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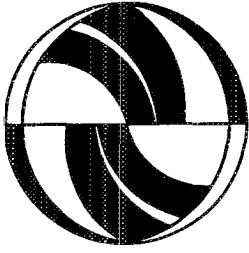
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**Modeling the Desire to Telecommute:  
The Importance of Attitudinal Factors  
in Behavioral Models**

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## MODELING THE DESIRE TO TELECOMMUTE: THE IMPORTANCE OF ATTITUDINAL FACTORS IN BEHAVIORAL MODELS

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**Abstract**—This paper begins to operationalize a previously published conceptual model of the individual decision to telecommute. Using survey data from 628 employees of the City of San Diego, hypothesized drives to telecommute and constraints on/facilitators of telecommuting are measured. A binary logit model of the preference to telecommute from home is estimated, having a  $\rho^2$  of 0.68. The explanatory variables include attitudinal and factual information. Factor analysis is performed on two groups of attitudinal questions, identifying a total of 17 (oblique) factors which can be classified as drives and constraints. Additional measures are created from other data in the survey, usually objective sociodemographic characteristics. Variables representing at least four of the five hypothesized drives (work, family, independence/leisure, and travel) are significant in the final model. Variables from four of the ten groups of constraints (job suitability, social/professional and household interaction concerns, and a perceived benefit of commuting) are significant, primarily representing internal rather than external constraints. The results clearly demonstrate the importance of attitudinal measures over sociodemographic ones, as the same demographic characteristics (such as the presence of children, commute time) will have different effects on preference for different people. Copyright © 1997 Elsevier Science Ltd

### 1. INTRODUCTION

Telecommuting is often suggested to be one of a series of public policy measures useful in reducing driving and its externalities. In an information age, when significant shares of the workforce are engaged in information processing, the use of telematics as a substitute for travel seems to be a desired and increasingly feasible alternative. Telecommuting is officially included in the list of optional measures to increase (effective) vehicle occupancy ratios in California and is on the agenda in many other places around the world.

As attractive as telecommuting sounds, it seems that forecasts of its adoption (e.g. Nilles, 1988; Boghani *et al.*, 1991) have been over-optimistic (Gold, 1991). Nilles (1988), for example, has forecasted that by 1995, under the nominal growth rate, there will be 21.2 million telecommuters in the United States, 16% of the workforce or 28% of all information workers. This gap between expectations and reality has warranted deeper analysis as to why people refrain from telecommuting, even when seemingly offered the opportunity to do so. This paper is part of an effort to model the preference for and choice of telecommuting. Herein, we attempt to understand the formation of the preference for telecommuting, which is a precursor of choice. We do not attempt to forecast future preferences, but we present a model of preference in order to identify the factors which affect it.

A conceptual model of telecommuting adoption developed by the authors describes the relationships among drives, constraints and facilitators as the elements which form preference and choice of telecommuting. The model is briefly discussed in the next

section. To empirically test these relationships, data were collected from 628 employees of the City of San Diego, who were queried about their perceptions of telecommuting, their own experience (if any) with telecommuting, and attitudes towards work, travel, technology, family and ideology.

In this exploratory stage of research into the telecommuting adoption process, the identification of the variables most relevant to that process, and the most effective ways of measuring those variables, are still uncertain. A focus of the research described here has been the development and testing of a large number of potentially-useful measures of explanatory variables of telecommuting preference and choice. Development of those measures, and of their hypothesized impact on telecommuting adoption, has followed the conceptual model described below. Once the pool of candidate explanatory variables had been created, empirical statistical measures were used to select the variables which collectively were believed to have the greatest power to explain telecommuting preference. The high proportion of information explained by the final model (0.68) is taken as a general validation of the underlying conceptual constructs and the variable measurement methodology, although refinements in both are clearly possible.

The organization of this paper is as follows: Section 2 presents a brief description of the model, the research design and the data. Section 3 describes the candidate explanatory variables identified, including those derived from factor analyses of attitudinal variables. Section 4 presents the results of the estimation of telecommuting preference models. The conclusions and implications for further research are presented in Section 5.

## 2. THE RESEARCH DESIGN

### 2.1. *The conceptual model*

The model of telecommuting behavior (described in detail in Mokhtarian & Salomon (1994) and depicted in a simplified form in Fig. 1) suggests that the internal decision-making process in which telecommuting is being considered is initiated by some threshold level of dissatisfaction with one or more aspects of life. Such a search for solutions is motivated by "drives". Drives are constructs which "define" aspects of the long-term objectives that a person aspires to accomplish, such as an orientation towards family, work, leisure and travel. If there is some dissatisfaction, it is the drives which activate a search for adjustments to reduce the dissatisfaction. Drives, by definition, are "positive" constructs, in the sense that they point to the desired direction of change. When a search for improvement is initiated, information actively or passively received from the environment offers the individual the range of possible (and some impossible) alternatives. Telecommuting may be one of these.

Constraints, on the other hand, are factors which inhibit the formation of preference or inhibit action to be carried out. If a certain factor is present in a positive rather than a negative sense (such as management support rather than management resistance), it is considered a facilitator rather than a constraint. Constraints act either in a continuous fashion, that is reduce the probability that the individual will pursue a particular adjustment, or dichotomously, that is completely preclude the choice of a given adjustment. Constraints differ from drives in two important dimensions. First, whereas drives are internal constructs, some constraints (especially dichotomous ones) are exogenous, imposed by the physical environment, other people or institutions. Second, while drives are long-term constructs, constraints (especially external ones) may be temporary and be changed in very short time spans. The implication of these differences relates to the degree of control one can exercise over these factors. Understanding the effect of constraints, in addition to the role of drives, is important for forecasting purposes if policies to relax constraints are considered.

