of the individual decision to telecommute. The conceptual model was developed by Mokhtarian and Salomon (1994) and empirically estimated for home-based telecommuting preference (Mokhtarian & Salomon 1997) and choice (Mokhtarian & Salomon 1996b). The contribution of this paper is the application of their methodology to the preference to telecommute from a center. This application raises interesting modeling questions about the proper definition of the dependent variable (as discussed in Section 3.2), and raises policy questions about the level of emphasis that should be given to each form of telecommuting (as discussed in Section 5.3).

This paper is organized as follows: Section 2 briefly describes the data collection process and the final data set, Section 3 presents the three telecommuting preference models developed for this study, and Section 4 compares the results across the three models. Section 5 summarizes the main findings and implications of the study.

## 2. Data description

The models developed in this study are based on data obtained from a questionnaire designed to allow the testing of the conceptual structure proposed by Mokhtarian and Salomon (1994), as described in Section 3.1. The sample consists of 628 useable responses obtained from a fourteen-page self-administered questionnaire distributed to 1428 employees of the City of San Diego in December 1992. Survey questions related to previous awareness of and experience with telecommuting, job characteristics, ability to telecommute, perceived advantages and disadvantages of telecommuting, information on other choices made to satisfy hypothesized lifestyle drives, attitudes toward telecommuting and issues related to lifestyle drives, and sociodemographic characteristics.

Respondents were 53% female, predominantly professional/technical workers, relatively affluent, mainly in their 30s and 40s, and most often (64%) without children under 16 at home. More detail on the characteristics of the sample is found in Mokhtarian and Salomon (1996a). Although the sample was designed to obtain data from a diversity of respondents, descriptive statistics obtained from the survey are not directly generalizable to the workforce population due to sampling and response biases. However, the model coefficients are consistently (in the statistical sense) estimated, meaning that the estimated importance in the decision to telecommute of the explanatory variables presented here should be generalizable to the workforce at large.

A number of variables were created as potential explanatory variables for the preference and choice to telecommute. These variables include those for which a clear causal hypothesis can be stated, those for which plausible competing hypotheses can be made, and those (especially socioeconomic) which are primarily descriptive indicators of a more indirect relationship (e.g., telecommuting preferrers are more likely to be young). Factor analysis was used to create a number of variables by reducing a set of interrelated attitudinal statements to a smaller group of underlying perceptual dimensions. Other variables used in the study, such as socio-economic traits, were developed directly from self-reported characteristics. Only variables found to be significant in one or more of the models in this paper are presented in Table 1. For a detailed description of other explanatory variables, one can refer to Mokhtarian and Salomon (1995; 1997).

Table 1. Description of variables significant to telecommuting preference

---

<i>Drive variables</i>	
Children	Number of children in the household between six and sixteen years of age.
Commute stress	An attitudinal factor related to a respondent's dislike of driving (especially for the commute trip) and his/her desire to improve air quality by driving less.
Commute time	Round trip commute time of an individual.
Personal benefits	A factor relating to positive expectations of telecommuting, such as having more flexibility and independence.
Stress	A factor based on the belief that telecommuting will reduce work-related pressures, such as commute stress and office stress, while increasing a person's control of his/her work environment.
Workaholic	A factor which relates to defining oneself as a workaholic and wanting to spend more time on work.
<i>Constraint/facilitator variables</i>	
Household interaction	A binary variable equal to one if household interaction is expressed as a concern when telecommuting from home.
Internal control	A factor which is positively correlated with being generally satisfied with life, being organized, spending time on oneself, and valuing family and friends above work.
Job suitability C	A binary measure of a job's appropriateness for telecommuting from a center, equal to zero if job is not suitable and equal to one if job has at least some suitability.
Job suitability D	A categorical measure, with values ranging from -5 to 5, of the difference of an individual's perception of his/her job suitability for telecommuting from a center versus telecommuting from home. A positive value denotes that the job is suitable for telecommuting more frequently from a center than from home. (Significant in Model 2).
Job suitability E	A binary variable equal to one if the respondent's job is suitable for telecommuting equally frequently from either a center or home, zero otherwise.
Job suitability H	A binary variable equal to one if respondent's job is suitable for telecommuting from home, zero otherwise.
Lack of resources	A binary variable equal to one if a respondent chooses "I don't have all the resources I would need to work at another location" as a reason for not currently telecommuting.
Manager support C	A categorical variable, with values ranging from 0 to 5, indicating the frequency with which the manager would permit an employee to telecommute from a center.
Manager support D	A categorical variable, with values ranging from -5 to 5, indicating the difference in perceived manager support for telecommuting from a center versus telecommuting from home. A positive value denotes the perception that the manager would let the respondent telecommute more frequently from a center than from home. (Significant in Model 2).

---



*Table 1. (Continued)*


---

Office discipline	A factor representing a constraint against individuals who may want to telecommute but should not because their work performance decreases when they work away from the regular office.
Overtime	The amount of overtime above the normal workload (typically 80 hours, if full time) a respondent has worked in a two-week period.
Phone line	A binary variable equal to one if the respondent would need to obtain an additional phone line to telecommute from home.
Supervisor	A binary variable equal to one if the respondent is a supervisor, zero otherwise.
Telecommuting experience	A binary variable equal to one if the respondent has ever telecommuted from home, zero otherwise.
Workplace interaction	A factor indicating a person's need for the social and professional interaction obtained at the regular workplace.
Work status	A binary variable equal to one if a respondent is a full-time worker and equal to zero if a respondent is a part-time worker.

*Demographic variables*

Age groups 1, 2, and 3	Dummy variables for age group. Group 1 (the base) consists of people 30 years old or younger, group 2 consists of people between the ages of 31 and 60, and group 3 consists of people more than 60 years old. (Both groups 2 and 3 significant in Model 1).
Age level	An indicator of the age level of the respondents, ranging from 1 (20 years old or less) to 6 (61 years old or more).
Education groups 1 and 2	Dummy variables for education. Group 1 (the base) consists of people with some college or technical school experience or less, and group 2 consists of people who have completed four-year degrees or more. (Significant in Model 1).
Education level	A categorical indicator of education level, ranging from 1 (some grade school or high school) to 6 (completed graduate degree).
Income level	An indicator of the annual household income of the respondent, ranging from 1 (less than \$15,000) to 6 (\$95,000 or more).

---

**3. Modeling the preference among telecommuting alternatives***3.1. Model framework*

The models discussed in this paper are based on the conceptual model of an individual's decision to telecommute developed by Mokhtarian and Salomon (1994). In summary, their model describes the relationships among drives which are assumed to motivate the individual to adopt telecommuting, constraints which act to inhibit telecommuting, and facilitators which support

telecommuting. Drives may be classified in terms of orientations such as work, family, leisure, and travel. If one or more drives are not satisfied, the model assumes that the individual will search for an adjustment or change in his/her life, such as adopting telecommuting, that will satisfy the drive(s). Constraints, internal or external, may reduce the probability that an individual will seek a particular change, and may even eliminate the possibility of choosing a certain change. Facilitators generally represent the same elements as constraints, only present in a positive sense rather than in a negative one (e.g., high cost is a constraint; low cost is a facilitator). Thus, facilitators are assumed to increase the probability of choosing a particular adjustment. However, if all drives are satisfied, facilitators are assumed to have no effect on the probability of an individual choosing an adjustment. Stated another way, even if no constraints are active, an individual will still not choose to change unless a drive is prompting him or her to do so.

### 3.2. *Potential dependent variables and model structures*

#### 3.2.1. *Definition of preference*

A number of different potential dependent variables could be chosen for telecommuting models. Dependent variables could be defined along several dimensions, including:

- the nature of the alternatives – binary choice/preference (yes or no) versus multinomial frequency (amount of telecommuting);
- the type of telecommuting being considered – home, center, or both; and
- whether a preference or an actual choice is being measured.

For this study, no models of the choice of telecommuting from a center could be estimated since there were not enough cases of center-based telecommuting adoption in the sample. Thus, the preference for telecommuting is the phenomenon addressed here.

Among mutually exclusive alternatives, a common way of assessing preference is to ask respondents to rank them. The difficulty in doing that in this context is that the three alternatives home, center, and regular workplace are not mutually exclusive work options. Most telecommuting is part-time (typically one day a week), but inferring from this that the regular workplace is the “preferred” alternative for almost everyone would tell us little. Further, between the two forms of telecommuting many people will be attracted to both, and in fact will be able to engage in both over the course of a given week.

Accordingly, respondents were not explicitly asked to rank workplace alternatives according to preference. Rather, as described below, preference was inferred from reported desired frequencies of telecommuting from home and a center respectively. Specifically, the dependent variables were constructed

from the responses to the following question: "Assuming that there are no work-related constraints, how much would you like to telecommute from: a) home, and b) a telecommuting center?" The respondent could choose from the following seven categories of telecommuting frequency: 1) not at all, 2) less than once a month, 3) about 1-3 days a month, 4) 1-2 days a week, 5) 3-4 days a week, 6) 5 days a week, and 7) occasional partial days (which was later equated with category two). Table 2 cross-tabulates the respondents' telecommuting frequency preferences for home against center.

Defining an appropriate dependent variable was not as straightforward as might be expected. Two issues are important: how to define preference for a particular form of telecommuting, and what the alternative(s) is (are). Regarding the first issue, the strongest form of preference, an absolute or exclusive preference, is to define respondents as preferring one form of telecommuting only if the desired frequency for that form is some positive amount and the desired frequency for the other form is "not at all". By this definition, only the three respondents in the third and fourth cells of the top row of Table 2 prefer telecommuting from a center. Consequently, not enough empirical data was available for developing a model of telecenter preference under this definition. This in itself is an important finding, suggesting that there are few people who prefer to telecommute exclusively from a center.

Table 2. Preferences for telecommuting frequency from home and from a center<sup>1</sup>

Prefer home	Prefer a center						Row total
	Not at all	Less than once a month	About 1 to 3 days a month	1 to 2 days a week	3 to 4 days a week	5 days a week	
Not at all	61	0	2	1	0	0	64
Less than once a month	11	15	1	0	0	0	27
About 1 to 3 days a month	42	8	45	5	0	0	100
1 to 2 days a week	105	7	15	121	15	2	265
3 to 4 days a week	23	2	3	12	35	5	80
5 days a week	8	2	1	2	3	29	45
Column total	250	34	67	141	53	36	581

<sup>1</sup> The shaded region (245 people) denotes preference for either form of telecommuting. In Models 2 and 3, all the people (244) below the shaded region are considered to prefer telecommuting from home over telecommuting from a center, while those (31) above the shaded region are considered to prefer telecommuting from a center. The upper left corner (61) represents those who prefer neither form of telecommuting.

The weakest definition of preference in this context, yet one which is quite conventional and used extensively when modeling home-based telecommuting, is to define respondents as preferring a certain form of telecommuting if they desire to do it any non-zero amount. In Table 2, those who would be classified as preferring telecenters under this definition include everyone except the cases in the first (“not at all”) column. Of course, many of these respondents also prefer home-based telecommuting by the same definition, so this does not create mutually exclusive groups based on type of telecommuting preference.

An intermediate form of preference is to define respondents as preferring one form of telecommuting if their desired frequency for that form is greater than for the other form. In the first (strongest) definition of preference, the subsample viewed as preferring *both* forms of telecommuting consists of those respondents falling in the  $5 \times 5$  submatrix of Table 2 obtained by eliminating the “not at all” row and column. In this current definition, those considered to prefer both forms of telecommuting equally are contained only in the 5 major diagonal cells of the same submatrix (i.e., the shaded region).

Other intermediate-strength definitions of preference could be created. For example, respondents could be defined as preferring a certain form if the desired frequency for that form is at least two categories greater than for the other form. This has the effect of widening the “indifference” band from just the diagonal elements to the cells immediately adjacent to the diagonal on each side. Another variation is to combine the “not at all” and “less than once a month” categories, on the assumption that such infrequent telecommuting does not demonstrate a strong preference (as was done by Stanek & Mokhtarian, forthcoming). Comparing models using these alternate definitions is an interesting direction for future research.