Constraints may take effect in different phases of the decision-making process. Some constraints affect the formation of preference, while others may only affect choice behavior independently of preference. In Mokhtarian and Salomon (1996a), we distinguish between

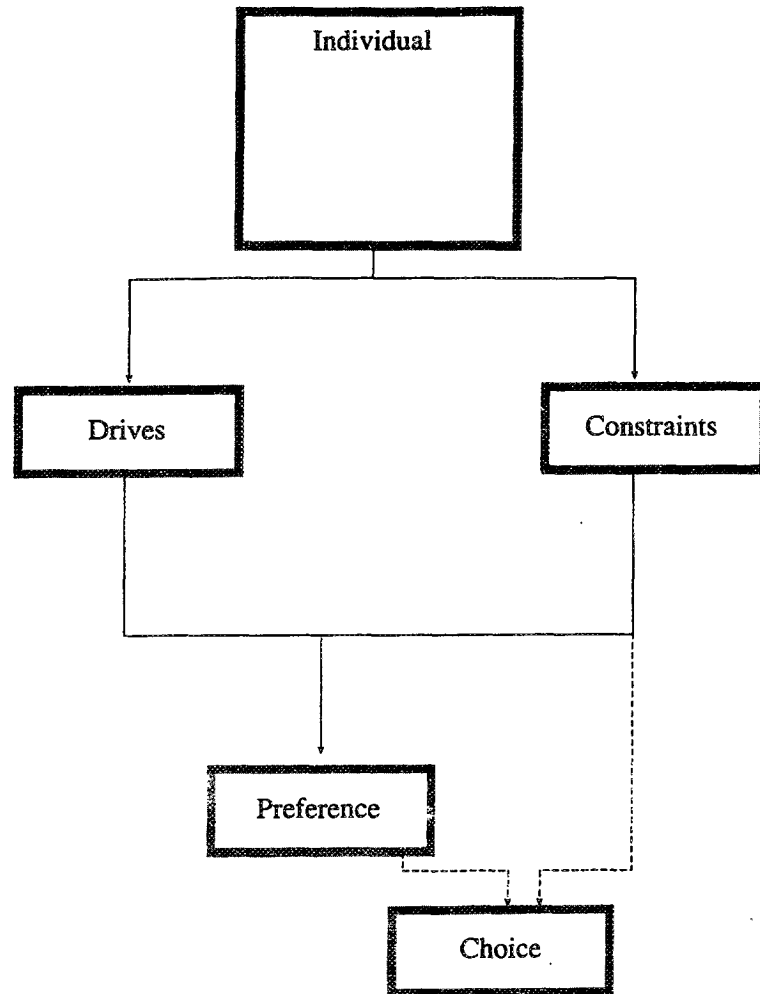


Fig. 1. The basic conceptual structure.

dichotomous and continuous constraints. Dichotomous constraints are those which, when active, essentially preclude telecommuting from being chosen. Logically, in a model of telecommuting *choice* these constraints should be used to define the choice set rather than to be included as explanatory variables in a utility function. Continuous constraints are those which (even if measured as a zero-one variable) are hypothesized merely to lower the probability of telecommuting, not preclude it entirely.

### 2.2. The model development process

To quantify the effect of drives and constraints on telecommuting behavior, it is possible to use either binary or multinomial dependent variables (see Mokhtarian & Salomon (1996a) for a more detailed discussion of potential dependent variables). In view of the wide gap between the stated preference for telecommuting and the small number of people who actually telecommute, following Koppelman and Pas (1980) and other studies, we have chosen to analyze separately the formation of preference and the choice to telecommute. In the present paper we focus only on the preference model. Binary logit models of home-based telecommuting choice have been estimated separately (Mokhtarian & Salomon, 1996b), and future extensions of this research will examine multinomial models of telecommuting frequency, preference for center-based telecommuting, and more complex choice sets.

The conceptual model suggests that preference is a necessary precursor of the choice of telecommuting. We are using the term "preference" as an intermediate concept. An individual is assumed to aspire to translate his or her preference into an action. However, a preference may express a long-term priority that may not always be exercised. The main reason for a mismatch between preference and action is assumed to be the presence of constraints. Thus, it is useful to examine the relationship of drives to both preference and choice. It is also desired to move beyond a naïve statement of preference (a response to the question "would you like to telecommute?") to a more elaborate model which explains the factors forming such a preference. The preference model estimated below does illustrate the trade-offs between advantages and disadvantages of telecommuting that an individual must consider in forming his or her preference.

In the following, we have estimated binary logit models in which the two alternatives are preferring to telecommute from home (as measured by a response of anything other than "not at all" to the question: "Assuming there are no work-related constraints, how much would you like to telecommute from home?") or preferring not to.

Most of the key explanatory variables were measured through multiple indicators, resulting in a large number of candidates for inclusion in a preference or choice model. It was necessary to consolidate and screen that number to define a set of potential explanatory variables which was parsimonious while still possessing most of the explanatory power of the full set of variables. Whereas conceptual considerations were the basis for generating the set of candidate explanatory variables, empirical statistical considerations were the basis for streamlining the set.

The screening process involved a number of stages, as shown in Fig. 2. First, factor analyses were performed to reduce two large sets of interrelated variables to smaller sets of factors representing distinct conceptual dimensions. Scores on these factors, together with other variables, were further screened in two ways. Initially, *t*- and  $\chi^2$  tests were performed to examine which variables "discriminate" best between those who prefer to telecommute and those who do not. Second, correlations within groups of related variables were examined so that highly correlated measures of the same construct were not included in the same model specification. For example, correlations between variables relating to the presence of children, and their counterparts relating to the number of children, were 0.9 and higher. In such a case, one variable at most from the correlated pair was included in the model. (Although including two nearly-collinear variables in the same model is technically not a problem if both are statistically significant, eliminating alternate indicators of a single construct is one practical and low-risk way of reducing the number of model specifications to test).

The outcome of this process was a reduced set of candidate explanatory variables which were consistent with the constructs developed in the conceptual model, available for inclusion in subsequent preference (and choice) models.