The preference for telecommuting from a center is the main focus of this research. Independently of which of the above definitions of preference is used, it remains to treat the second issue in creating the dependent variable, that is defining the alternative(s) to preferring a telecenter. Apparently the simplest, and certainly the most conventional, alternative is “not preferring a telecenter”. Other approaches attempt to divide the “not prefer” option into logical subgroups, such as “prefer home-based telecommuting” and “prefer the regular workplace, or not telecommuting.”

### 3.2.2. *The model structures used in this research*

Three discrete-alternative models were defined for this research. In some ways the most natural dependent variable is the one with the most conventional definition of telecenter preference (any non-zero desired frequency) and the most conventional alternative (not preferring the telecenter). Thus, Model 1 is a binary logit model with alternatives “prefers to telecommute from a center”,

where preference is defined as wanting to telecommute any frequency other than not at all, and “prefers not to telecommute from a center”. This seemingly straightforward definition raises some difficulties, however. In interpreting Model 1 results, it is important to remember that if a respondent chooses the alternative “prefers not to telecommute from a center”, s/he could still desire to work from home or the regular workplace. Hence, one cannot distinguish if the significant variables of Model 1 are explaining the preference of telecommuting from center over telecommuting from home, working from the regular workplace, or both. Further, because of the way preference is defined for this model, if a respondent is classified as “preferring to telecommute from a center”, s/he may actually prefer to telecommute more frequently from home.

Model 2 attempts to present a cleaner definition of the alternatives by examining just the preference between home- and center-based forms of telecommuting. Hence, those who prefer not to telecommute at all and those who prefer each form equally are discarded from the analysis for this model. Further, an intermediate definition of preference is used rather than the weak form employed in Model 1. Hence, Model 2 is a binary logit model with the alternatives “prefer to telecommute from a center” and “prefer to telecommute from home”, where preference for an alternative is interpreted to mean wanting to engage in that form of telecommuting more frequently than the other form. This construction of the dependent variable prevents those who do not want to telecommute at all from being lumped together with those who do, but it does not completely distinguish the home and center alternatives. As can be seen in Table 2, most of those “preferring” a center also desire to work at home some amount, and vice versa. However, this is comparable to the case that could occur in the conventional procedure of ranking alternatives according to preference: ranking an alternative first doesn’t necessarily imply an exclusive preference for that alternative; rather, other alternatives may also be preferred to a lesser extent.

In discarding those who did not want to telecommute at all and those who preferred both forms of telecommuting equally, Model 2 not only ignores those two important alternatives (and thereby eliminates more than half of the sample), it also cannot identify variables common to the preference of both forms of telecommuting. To address these concerns, Model 3, a nested logit model, was developed. This model initially had the three-layered structure shown in the top half of Figure 1, with an upper branch between not telecommuting (“neither”) and telecommuting, a branch from the latter alternative between indifference (“either”) and a strict preference, and a final branch from the strict preference alternative between “home” and “center”. For this model there are few “generic” variables for the four different alternatives (i.e. variables which take on different values for each alternative). Therefore, most variables are defined to be alternative-specific, that is, taking on a non-zero

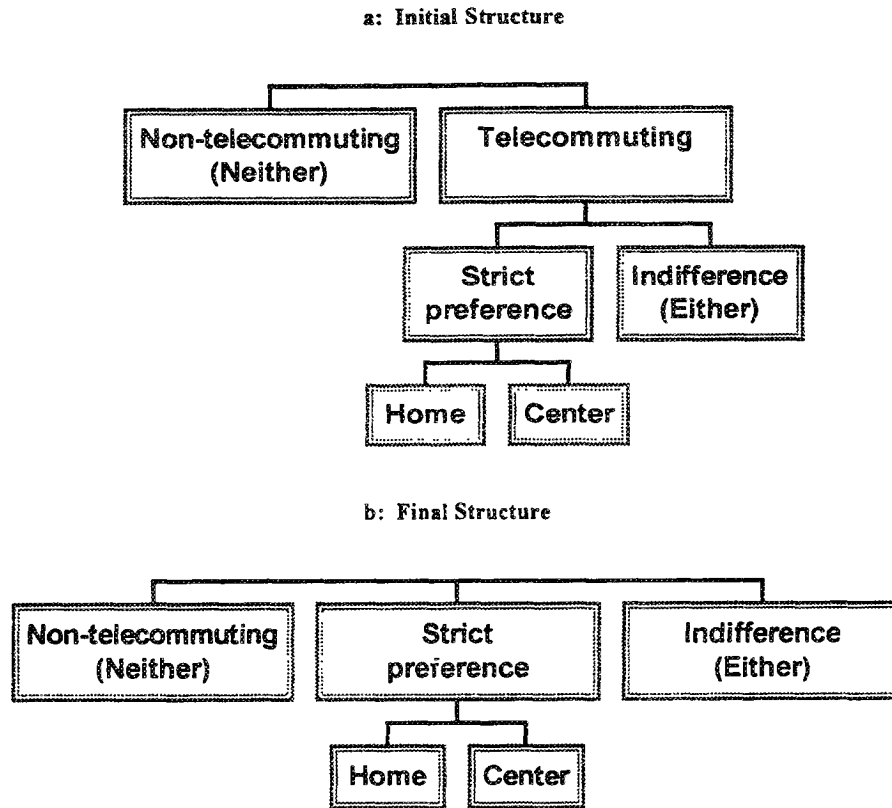


Fig. 1. Nested logit structure.

value for only one or a subset of the alternatives. The selection of specific alternative(s) with which to associate each variable was guided by statistical tests and by trial and error on different model specifications. Like Model 2, Model 3 uses the intermediate definition of preference between “home” and “center”, which means that most who are classified as preferring one form also prefer the other (to a lesser degree).

### 3.3. Results

Table 3 presents the variables that are significant in each of the models estimated. For the sake of brevity, the actual coefficients and t-values for Models 1 and 2 are not shown; they are available in Bagley (1995), together with additional detail on model development and test statistics. Key findings from each model are discussed qualitatively in the subsections below.

Table 3. Significant variables<sup>1</sup>: a comparison across models

Variable	Variable type	Model 1: C – not C	Model 2: C–H	Model 3: N–E–H–C
Children	Family drive	C		
Commute stress	Travel drive	C		H C E
Commute time	Travel drive	C		
Personal benefits	Independence and leisure drives			H C E
Stress	Work and travel drives	C	C	
Workaholic	Work drive	C	C	C N E
Household interaction	Constraint/facilitator	not C		C N
Internal control	Constraint/facilitator	not C		
Job suitability	Constraint/facilitator	C	H C <sup>2</sup>	H C E
Lack of resources	Constraint/facilitator	C		
Manager support	Constraint/facilitator		H C <sup>2</sup>	C
Office discipline	Constraint/facilitator			N
Overtime	Constraint/facilitator			H
Phone line	Constraint/facilitator		C	
Supervisor	Constraint/facilitator		H	
Telecommuting experience	Constraint/facilitator	not C		H
Workplace interaction	Constraint/facilitator	not C		N
Work status	Constraint/facilitator			H N E
Age	Demographic	not C		N
Education	Demographic	not C	H	H
Income	Demographic			H N E

<sup>1</sup> N, E, H, and C indicate whether high values on the variable are favorable to the preference for Neither, Either, Home, or Center respectively.

<sup>2</sup> In Model 2, job suitability and manager support are effectively generic variables. For either of them, a higher value on alternative *x* compared to the value for alternative *y* favors the preference of *x*.

### 3.3.1. Model 1: Preferring telecommuting from a center versus not preferring telecommuting from a center

The adjusted  $\rho^2$  value for Model 1, an informal goodness of fit measure, is 0.24. The  $\rho^2$  value (similar to  $R^2$  in regression analysis) can be interpreted as the proportion of total information in the sample explained by the model (Hauser 1978). Fifteen variables, including the constant and two age-related indicators, are significant. To control for differences in scale, the explanatory variables (except the constant term) were standardized and used to estimate another binary logit model with the same specification (Bagley 1995). From the coefficients of the standardized variables one can rank the contribution of each to the preference to telecommute. The highest ranked explanatory variables are discussed below in addition to variables that provide unique insight into the preference formation for telecommuting. Other variables are discussed below in comparison to Model 3.

Model 1 contains five drive variables which relate to three drive types: family, travel, and work. The workaholic variable was the second highest contributor to the preference of telecommuting from a center. This and the other work drive variable (stress) capture the importance of being able to work productively and comfortably, two hypothesized advantages of telecommuting from a center.

Constraint and facilitator variables, also defined in terms of family, travel, and work, played an important role in explaining the preference to telecommute from a center. In fact, the facilitator job suitability C was by far the most significant contributor to the preference for center-based telecommuting (nearly three times larger than the second leading contributor, workaholic). On the other hand, lack of resources was the variable contributing the least in terms of magnitude and was also the least significant. Nevertheless, a chi-squared test determined that the model was significantly better with this variable. This finding, coupled with the fact that the variable makes conceptual sense (an advantage of telecommuting from a center over home is the ability to cost-effectively share needed resources at the center, so someone who, for example, does not have a computer at home may prefer to work from a center), justified its inclusion.

Internal control, a facilitator variable, is positively correlated with being generally satisfied with life, being organized, spending time on oneself, and valuing family and friends over work. It was hypothesized that a high value on this variable would support telecommuting from a center, since doing so would allow people to have more time for themselves (by reducing commute time) and to have more flexibility in balancing work and family. However, the coefficient for internal control was unexpectedly negative. This may be interpreted to mean that respondents who had a high internal control score are already satisfied with the balance in their lives and hence are not motivated to try telecommuting. On the other hand, it may also mean that home-based telecommuting is preferable to center-based telecommuting for people with these characteristics – an example of the interpretation difficulties posed by the simple dependent variable construction of Model 1.

### 3.3.2. *Model 2: Preferring telecommuting from a center versus preferring telecommuting from home*

The adjusted  $\rho^2$  value for Model 2 is 0.64, indicating that the model possesses a relatively high degree of explanatory power. All seven of the significant coefficients had appropriate signs. Constraint and facilitator variables played the greatest role in differentiating between an individual's preference for home- or center-based telecommuting. Job suitability D and manager support D were ranked first and second, respectively, in the contribution to the relative preference for a telecommuting center. Job suitability



D and manager support D are variables denoting the difference between center- and home-based telecommuting in perceived job suitability and manager support, respectively. They both had positive signs, meaning that if respondents believed, for example, that their manager would support telecommuting more frequently from a center than from home, then they would more likely prefer center-based telecommuting. This strongly suggests the importance of a person's perception of telecommuting feasibility in the development of his/her preference toward it.

Only two drive variables were significant in Model 2, workaholic and stress. The absence of a significant family drive suggests that family-related motivations do not distinguish preference between the two forms of telecommuting. This could mean that an individual perceives family-related benefits to be similar for both forms of telecommuting. Therefore, in distinguishing between home and center forms of telecommuting, facilitators appear to be more important determinants of preference than drives. This is plausible, since many of the benefits of telecommuting that would motivate an individual to prefer it may apply nearly equally to both home and center.

### 3.3.3. *Model 3: Preference among neither, either, center, or home alternatives*

Models 1 and 2, despite the conceptual shortcomings discussed in Section 3.2, are straightforward to estimate (binary) and are for the most part usefully interpretable. However, to avoid some of those shortcomings, it is obviously desirable to try to incorporate all four alternatives (neither, either, home, center) into a single model. The most straightforward way to do that is to estimate a multinomial logit (MNL) model, which has been done and reported in Bagley (1995). The problem with an MNL model, however, is that the assumption of independence of irrelevant alternatives (IIA) is likely not to hold (see, e.g., Ben-Akiva & Lerman 1985). IIA, which is an assumption necessary to the development and application of MNL, is violated when the error terms in the utility functions of different alternatives are correlated. Since three of the four alternatives in the MNL formulation of the model relate to telecommuting, they almost certainly share some unobserved characteristics, which would result in correlated error terms. In fact, tests (McFadden et al. 1977; Small & Hsiao 1985) performed on the MNL model estimated in this study confirmed that IIA was violated for the specification in question.