### 2.3. *The data*

The data were obtained from a 14-page self-administered questionnaire administered to employees of the City of San Diego in December 1992. It was designed specifically to test the conceptual model developed by the authors. The data contained information regarding respondents' previous awareness of and experience with telecommuting; their job characteristics; their ability to telecommute; perceived advantages and disadvantages of telecommuting; information on other choices they may have made to satisfy the hypothesized lifestyle drives; attitudes toward telecommuting and issues related to lifestyle drives; and sociodemographic characteristics.

The City has had a growing and relatively visible telecommuting program for its employees since early 1990. The sample was intended to obtain data from a diversity of respondents, including those for whom constraints such as job suitability prevented them from telecommuting. Further, given that many "non-information-worker" jobs deal with information to some extent, it was felt that attempts to exclude employees from the



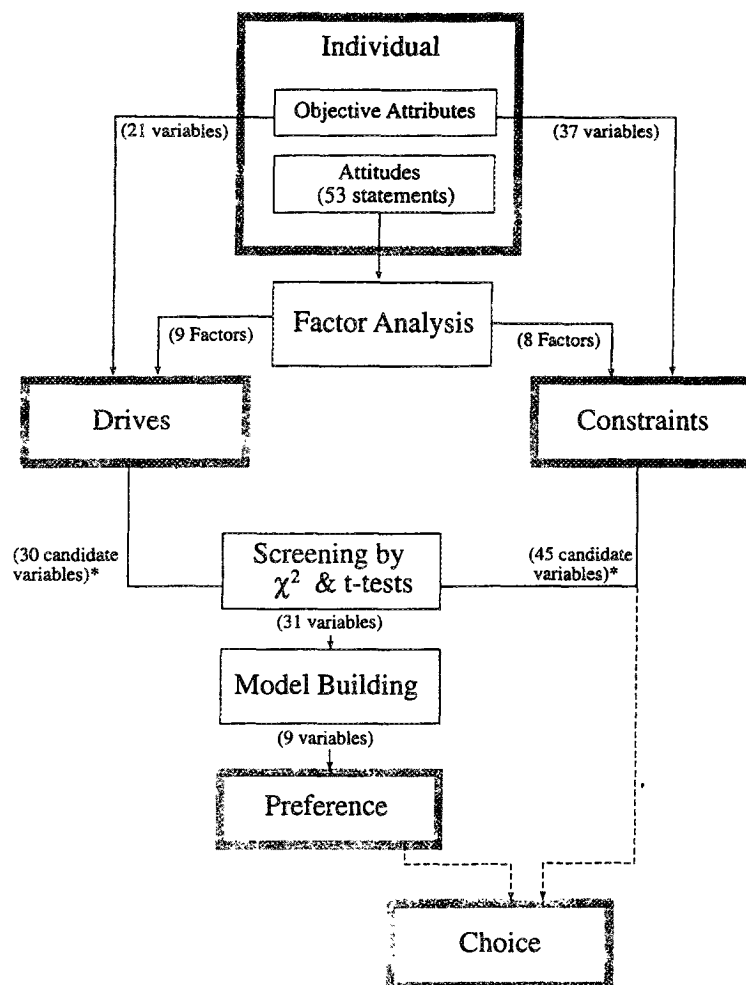


Fig. 2. The process of data reduction.

sampling frame based on job title alone was likely to eliminate many people who could telecommute at least part-time and/or on occasional partial days (Mokhtarian, 1991).

Although the sampling frame contains a diversity of occupations, it is important to realize that neither it nor the final sample can be considered representative of the workforce as a whole in terms of the population distribution of key variables including the choice of telecommuting. It may be argued, however, that the sample adequately represents the population relationships of explanatory variables to the choice and preference of telecommuting (i.e. the importance of those variables as determined by their magnitude and significance in a quantitative model).

A total of 1428 surveys were sent out in late 1992, of which six were undeliverable and six were duplicated names. Of the remaining 1416 surveys, 629 were returned. One of these was largely blank and was discarded from further analysis. The remaining 628 yielded an effective response rate of 44%, which was considered excellent for a survey of such length and general distribution. Response rates varied across departments between 41 and 50%. Some possible implications of a response bias are discussed in Mokhtarian and Salomon (1996a).

In terms of occupation, 58.6% of the sample was professional/technical, 25.0% clerical/administrative support, 11.6% manager/administration, and 4.6% other. A higher proportion of the sample had supervisory responsibilities than suggested by this distribution, however: 10.7% supervised "one or more supervisors", while an additional 24.5% supervised "one

\*Because some variables appear as both constraints and drives, the numbers add to more than the total given in the text.

or more staff". On average, respondents had been with their present department for 6 yr, their present employer for 8.7 yr, and their present occupation for 8.5 yr.

The sample was 52.9% female. The modal age category was 31–40 (38.4%), with the adjacent categories of 41–50 (28.2%) and 21–30 (19.3%) possessing the second and third highest proportion of respondents, respectively. Eleven percent were 51–60 years old, and 2.4% over 60. The average household size was 2.7 persons. Thirty-six percent of the respondents had children aged 15 or under in the household, including 21% with children aged 5 or under.

On average, 1.9 vehicles were available to respondent households, 0.99 vehicles per licensed driver. Respondents lived an average of 12.9 miles from work, with an average round-trip commute time of 54.5 min. The modal household income category was \$35,000–54,999 (31.1%), with an additional 40.5% in the adjacent categories of \$55,000–74,999 (22.8%) and \$15,000–34,999 (17.7%). Nearly 15% of the sample had household incomes of \$75,000–94,999, and 11.3% had incomes of \$95,000 and above.

It should be noted that in view of the fast pace of change in computer and information technology, data collected in 1992 may in some respects quickly become obsolete. For example, the proliferation of laptop and notebook computers over the last 3 yr may result in different responses to a number of questions if the survey were to be administered now. As we focus on behavioral relationships, such changes are not likely to make the results of the study obsolete, but it should be borne in mind that new technologies, which may facilitate behavioral changes, are continuously entering the market.

### 3. MEASURING DRIVES AND CONTINUOUS CONSTRAINTS

The hypotheses of this study, as evolved from the previously described conceptual model, relate the presence of drives and constraints to the preference and choice of telecommuting. To identify the presence of such factors we have collected an array of attitudinal and objective data designed to reveal the respondent's motivations and constraints.

#### *3.1. Factor analyzing the attitudinal data*

Since telecommuting is presently not a popular and well known work arrangement, knowledge about the features of telecommuting is often somewhat distorted. In looking into the attitudes expressed by the respondents, it is necessary to bear in mind that for those who do not have personal experience with this work arrangement, their attitudes are based on hearsay, media reports and so on.

Two sections of the questionnaire were used for the purpose of obtaining perceptions on potential drives and constraints relating to telecommuting. Section C included a listing of 17 advantages and 11 disadvantages of telecommuting, and respondents were requested to show how important each of these were to them. We assume that the importance a person attributes to each of these statements directly reveals the extent to which telecommuting may satisfy various drives or be limited due to various constraints, and indirectly reveals his or her awareness of and familiarity with telecommuting.

Section E of the questionnaire included 25 statements related to work, family, personality, travel, technology and the environment. Respondents were requested to state on a five-point scale the extent to which they agreed or disagreed with the content of each statement. The statements were selected so that agreement (or disagreement) reveals the drives which may motivate the respondent's preference or the constraints which inhibit choice.

In designing the questionnaire, we attempted to correlate each of these statements with either a drive or a constraint. Although each statement captures but one aspect of what we suggest constitutes a drive or constraint, collectively they are expected to span the perceptual space. Factor analysis was performed to develop scales based on linear combinations of statement responses that have similar patterns of variation across the sample. These linear combinations identify the major dimensions of the perceptual space (Rummel, 1970), dimensions which ideally approximate the key elements of the preference/choice process.

A more detailed discussion of the factor analysis and of the contents of the resulting factors is found in Mokhhrian and Salomon (1995). Here, we only briefly list and describe each factor. For both sets of attitude statements an oblique rotation solution was selected, as it provided more interpretable results due to the conceptual and empirical overlap among some factor dimensions.

Factor-analyzing the 28 advantages and disadvantages of telecommuting resulted in nine factors: five drives associated with the advantages, and four constraints associated with the disadvantages.

1. **Personal Benefits.** This factor comprises a number of the personal benefits of telecommuting cited in the literature, represented by heavily-loading statements such as to have more time for oneself, expand opportunities to pursue further education, have more independence, exercise more control over the physical work environment, save money, and so on. We suggest that this factor represents the independence and leisure drives.
2. **Family.** Telecommuting advantages loading on this factor relate to the support of family life, including "to spend more time with my family" and "to make it easier to handle dependent care". This factor represents the family drive.
3. **Disability/Parental Leave.** This factor illustrates the perception of telecommuting as a solution for individuals who need to work while permanently or temporarily unable to access the normal work place (Anderson & Wood, 1993; Hesse, 1995). This factor primarily represents a work drive, but one advantage, the ability to work instead of taking parental leave, gives the factor some aspects of a family drive.
4. **Relocation.** One of the perceived advantages of telecommuting is the added option it offers to individuals who face relocation of the home or job. This factor represents a work drive.
5. **Stress.** From the statements loading on it, this factor represents at least two drives: the commute drive (i.e. the desire to reduce the stress of commuting) and the work drive (getting more work done and reducing the stress at the main office). Like the Personal Benefits factor, this factor also captures some of the common "first-order" benefits, that is those benefits of telecommuting that are suggested most often.
6. **Office Discipline.** This factor relates to the negative aspects of working away from the normal office environment: the need for self-discipline and organization. It indicates the presence of a constraint inhibiting, but not necessarily preventing, telecommuting.
7. **Visibility to Management.** Concern about visibility at work has often been raised in discussions of telecommuting. Two variables which relate to this issue, visibility with its impact on career advancement and the risk of being negatively viewed by management, load highly on this dimension. This factor is considered to be a constraint inhibiting telecommuting. It relates both to organizational and to manager support.
8. **Workplace Interaction.** The potential lack of social and professional interaction at the conventional workplace is often suggested to be one of the downsides of telecommuting. The statements addressing each one of these types of interactions form this factor, with relatively high loadings. It suggests that the two types of interactions are not perceived as separate entities. High scores on this factor indicate a constraint on the adoption of telecommuting.
9. **Commuting Benefit.** While commonly believed to be an undesired cost, commuting seems to have a positive utility for some workers, as it allows them to make the transition between home and work realms (Salomon, 1985). This factor is positively correlated with several variables which are indicative of the benefits of commuting. This factor is suggested to represent a constraint on the propensity to choose telecommuting: individuals who value the transition time and space offered by the commute are less likely to prefer telecommuting which eliminates this interlude.

Factor-analyzing the more general attitudinal statements found in Section E of the questionnaire also resulted in nine oblique factors: four drives, four constraints, and one single-variable factor which was discarded from further analysis. The eight factors that were retained are defined as follows.