There are several ways to resolve an IIA violation. The solution adopted here was to estimate a nested logit model using the NLOGIT feature of the LIMDEP software package (Greene 1995). Initially, the model with the structure described in Section 3.2.2 and portrayed in the top half of Figure 1 was estimated. For that model, the estimated inclusive value coefficient for the telecommuting branch was greater than one, which means that "the proba-

bilities are still well defined. However, the interpretation of the model as a choice model is not clearcut" (Hausman & McFadden 1984, p. 1228). Since the inclusive value coefficient was not significantly different from one, it was fixed at one for the final estimation. This is equivalent to the two-layered model structure shown in the lower half of Figure 1, in which the "neither", "strict", and "either" alternatives are the branches of the upper level, and "home" and "center" branch out from the "strict" alternative. In effect, the error terms of the utility functions of the top three alternatives are independent.

Table 4 contains the coefficients and *t*-values for Model 3, which had a  $\rho^2$  of 0.36 and an adjusted  $\rho^2$  of 0.35. Note first that the inclusive value coefficient for the "strict" branch is not very different from one (0.81), and the null hypothesis that it equals one is rejected only at a 9% level of significance. The implication is that the violation of IIA is not very severe; that is, that the model structure is very close to that of a conventional four-alternative MNL model. Indeed, the coefficients of Model 3 are identical in sign and quite similar in magnitude to those of the comparable MNL model.

Every variable had the expected sign, and each was statistically significant at  $\alpha \leq 0.1$ , except for workplace interaction (*t*-value = 1.61) which was kept for its conceptual contribution. Facilitator and constraint variables contributed most to the understanding of the preference to telecommute, consisting of ten of the sixteen non-constant variables. Three drive and three demographic variables comprised the rest of the group. Discussion for all the significant variables is given below and categorized into three sections: drives, facilitators/constraints, and demographic variables.

*Drive variables.* The three drive variables, personal benefits, commute stress, and workaholic, placed second, fourth, and ninth (respectively) in ranked contributions to the preference for telecommuting. Personal benefits, a drive based on a person's desire for independence and leisure, was negatively correlated with the preference to "not telecommute". This finding, along with its number two ranking, shows that the often cited advantage of telecommuting, personal benefits, is very important in the development of an individual's preference to telecommute. Likewise, the respondents who found the commute to work burdensome (and who would therefore have a large, positive factor score for the variable commute stress) were less likely to prefer not telecommuting over the three telecommuting alternatives. The workaholic drive had a negative coefficient with respect to preferring to telecommute from home, suggesting that respondents who want to be the most productive will prefer to work elsewhere. This finding supports the hypothesis that household distractions, as well as those of the main workplace, can impede productivity.

Table 4. Model 3: Preference among neither, either, center, or home alternatives

Variable	Variable type	Coefficient	t-statistic
<i>Home</i>			
Constant		0.41	0.30
Workaholic	Work drive	-0.55	-3.60
Job suitability	Facilitator	2.46	5.17
Overtime	Facilitator	0.035	1.69
Telecommuting experience	Facilitator	0.66	2.19
Education level	Demographic	0.26	2.60
<i>Center</i>			
Job suitability	Facilitator	4.15	3.77
Manager support	Facilitator	0.24	2.00
Household interaction	Constraint	1.08	1.70
Work status	Constraint	-1.14	-1.85
Income level	Demographic	-0.38	-1.88
'Strict' inclusive value		0.81	1.71 <sup>1</sup>
<i>Either</i>			
Constant		0.95	0.80
Job suitability	Facilitator	2.46	5.17
'TC' inclusive value		1.00	fixed
<i>Neither</i>			
Constant		-1.74	-1.25
Personal benefits	Independence and leisure drives	-1.39	-5.31
Commute stress	Travel drive	-1.05	-3.29
Workplace interaction	Constraint	0.37	1.44
Household interaction	Constraint	1.28	2.72
Office discipline	Constraint	0.68	2.76
Age level	Demographic	0.50	2.50
Summary statistics			
Number of cases preferring home			242
Number of cases preferring center			31
Number of cases preferring neither			58
Number of cases preferring either			237
Log-likelihood at zero			-812.37
Log-likelihood at convergence			-520.21
$\rho^2$			0.36
Adjusted $\rho^2$			0.35
$\chi^2$			584.32

<sup>1</sup> t-test on the null hypothesis that the coefficient is equal to one.

*Constraint/facilitator variables.* Constraint and facilitator variables played a fundamental role among factors associated with the preference to telecommute. Model 3 included the following ten constraint/facilitator variables (with their relative rankings in parentheses): job suitability C (1), job suitability H, E (3), office discipline (5), household interaction ("neither"-specific) (8), manager support C (10), workplace interaction (11), household interaction ("center"-specific) (12), work status (14), and telecommuting experience (15).

The higher the value for job suitability C (equal to one if a respondent believes the job is suitable to telecommute from a center, and zero else) the higher the likelihood of preferring to telecommute from a center. Similarly, job suitability H, E showed that employees who believed their jobs could be performed remotely (either from home or a center) were more likely to prefer telecommuting. Importantly, both of these variables confirm that a person's attitudes can be and are shaped by external constraints such as his/her job attributes. Noting that these variables rank first and third, respectively, it is clear that job suitability is a very important factor in the preference to telecommute. This is consistent with a similar finding for modeling the preference for home-based telecommuting using this same data (Mokhtarian & Salomon 1997).

Overtime and telecommuting experience are both facilitators of the decision to prefer telecommuting from home. First, overtime, a measure of the total number of hours above the normal workload in a two week period, points to an individual desiring the amenities of home when free time becomes scarce. For example, a person may be able to spend some time with the family and/or do chores during work breaks. It may at first seem that overtime is capturing an effect similar to that of the variable workaholic, but a correlation test shows otherwise ( $r^2 = 0.007$ ). Second, a person's experience with telecommuting from home is positively correlated with his/her preferring to telecommute from home. People who fall into this category may not prefer telecommuting from a center for various reasons, including: 1) they know the benefits of telecommuting from home and are not sure if the benefits of telecommuting from a center are worth the effort to switch, and 2) they may feel that they have already been given a privilege to telecommute from home and that asking to telecommute from a center may be excessive.