1. **Lack of Control.** This factor includes statements such as: "I often feel like I don't have much control over my life"; "It's hard to be fully productive in the place where I work"; and "Work and family don't leave me much time for myself". The hypothesis is that individuals who are frustrated by a lack of control over their time may believe that telecommuting will provide them with a solution to their current situation. As such, this factor is viewed as another representation of the independence and leisure drives. However, an alternate hypothesis is that individuals who believe themselves to be at the mercy of external circumstances may prefer the structure of a conventional work arrangement and hence be less likely to want to telecommute.
2. **Family/Community Orientation.** This factor solidly represents the family drive, containing statements relating to the importance of family and friends, and to the desire to spend more time with them.
3. **Workaholic.** Although this factor unambiguously captures the workaholic syndrome, its effect on the choice of telecommuting is debatable. On the one hand, the workaholic may see the ability to telecommute as an opportunity for getting more work done. On the other hand, if he or she has limited ability to control the family/work boundary at home, working from a normal office environment may be preferred. In any case, this factor represents a work drive.
4. **Commute Stress.** Commuting is often associated with stress (Novaco *et al.*, 1990), at least for some workers. If commuting is so perceived, it is certainly a drive for telecommuting. This factor contains three statements, two directly related to the dislike of driving, and the third indicative of the same taste but wrapped in an environmental concern.
5. **Status Auto User.** For some people, an automobile is not just a means of transportation, but also a status symbol. Such individuals are less likely to adopt telecommuting, as the use of the automobile offers some utility and thus the commute trip is less costly in the psychological sense. This factor captures that attitude, and hence constitutes a constraint on the decision to adopt telecommuting. This is another manifestation of the benefits of commuting.
6. **Lack of Self-discipline.** This factor comprises statements which express the individual's level of self-discipline and organization. Lack of self-discipline is generally considered a barrier to telecommuting which suits better those individuals who are capable of setting clear boundaries between work and other realms of life, and hence do not need the formal structure and physical setting of the workplace in order to perform their work duties. However, it could also be argued that individuals who recognize their lack of self-discipline will prefer to telecommute, seeing in it an escape from the rigid structure of the normal office. Thus, the impact of this factor on the desire to telecommute is ambiguous.
7. **Internal Control.** This factor is positively correlated with being organized, trying to have some time for oneself (indicating independent interests) and being generally satisfied with life. It suggests an internal locus of control character trait (Lefcourt, 1982). While internal control may not be a necessary condition for one's ability to telecommute, it is hypothesized that it is a personality attribute which supports or increases the probability of choosing to telecommute.
8. **Misunderstanding Telecommuting.** Misunderstanding telecommuting based on partial information is likely to negatively affect the probabilities of preferring and choosing to telecommute. A high score on this factor (which includes statements such as "telecommuting is inappropriate for managers", "telecommuting is primarily for women with child-care responsibilities", and "telecommuting is synonymous with work at home"), indicates a high level of misunderstanding regarding telecommuting. This factor is a constraint on the choice of telecommuting.

In summary, the identification of factors which reduced the raw statements into some higher order variables resulted in measures of a number of drives and constraints. Although the statements comprising the factors were specifically designed to span the set of drives we have conceptually identified (as well as various constraints), it is not surprising that the final factors did not perfectly match the hypothesized drives. Some factors combine aspects of two or more drives. On the other hand, one drive—ideology—was not distinctly measured by any of the factors, although statements relating to environmental ideology load separately on several factors. The implication is either that the environmental construct was not well-defined by the survey questions, or that responses to the questions on environment were not highly correlated with each other. In either case, while benefiting the environment, frequently touted as an advantage of telecommuting, it will be difficult to identify that reason as a motivation for telecommuting adoption in this sample.

### 3.2. *Measuring drives and constraints through factors and other variables*

The factors identified above constitute the primary measures of the drives toward and constraints on telecommuting. The assumption of this study is that these attitudinal measures are likely to be the most important elements of the desire to telecommute. However, additional measures of drives and constraints were developed from responses to other portions of the survey instrument. These additional measures represent for the most part alternate ways of constructing explanatory variables representing the same drives and constraints as do the factors, only based on (self-reported) objective characteristics rather than attitudes. They include the traditional sociodemographic attributes as well as other measures such as awareness and job suitability. In some cases, they can only be viewed as proxies for an underlying drive or constraint, and as will be seen, in some cases they may represent either.

In this subsection, the 30 distinct measures associated with the five hypothesized drives—work, family, independence and leisure, ideology, and travel—are briefly discussed. This is followed by a summary of the measures associated with constraints. Again, a more complete description of the variables and of their hypothesized impacts on the adoption of telecommuting may be found in Mokhtarian and Salomon (1995).

*Work.* The work drive is measured through four factors and two additional variables. The four factors are Disability/Parental Leave, Relocation, Stress and Workaholic. The other variables are based on the amount of overtime worked and on a response of “work” to a question about how an extra hour would be spent.

*Family.* The family drive is measured by three factors and by a number of objective sociodemographic characteristics, as well as by a response of “family” to the question on how one would spend an extra hour. The three factors are Disability/Parental Leave, Family, and Family/Community Orientation. The sociodemographic characteristics are based on the number or presence of children of various age groups or other dependents needing special care, gender, and interactions of gender with children or other dependents.

The sociodemographic variables described above are clearly not precise indicators of a family drive. Two people may each have the same number and ages of children, yet family may be important to one and not the other. Thus, it is important to capture an attitude toward family, which is accomplished through the three factors described above. The sociodemographic indicators are included for completeness, and for comparison to previous studies which considered those variables (e.g. Bernardino *et al.*, 1993; Sullivan *et al.*, 1993). However, it is not surprising that for *t*-tests conducted on this group of variables, all family-related attitudinal factors show significant discrimination between preferers and non-preferers of home-based telecommuting, while among the sociodemographic variables, only gender is significant.

*Independence and leisure.* Three variables relate to the independence and leisure drives: the Personal Benefits factor, the Lack of Control factor, and a dummy variable representing a response of “on myself” to the question of how an extra hour would be spent.

*Ideology.* As mentioned above, the hypothesized ideology drive (particularly a pro-environment orientation) is not well-captured in the survey data. The purest measure of an ideology drive is the response of "a 'cause' I believe in" to the question of how one would spend an extra hour; however, this measure obviously does not necessarily imply that the cause in question is environmentally-related.

*Travel.* Two factors and five objective variables measure the travel drive. The two factors are Stress and Commute Stress. Three of the other variables are objective measures of the nature of the work trip: commute distance, commute time, and average commute speed. The final two variables are alternate measures of vehicle availability: number of vehicles per licensed driver and number of vehicles per worker in the household.

As in the case for drives, we have designed our research instrument to identify the constraints we have hypothesized, based on previous research. Empirically, the constraints are identified in part through the factors described above, and in part by objective measures which were collected in the questionnaire. Below we summarize the 45 distinct measures associated with the 10 hypothesized constraints/facilitators: awareness, organization/manager support, job suitability, technology availability, cost, social/professional interaction, household interaction, discipline/control, risk aversion, and benefit of the commute.

*Awareness.* Three variables relate to the awareness and understanding constraints. The first is the dichotomous variable Unaware, a dummy variable set equal to one if the respondent had never heard of telecommuting before receiving the survey. The second variable is the Misunderstanding factor, and the third is a dummy variable representing the response of "I never really thought about it" to the question of why the individual is not currently telecommuting.

*Organizational/managerial support.* The second group of constraints relates to organizational and managerial support of telecommuting. This group of constraints contains one factor, Visibility to Management, and four other variables. The first two other measures are dummy variables representing answers of "Not offered or discussed" and "Management disapproves", respectively, to the question on why the respondent is not currently telecommuting. The third measure is the dichotomous variable Manconst, set equal to one if the supervisor were not willing for the respondent to telecommute from home at all. The fourth variable in this group, constructed as a facilitator rather than a constraint, is a continuous measure of supervisor support, based on the perceived frequency with which the manager was willing to allow the respondent to telecommute from home.

*Job suitability.* One dichotomous and eight continuous variables measured job suitability. The dichotomous variable Jobconst was set equal to one if the respondent considered his or her job to be completely unsuitable for telecommuting from home. The corresponding continuous (facilitator) variable was based on the frequency with which respondents believed their jobs to permit telecommuting from home. Another measure is a dummy variable set equal to one if the respondent is a supervisor, although arguments in that case could be made for an impact in either direction on the ability/desire to telecommute. The remaining variables relate to the amount of location dependent (LD) and independent (LI) content of the job, and to the amount of control the respondent has over scheduling LD and LI tasks.

*Technology availability.* Four variables address the technology availability constraint. The first two may also relate to other types of constraints but are classified here for convenience. They are dummy variables based on responses of "I don't have all the resources I would need" or "I would telecommute from a center, but there is none available" to the question on why he or she is currently not telecommuting. The third measure of technological availability was a dummy variable set equal to one if respondents reported that they would need a computer to be able to work from home and that they would not be able to borrow one from the workplace. The final measure was an index equal to the number out of seven technological items (phone and computer products and services) that the respondent indicated as needing to acquire or upgrade to be able to work effectively from home.

*Cost.* Four dummy variables addressed the constraint of cost on the ability to telecommute. The first is set equal to one for the response of "It would cost me too much" to the question of why one is not currently telecommuting; the other three variables are drawn from several questions relating to insufficient space at home.

*Social/professional interaction.* A single variable captured the desire for interpersonal interaction: the Social/Professional Interaction factor. A high score on this factor represents a high importance placed on the opportunities for social and/or professional interaction at the workplace.

*Household interaction.* Two dummy variables directly measured the impact of household interaction constraints on the adoption of telecommuting. The first one represents an affirmative response to the question "Would distractions from other household members be a concern if you worked from home?" The second represents a response of "My home environment is not suitable for telecommuting" to the question about why one is not currently telecommuting. In addition, several variables already discussed are considered indirectly to measure concerns about household interactions. The variables regarding insufficient space at home (described under the Cost heading earlier) may relate to this dimension as well: the smaller the home, the more likely there are to be distractions from and conflicts with other household members. Similarly, the variables regarding dependent care may relate here also. When discussed earlier, they were hypothesized to represent a Family drive. However, they may just as well represent undesired distractions (in a work context) that constitute a constraint on the choice of telecommuting, especially telecommuting from home.

*Discipline/control.* Three factors relate to the respondent's level of discipline and/or control: the Office Discipline factor from Section C of the survey, and the Lack of Self-discipline and Internal Control factors from Section E. As the latter factor is constructed, it represents a facilitator rather than a constraint; that is, high scores on the Internal Control factor are considered to increase the propensity to telecommute.

*Risk aversion.* It is hypothesized that the risk-averse individual may have a lower propensity to telecommute, due to a desire not to "rock the boat" by requesting and obtaining special treatment. A single statement in Section E of the survey assessed the respondent's attitude toward risk: "I like to take risks when there is a chance for a good payoff." As worded, it constitutes a facilitator.

*Benefit of the commute.* As described earlier, two factors relate to the benefit some individuals derive from the work trip: Commuting Benefit, and Status Auto User. The higher the scores on these variables, the less likely the individual is to consider telecommuting.

#### 4. PREFERENCE MODEL

The process of reducing the original list of 64 candidate explanatory variables to a pool of 31 "most powerful" variables was described in Section 2. This smaller set of variables, plus a constant term, formed the initial model specification. Then insignificant variables were removed in stages and minor variations in specification were tested until a final model was achieved in which all variables were statistically significant and conceptually interpretable. A  $\chi^2$ -test between the final model with 10 variables and the initial model with 32 variables found no significant difference between the two ( $\chi^2 = 13.98$ , compared to a critical value of 30.8 for  $\alpha = 0.1$  and 22 d.f.), indicating that the final 10 variables capture essentially the full explanatory power of the larger set.