Manager support C, household interaction, and work status are variables significant to the preference of telecommuting from a center. Manager support C, the frequency with which the supervisor would permit the employee to work at a telecommuting center, is positively correlated with an individual preferring center-based telecommuting. The same type of variable was not significant to the preference of home-based telecommuting, which suggests that having manager support was more critical to the ability to telecommute from a center. This finding could be attributed to the fact that telecommuting from home

was an established practice at the respondents' organization (the City of San Diego), while telecommuting from a center was uncommon. Household interaction was positively associated with center-based telecommuting preference, as well as (even more strongly) with the preference for neither form of telecommuting. This result supports the hypothesis that household distractions are a constraint to telecommuting from home. On the other hand, full-time work status contributed negatively to the preference to telecommute from a center. One explanation for this finding is that part-time workers in this sample were more likely to have children at home between the ages of 6 and 16, which may have caused them to desire the family/work boundary associated with telecommuting from a center. Further, working from a center allows them to enjoy work-related social interaction. On the other hand, full-time workers in our sample had higher incomes, on average, and more affluent workers may be less likely to prefer a potentially small and nondescript workspace at a hypothetical telecommuting center over a personalized, known workspace at home or at the regular workplace.

Office discipline and workplace interaction are both constraints on the preference to telecommute. Telecommuting is not a productive work option for those people who do not have solid work habits outside of the regular office, and consequently, office discipline acts a constraint against telecommuting from home or a center. Similarly, workplace interaction, an indicator of an individual's need for the social and professional interaction found at work, is found to be positively correlated with the preference to "not telecommute". This finding suggests that respondents believe that the social and professional interaction found at a telecommuting center would not be adequate to replace the interaction provided at the regular workplace. In light of the fact that developing meaningful social relationships while working part-time at a telecommuting center will be difficult, as will be finding other telecommuters who share a similar enough occupation to offer some professional stimulation, it is not unreasonable to expect that a telecommuting center will not be an adequate source of workplace interaction for those who strongly desire it.

*Demographic variables.* Education (ranked thirteenth), income (sixth), and age (seventh) were three demographic factors that contributed to the understanding of an individual's preference to telecommute. First, the model showed that education contributed positively to the preference for home-based telecommuting. This finding supports the hypothesis that workers with a high education are more likely to have a comfortable home office, and would not want to work at a telecommuting center which may be perceived to have less desirable workspaces. Thus, the people in this category who wanted the benefits of telecommuting would likely prefer to telecommute from home. Second, it was found that as income increased, the likelihood of an individual to prefer

telecommuting from a center decreased. Similar to the explanation given for education, higher-income respondents are more likely to have comfortable offices both at home and at the regular office (which they would prefer over a plain office at a telecommuting center), and they are also more likely to have jobs which are less suitable for work at a center. Finally, it was seen that as age increased, the likelihood that an individual would prefer not to telecommute also increased. Two reasons for this phenomenon may be: 1) older people are more likely to have jobs with more responsibility and that are less suited for telecommuting and 2) older people may be less likely to desire change, and would find that changing from a comfortable, well practiced and known work environment to a new work option would not be worth doing.

#### **4. Comparison of model results**

After reviewing each model separately, it is fruitful to compare results across models. Table 3 contains the twenty-one different explanatory variables found in Models 1 through 3 and for each model indicates which alternative a high value on each variable favors. Constraint and facilitator variables were clearly dominant in the models, accounting for twelve of the twenty-one significant variables. Telecommuting drives were the next most frequent with six significant variables, while three demographic variables also contributed to the models.

Noting that different variables are significant to different models, it can be concluded that the variables found to affect the preference for telecommuting depend very much on the definition of the dependent variable and the model structure. The dependent variable for Model 1 was created as the simplest, most straightforward definition. Unfortunately, interpretation turned out not to be so straightforward, as the "prefer not to telecommute from a center" alternative confounded people who prefer home-based telecommuting with those who prefer the regular office. Further, Model 1's "prefer to telecommute from a center" alternative is also ambiguous because respondents who are in this group may actually prefer to telecommute from home even more.

Model 2's dependent variable did not have this problem, and consequently, significant variables actually differentiated between respondents who preferred home-based telecommuting and those who preferred center-based telecommuting. However, there are still drawbacks to Model 2. It is only explaining the preference *between* two forms of telecommuting, and many respondents (those who prefer not to telecommute and those who are indifferent between the two forms) are left out. Thus, it cannot capture the effect of variables differentiating between telecommuting and not telecommuting, nor the effect

of variables common to both forms of telecommuting. Further, Model 2's dependent variable still does not completely distinguish the home and center alternatives, as people are classified as preferring the center, for example, only if they want to work from a center more frequently than from home. Most of those "preferring" a center also desire to work at home some amount, and vice versa. Model 3 is designed to overcome, in some measure, the weaknesses of Models 1 and 2. By including all possible alternatives separately, Model 3's structure allowed the explanatory variables to distinguish among different alternatives. However, even for Model 3 a preference for the telecommuting center does not preclude wanting to work from home (less often) as well, and vice versa.

In general, the results from the conceptually superior Model 3 expand and clarify the results from the other two (simpler to estimate but sometimes more difficult to interpret) models. For example, in Model 1, the negative coefficient of household interaction appears to support the "prefer not to telecommute from a center" alternative, which is contradictory to the hypothesis that household distractions facilitate the preference to telecommute from a center. However, it is not known by Model 1 alone if household interaction distinguishes between the center and home, or between the center and the regular workplace. Model 3, with its two household interaction variables, clears up this confusion. Its two positive coefficients (one with respect to the "neither" alternative and one with respect to the "center" alternative) show that household interaction is a factor which increases the likelihood both of preferring telecommuting from a center (as expected) and of preferring to work from the main office (as expected). Similar clarification of the counter-intuitive coefficient for workplace interaction in Model 1 is provided by Model 3.