Table 1 presents the coefficients, *t*-values, and overall goodness-of-fit statistics for the final model. Turning first to the goodness-of-fit statistics, we note that the  $\chi^2$  value of 593.7 is significant at  $\alpha \ll 0.005$ , meaning that the null hypothesis that all coefficients are equal to 0 (the equally likely model) may safely be rejected. The  $\rho^2$  value is the proportion of the initial log-likelihood value accounted for by the model, and has an information-theoretic interpretation as the proportion of entropy or information explained by the model (Hauser, 1978). A  $\rho^2$  of 0.68, meaning that 68% of the information in these data is explained by the model, is considered quite high.

Table 1. Preference model estimation results

Variable	Variable type	Coefficient	t-statistic
Constant		0.83	1.75
Disability/Parental Leave	Work and Family Drives	0.39	2.02
Stress	Work and Travel Drives	0.74	2.71
Personal Benefits	Independence and Leisure Drives	0.65	2.33
Commute Stress	Travel Drive	0.61	2.58
Commute Time	Travel Drive	0.018	2.29
Amt. of Te'ing Job Allows	Job Suitability Facilitator	0.83	5.83
Workplace Interaction	Social/Prof. Interaction Constraint	-0.40	-2.02
HH Distractions a Concern	Household Interaction Constraint	-1.08	-2.62
Commuting Benefit	Benefit of Commute Constraint	-0.43	-2.31
Number of observations		626	
Log-Likelihood at 0		-433.91	
Log-Likelihood at convergence		-137.06	
$\rho^2$		0.68	
Adjusted $\rho^2$		0.66	
$\chi^2$		593.7	

However,  $\rho^2$  for the final model can only properly be interpreted in comparison with the  $\rho^2$  for the market share model, i.e. the model containing only a constant term. For such a model, the probability of preferring telecommuting will be constant for each individual and equal to the observed share of telecommuting preference in the sample. With relatively unbalanced shares for the two alternatives (88% of the sample preferred to telecommute), the market share model itself contains a lot of information. Its  $\rho^2$  is 0.47, suggesting that the variables in our final model explain only an additional 21 percentage points of information. Although this additional increment is statistically significant at  $\alpha \ll 0.005$  ( $\chi^2 = 180.78$  with 9 d.f.), the situation is even more positive than that result suggests. In keeping with accepted practice, the constant term is retained in the final model because it captures the average effect of the unmeasured influences on preference and because it captures the effect of sampling bias (Manski & Lerman, 1977). However, re-estimating the final model without the constant term also results in a  $\rho^2$  of 0.68. That model is not significantly different (at  $\alpha = 0.05$ ) from the final model ( $\chi^2 = 3.14$ , compared to a critical  $\chi^2$  with one d.f. of 2.7 for  $\alpha = 0.1$  and 3.8 for  $\alpha = 0.05$ ), indicating that essentially all of the explanatory power of the model resides with the true explanatory variables.

Turning now to the coefficient estimates, we note that all coefficients have absolute *t*-values greater than 2.0, except for the constant term which is only marginally significant with *t* = 1.75. All coefficients have the expected sign. The positive sign of the constant term indicates that unmeasured variables have an average bias in favor of preferring to telecommute.

The significant variables comprise five drive and four facilitator/constraint measures. Interestingly, after accounting for differences of scale among the explanatory variables, the one with the strongest effect on preference is not a drive but rather an external facilitator, the amount of telecommuting permitted by the job (coefficient 0.83). This implies that job suitability is an important characteristic affecting not only the individual's ability to choose telecommuting, but also his or her desire to telecommute in the first place.

Consistent with the benefits of telecommuting often cited in the popular media, variables related to the work trip and to stress are also important to preference. The coefficient of Commute Time is small in magnitude (0.018), but only because this variable is measured on a much larger scale than any of the others (recall that the mean round trip commute time in the sample is 54.5 min). Somewhat independently from this objective measure of commute difficulty, the perceptual factors Stress and Commuting-related Stress (magnitudes 0.74 and 0.61, respectively) also have positive effects on the preference for telecommuting. However, these variables are partly balanced by the negative coefficient for the Commuting Benefit factor. This suggests that the model has successfully captured the counteracting effects of the positive aspects of the commute (constituting



a constraint on the desire to telecommute) for some, and the negative aspects (constituting a drive to telecommute) for others (or even for the same individual).

The factor representing Personal Benefits has a significant positive effect (coefficient 0.65), in keeping with the common image of the advantages of telecommuting. The Disability/Parental Leave factor is also positively associated with the preference to telecommute (although with a coefficient of 0.39 its influence is weaker than the variables previously discussed), indicating that people see telecommuting as a way of coping with situations which require attending to multiple responsibilities.

Two additional variables have a negative effect on the preference to telecommute. Individuals who assign a high value to social or professional interaction at work, as is indicated by the Workplace Interaction factor, are less likely to prefer the option of working at home. This may be viewed as a "pull" force, as opposed to the "push" force found among people for whom the "Household distractions a concern" constraint is active.

Of the nine explanatory variables other than the constant term, six are factor scores, as opposed to direct simple variables. This supports the hypothesis that attitudes, represented by the factors which are in fact composite variables, contribute significantly to the explanatory power of the model. The view that "reducing" the individual to simple socio-demographic variables involves a loss of information on the decision-maker's preference and consequent choice has been presented before (Salomon & Ben-Akiva, 1983). Here, we have empirically confirmed the importance of including such composite variables instead of the conventional socio-demographic variables commonly used to represent the decision-maker in discrete choice models. For example, gender, which often appears as an (easily measurable) explanatory variable, was not significant in our model. However, we found that many of the variables included in the model are in fact capturing gender differences. By performing  $\chi^2$ -tests (for discrete variables) and *t*-tests on all nine variables against gender, we found that in seven (all except Commute Time and Commuting Benefits) there are significant gender differences (highest  $P = 0.006$ ). Thus, one may conclude that gender effects are present, and are captured by more relevant variables than the simple gender affiliation.