Income, office discipline, overtime, and personal benefits were found to be significant to telecommuting preference only in Model 3. This is strong evidence of the importance of a well-formulated model structure, as these hypothesized contributors to the preference for telecommuting were missed in Models 1 and 2. The personal benefits drive and the office discipline constraint apply more or less equally to all telecommuting alternatives, and hence, could not be identified as important in Models 1 and 2. Income is negatively correlated with the preference to telecommute from a center but fails to distinguish between the two groups (prefer home, prefer center) in Model 2. Likewise, overtime, positively correlated with preferring to telecommute from home, does not distinguish between alternatives in Models 1 and 2. These four variables were identified due to the more clearly defined model structure that allowed all types of alternatives to be distinguished.

On the other hand, several variables were significant to either Model 1 (children, commute time, lack of resources) or Model 2 (phone line, super-

visor), or both (stress), but not to Model 3. Evidently the differences in model structure and in the estimation sample caused the significance of these variables in distinguishing among alternatives to decrease in Model 3.

Education, job suitability, and workaholic variables contributed significantly to all three models. This suggests that these demographic, constraint/facilitator, and drive variables are fundamental to the preference to telecommute from a center. Here, both Models 2 and 3 clarify the results of Model 1. For example, education was negatively correlated with the preference to telecommute from a center in Model 1. However, Model 1 does not give enough information to determine if respondents with a high level of education will prefer to telecommute from home or to work at the regular workplace. Model 2 shows that highly educated people are more likely to prefer telecommuting from home rather than from a center. Model 3, with its alternative-specific education variable, further validates the hypothesis that as education increases the utility of telecommuting from home increases, whereas it has no independent effect on the utility of the "not telecommuting" alternative.

## **5. Conclusions and implications for the future**

### *5.1. Modeling results*

This study examined the individual's preference to telecommute, focusing on the center-based form. Data obtained from 628 employees of the City of San Diego were used in the development of three preference models based on a previously developed conceptual model of the decision to telecommute. Two binary logit models were presented, one on the preference to telecommute from a center versus not telecommuting from a center (adjusted  $\rho^2 = 0.24$ ), and the other on the strict preference to telecommute from a center over telecommuting from home (adjusted  $\rho^2 = 0.64$ ). A nested logit model was also estimated on the following four alternatives: preferring not to telecommute, preferring either form of telecommuting, preferring to telecommute from home, and preferring to telecommute from a center (adjusted  $\rho^2 = 0.35$ ).

The results of the models illustrated the importance of attitudinal measures in predicting an individual's preference to telecommute. Oblique factor scores representing workplace interaction, stress, workaholism, internal control, and commute stress were statistically significant in some or all of the models. Other explanatory variables which were found to be consistently significant were education, job suitability, and age.

Constraint and facilitator variables were the most prominent contributors to the explanation of telecommuting preference in all three models. In addition to being the most common category of explanatory variable, a constraint/



facilitator variable (job suitability) captured the number one ranking in every model. Constraint/facilitator variables have been found to play an important role in a respondent's *choice* to telecommute (e.g., Mokhtarian & Salomon 1996b), but they had not initially been expected to play such an important part in the development of *preference*. Theoretically, a person might develop a preference for telecommuting despite knowing that constraints preclude it. However (consistent with the findings of Mokhtarian & Salomon 1997, for the preference of home-based telecommuting), this study clearly indicates that preference is affected by constraints, and leads to the conclusion that people internalize constraints into their preference development.

Variables unexpectedly not significant in any of the models include: commute boundary (hypothesized to facilitate the preference of telecommuting from a center for those people who want the benefits of telecommuting, but need to have a separation between work and home that the commute can bring), and lack of space at home (hypothesized to facilitate the preference of telecommuting from a center for those people who want the benefits of telecommuting, but do not have adequate space to work from home). In the first instance, it may be perceived that a telecenter does not offer a commute that is long enough to be useful. In the second instance, it may be either that space is not a concern for enough people in the sample to be significant, or that the influence of space has been captured by correlated variables such as age, education, and income.

Understanding the differences in working from home as opposed to working from a center is important. A firm grasp of the perceived advantages and disadvantages of these two forms of telecommuting will facilitate the best implementation strategies for increased telecommuting adoption. Model 2 helped increase the understanding of an individual's preference between home- and center-based telecommuting, showing that the following seven explanatory variables distinguished between the two forms: education, job suitability, manager support, phone line, stress, supervisor, and workaholic.

### 5.2. *Future modeling research*

This study also illustrates a basic but important point regarding the dependent variable for a discrete choice model. Depending on the context, a simple binary variable definition may not be adequate. In conventional transportation mode choice modeling, for example, few, if any, serious models are based on a "car", "not car" dichotomy; the "not car" alternative is too heterogeneous. Even the early binary mode choice models were based on auto and transit alternatives – neglecting other possibilities rather than inappropriately combining them with transit. In the context of modeling telecommuting, as long as home-based telecommuting dominated public awareness and adoption, it was plausible to define a "(home-based) telecommuting", "not (home-based)

telecommuting” dependent variable, where the latter alternative could reasonably be assumed to be the homogeneous option of working at the conventional office. With the increased permeation of center-based telecommuting into public awareness and trial, however, more sophisticated dependent variables are necessary.

Thus, development of models with dependent variables based on varying definitions of *preference* would be a useful extension of this research. It would be desirable to model the strong (exclusive) form of preference on another data set with sufficient sample sizes in each category in Table 2. Alternatively, other future models could be based on the following definition of preference: “prefer *x*” only if the respondent wants to telecommute from *x* at least two frequency categories more often than for *y*. This would have the effect of increasing the size of the “indifferent” group. Further, it is recommended for future research that model structures which do not assume independence from irrelevant alternatives, such as nested logit or multinomial probit (with non-independent alternatives), be used on the same or similar data.

### 5.3. Policy implications

There are several implications of this study for center-based telecommuting adoption. First, the telecommuting experience variable in Models 1 and 3 showed that respondents with telecommuting experience (from home) were more likely to prefer telecommuting from home. This finding suggests that unfamiliarity with telecommuting from a center plays a role in the individual preference for this work option. Hence, in addition to explaining the basics of what telecommuting from a center is like, marketing the benefits of center-based telecommuting to employees and their supervisors may be necessary. Efforts like these may change the beliefs that job suitability and manager support would be low for a center as compared to home or the regular workplace, and consequently, employees’ preference for center-based telecommuting could increase and lead to greater center-based telecommuting adoption.