Specifically, it was found that while men and women did not differ in mean values of Commute Time, women had higher mean values of Stress and Commute Stress. This is an especially interesting result, illustrating that individuals can have quite different perceptions of similar objectively-measured characteristics. As Novaco *et al.* (1990) put it, "subjective impedance is not 'isomorphic' with physical impedance". In particular there is a clear gender difference in the stress level as opposed to the time factor in commuting, consistent with the finding of Novaco *et al.* (1991) that commute stress is highest among women with long commutes.

On average, women also recorded higher values on the Disability/Parental Leave factor and lower values on the Workplace Interaction factor than men. There was no significant gender-based difference with regard to mean scores on the Commuting Benefits factor, meaning that on average men and women have similar evaluations of the boundary role of commuting which this factor represents. This contrasts somewhat with expectations, as women, who in most cases have multiple roles to fulfil (Hall, 1972), might have been expected to assign greater value to the boundary role of commuting. However, it may be the case that for men this factor exists as well, but is so much structured into their daily routine that it is less recognized.

## 5. DISCUSSION AND CONCLUSIONS

This paper presents the results of measuring the variables believed to be important to the preference for telecommuting, and quantitatively modeling preference as a function of those explanatory variables. We believe that the high goodness-of-fit ( $\rho^2 = 0.68$ ) in the final model and the prominence of attitudinal variables a priori hypothesized to be significant offer strong empirical validation for the inclusion of such variables in behavioral models in general, and validation of our conceptual model of telecommuting adoption in

particular. The results support our contention that the so-called socio-economic or demographic variables which are commonly used to describe the decision-maker in discrete choice models are too narrow to represent the person. To capture more in-depth the entirety of individuals, it is necessary to use composite variables, such as those obtained in this study.

In the previous section we discussed the variables which were significant in our model of telecommuting preference; it is worth briefly examining here the variables which were not significant. As we described the explanatory variables in Section 3, in several instances we indicated that logical arguments could be made for an impact on telecommuting in either direction. This was the case for the Lack of Control, Workaholic, and Lack of Self-discipline factors, and for the Supervisor variable. To the extent that Overtime is indicative of a workaholic nature, similar arguments could be made for that variable as for the Workaholic factor. Given the ambiguous or bi-directional nature of the potential impacts of these variables, it is not surprising that none of them was significant in the final model.

Such ambiguity of potential impacts is epitomized by the sociodemographic variables representing gender and family characteristics, which, as pointed out earlier, could either be measuring a family-oriented drive to telecommute or a household-interaction constraint on the desire to telecommute, or both simultaneously! (And thus, none of those variables was significant either.) Only carefully-measured attitudinal variables can distinguish which of these opposing impacts derives from a given set of objective characteristics. In our case, in view of the significance of the variable expressing concern over Household Distractions and the insignificance of the Family and Family/Community Orientation factors, it appears that family acts more as a constraint than a drive across the sample as a whole. This is completely plausible. However, it may also be the case that the family drive is being partially captured by other variables that are significant in the model (notably the Disability/Parental Leave factor, but also the Personal Benefits and two stress factors), and/or that a family drive is significant only for some relatively small segment of the sample.

The situation for family variables, in which family was found to be significant only in one direction, contrasts with that for commute-related variables, in which significant effects in both directions (drive and constraint) were successfully identified. Here as well, however, the definition of carefully-measured attitudinal variables was essential to capturing that distinction.

In examining groups of variables which were not significant in the final model, the following observations may be made. Of the five drive categories, only the ideology drive was not explicitly present in the model. However, even this drive indirectly appeared, insofar as it was reflected in relevant attributes loading on the Stress and Commute Stress factors ("Help the environment by driving less" and "Willing to reduce driving to improve transportation and air quality", respectively). Given that ideologically- (particularly environmentally-) driven individuals are hypothesized to form a relatively small segment of the population, it is not surprising that this aspect was not more prominent.

Of the 10 constraint categories, six were not significant in the final model. For the most part (with the exception of job suitability), the categories that were significant represented internal constraints, that is personality traits or attitudes at odds with telecommuting (social/professional interaction, household interaction, benefit of the commute). Conversely, the categories that were not significant generally represented external constraints: awareness, organization/manager support, technology availability, and cost. (Discipline/control and risk aversion are the two internal constraints that were not significant, which at least in the former case is probably partly due to the potentially bi-directional impact discussed above.) However, this is exactly what would be expected for a model of telecommuting preference: It should be primarily internal rather than external constraints that affect the desire to telecommute. That is, an individual may well want to telecommute regardless of whether it is costly or the manager supports it or the proper technology is available. External constraints should play a more prominent role in the actual ability to telecommute.

The model developed in this study explains the factors which account for the high share of the employees in our sample who state that they prefer to engage in telecommuting. The understanding of preference is very important in situations where there is evidently a wide gap between preference and behavior, as in the case of telecommuting and some other new technological applications offered to the household market (e.g. teleshopping).

The gap between preference and choice is, at a conceptual level, attributed to constraints. It is assumed that a preferred behavioral pattern that is not exercised can be attributed to some (mostly) external active constraints. However, it may also be the case that some of the gap may be attributed to an image that the respondents adopt, based on information they acquire from the popular media which presents the main advantages of telecommuting. This may generally be true for a broader class of situations where newly emerging technology-based alternatives are studied. If misunderstanding is a constraint acting on individuals, it should be studied in further modeling efforts directed at the choice of telecommuting and other new technological applications.

The specific variables which account for the preference of telecommuting vary in the degree to which they can be subjected to policy intervention. Most are internal constraints or drives, which are not sensitive to external changes. Even the important job suitability variable, although an external facilitator, is not readily subject to change in the short term. However, the data clearly show that the low adoption of telecommuting is not due to a lack of preference. Rather, external factors which may be more subject to policy influence appear to be of primary importance. A subsequent study of choice may be more indicative of factors which can be changed by means of policy in order to affect behavior.

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