However, the amount of effort given to promoting center-based telecommuting should be carefully considered. Only three of the respondents in our sample preferred telecommuting from a center to the exclusion of telecommuting from home, while 189 respondents preferred telecommuting from home to the exclusion of telecommuting from a center. Thus, most respondents (517 out of 624) preferred either to telecommute from home or were indifferent between either form of telecommuting, which raises the question as to whether there really is a sizeable market niche to be filled by telecommuting centers. On the other hand, it is important to note that this study looks only at *preference* for telecommuting. The actual role that telecommuting centers will ultimately play depends on individuals’ *choice* to telecommute, which

is affected by constraints. Thus, people may prefer to telecommute from home but choose to telecommute from a center due to constraints such as space availability or household distractions. Further, the observed bias toward home-based telecommuting may be a consequence of the lack of familiarity with telecenters mentioned above, and therefore may have changed considerably since these data were collected (1992).

The ability to accurately forecast the demand for telecommuting, both from home and from a center, is improved through a better understanding of the individual preference for telecommuting. The ultimate goal is to forecast changes over time in the adoption of each form of telecommuting (including the frequency of doing so), as a function of relevant explanatory variables. The forecasting models should permit the testing of various future scenarios, including the introduction of different policy measures expected to impact the adoption of telecommuting. This forecasting ability, coupled with an assessment of the (different) transportation-related impacts of each form of telecommuting, can generate baseline and alternative aggregate forecasts of the congestion, emissions, and energy impacts of telecommuting that will be of use to transportation planners and policy-makers trying to factor the effects of telecommuting into the planning process.

### Acknowledgments

The research reported here is funded by the USDOT University Transportation Centers program, through the University of California Transportation Center. This paper has benefited from the contributions of Professor Ilan Salomon, Professor Rahman Azari, David Stanek, and Laura Laidet.

### References

- Bagley MN, Mannering JS & Mokhtarian PL (1994) *Telecommuting Centers and Related Concepts: A Review of Practice*. University of California at Davis: Institute of Transportation Studies Research Report No. UCD-ITS-RR-94-4. Prepared for the California Department of Transportation Office of Traffic Improvement: Sacramento CA.
- Bagley MN (1995) *Binary & Multinomial Logit Models of the Preference for Center-Based Telecommuting*. Master's Thesis, Department of Civil & Environmental Engineering, University of California at Davis. Available as Research Report No. UCD-ITS-RR-95-16 University of California Davis: Institute of Transportation Studies.
- Ben-Akiva M & Lerman S (1985) *Discrete Choice Analysis: Theory & Application to Travel Demand*. Cambridge MA: MIT Press.
- Bernardino A, Ben-Akiva M & Salomon I (1993) A stated preference approach to modeling the adoption of telecommuting. *Transportation Research Record* 1413: 22-30.
- Bernardino A & Ben-Akiva M (1994) Adoption of telecommuting: The employer's perspec-

- tive. Prepared for the European Assembly on Teleworking & New Ways of Working: Berlin November 3–4.
- Greene WH (1995) *LIMDEP Version 7.0 User's Manual*. New York: Econometric Software, Inc.
- Healy T (1968) Transportation or communications – some broad considerations. *IEEE Transactions on Communication Technology* 16(2): 195–198.
- Hauser J (1978) Testing the accuracy, usefulness and significance of probabilistic choice models: An information-theoretic approach. *Operations Research* 26(3): 406–421.
- Hausman J & McFadden D (1984) Specification tests for the multinomial logit model. *Econometrica* 52(5): 1219–1240.
- Mahmassani H, Yen J, Herman R & Sullivan M (1993) Employee attitudes & stated preferences towards telecommuting: An exploratory analysis. *Transportation Research Record* 1413: 31–41.
- Mannering J & Mokhtarian P (1995) Modeling the choice of telecommuting frequency in California: An exploratory analysis. *Technological Forecasting & Social Change* 49(1): 49–73.
- McFadden D, Train K & Tye W (1977) An application of diagnostic tests for the independence from irrelevant alternatives property of the multinomial logit model. *Transportation Research Record* 637: 39–46.
- Mokhtarian P (1991) Defining telecommuting. *Transportation Research Record* 1305: 273–281.
- Mokhtarian PL, Balepur N, Derr M, Ho C-I, Stanek D & Varma K (1996) *Residential Area-Based Offices Project: Interim Findings Report on the Evaluation of Impacts*. Institute of Transportation Studies, University of California, Davis, Research Report No. UCD-ITS-RR-96-11, November.
- Mokhtarian PL & Salomon I (1994) Modeling the choice of telecommuting: Setting the context. *Environment & Planning A* 26(5): 749–766.
- Mokhtarian PL & Salomon I (1995) *Modeling the Preference for Telecommuting: Measuring Attitudes & Other Variables*. Research Report No. UCD-ITS-RR-95-17: University of California at Davis: Institute of Transportation Studies.
- Mokhtarian PL & Salomon I (1996a) Modeling the choice of telecommuting 2: A case of the preferred impossible alternative. *Environment & Planning A* 28: 1859–1876.
- Mokhtarian PL & Salomon I (1996b) Modeling the choice of telecommuting 3: Identifying the choice set and estimating binary choice models for technology-based alternatives. *Environment & Planning A* 28: 1877–1894.
- Mokhtarian PL & Salomon I (1997) Modeling the desire to telecommute: The importance of attitudinal factors in behavioral models. *Transportation Research A* 31(1): 35–50.
- Small K & Hsiao C (1985) Multinomial logit specification tests. *International Economic Review* 26(3): 619–627.
- Stanek D & Mokhtarian P (forthcoming) Developing models of preference for home-based and center-based telecommuting: Findings and forecasts. *Technological Forecasting and Social Change*.
- Sullivan M, Mahmassani H & Yen J (1993) A choice model of employee participation in telecommuting under a cost-neutral scenario. *Transportation Research Record* 1413: 42–48.
- Yen J & Mahmassani H (1994) Telecommuting adoption: Conceptual framework & model estimation. Presented at the Annual Meeting of the Transportation Research Board, Washington D.C.