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The Impact of Telecommuter Rail Cars on Modal Choice, MTI Report 04-01

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16. Abstract

Telecommuter technologies on rail cars enable a traveler on public transit to access the Internet, thereby enhancing the ability to work while traveling to and from work. This technology brings new opportunities for employers to expand their potential labor pool and for employees to shift the costs of work-related travel.

Research into more "traditional" forms of telecommuting arrangements such as working from home, a dedicated telecenter, or while traveling on business has found numerous benefits for society, employers, and employees.

The present study asks to what extent does the opportunity to engage in paid work while commuting to and from the workplace result in a shift in commuter modal choice away from automobile travel toward public transit. We present evidence that consumer demand for public transit is particularly elastic with respect to the value of time spent traveling.

This study provides evidence that by implementing telecommuter technology on rail cars, society could benefit by a significant increase in ridership on public transit. Such benefits should encourage the relevant stakeholders to pursue the implementation and promotion of this technology.

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Telecommuter technologies on rail cars enable a traveler on public transit to access the Internet, thereby enhancing the ability to work while traveling to and from work. This technology brings new opportunities for employers to expand their potential labor pool and for employees to shift the costs of work-related travel.

Research into more traditional forms of telecommuting arrangements such as working from home, a dedicated telecenter, or while traveling on business has found numerous benefits for society, employers, and employees. Society benefits from reduced congestion and reductions in harmful vehicle emissions. Employers benefit from reduced costs associated with maintaining physical facilities, and more satisfied and more productive employees. Employees benefit from increased flexibility and reduced stress related to traveling to and from work.

The present study asks to what extent does the opportunity to engage in paid work while commuting to and from the workplace result in a shift in commuter modal choice away from automobile travel toward intercity rail forms of public transit. We present evidence that consumer demand for public transit is particularly elastic with respect to the value of time spent traveling on intercity rail services. Thus, by reducing the personal cost of traveling, we expect to be able to increase ridership on this form of public transit. We therefore propose that if employers are willing to accept travel time as work time, the cost of the commute is shifted away from the employee. By reducing or even eliminating this cost, we expect that individual modal choice will shift toward intercity rail forms of public transit.

We employ a two-stage research program to test this proposition. First, using secondary data on the individual work-related trips of 18,068 San Francisco Bay area households (41,609 people), we estimate the value of time spent traveling by Bay Area residents. Second, drawing on primary data from a survey of Bay Area businesses, we assess the extent to which these employers will accept work conducted during the commute to and from the workplace as paid time. Combining these data, we then estimate the extent to which public transit ridership will increase as a result of the implementation of this technology. Our estimate, based upon a modest sample (n=61) of Bay Area employers, suggests that ridership will increase by 60 percent as a result of this new telecommuting technology.

This study provides evidence that by implementing telecommuter technology on rail cars, society could benefit by a significant increase in ridership on intercity rail forms of public transit. Such an increase has the potential to reduce traffic congestion and the associated emissions. For employers, this technology brings the possibility of enhanced access to a broader range of qualified individuals through an expanded geographic labor pool and enhanced retention by increasing employee well being and satisfaction. For employees, the technology brings the opportunity to live a greater distance from work, with its associated reduction in the cost of living, to avoid the stress caused by commuting by auto, and the increased flexibility that has been observed in more traditional telecommuting from home or a telecenter. Such benefits should encourage the relevant stakeholders to pursue the implementation and promotion of this technology.

INTRODUCTION

The purpose of this report is to investigate the impact of telecommuter rail cars on modal choice. Telecommuter rail cars are rail cars equipped with telecommunications technology such as Internet connections that enable railway commuters to work during their commute journey to or from work. Such telecommuter rail cars have recently been implemented in the San Francisco Bay Area of Northern California by Altamont Commuter Express. One of the most significant benefits of this innovation is the impetus it provides for modal shift by commuters from automobiles to public transit.

However, the realization of this benefit hinges on whether employers will accept commute time as work time. In this study we refer to work time to mean time spent on employer defined tasks for remuneration under a contract of employment. Furthermore, if employers are willing to accept commute time as work time, the realization of any benefits will also depend upon how responsive commuters are to the decrease in personal time spent commuting on public transit. That is, will any positive effect be sizeable enough to induce them to shift their mode of transportation from personal auto to public transit?

We begin our study with a review of the telecommuting literature. This is followed by a review of the modal choice literature. We then describe a research project that examines empirically whether the expected benefits of this new technology for transportation are likely to be realized.

LITERATURE REVIEW–TELECOMMUTING

Telecommuting involves the use of telecommunications technology to maintain regular contact with the employing organization. It refers to a specific form of telework where the employee conducts work either from home or from a purpose-built "telecenter." The type of work conducted this way involves two-way symmetric communication, or asymmetric communication at a distance and in work requiring some level of interdependence between an individual worker, his or her coworkers, supervisors, customers, suppliers, or the object of work itself. A familiar form of telecommuting involves the use of "group-ware" to stay in touch as the needs of the communication target change. A specific example is the interaction between a sales person, his or her sales team, supervisor, and customers whose needs adapt to changing circumstances, and whose satisfaction is dependent upon their needs being met by the focal employee. In this way, telecommuting is considered distinct from work that may be carried home or conducted anywhere beyond the structural boundaries of the employer–for example, working on the physical contents of one's in-box. Telecommuting is a transportation-oriented definition of telework with the focus on elimination or reduction of commute trips.[1]

There is no shortage of evidence on how widespread telecommuting is. In a study released in March 1998, the U.S. Department of Labor (DOL) reported that in 1997 there were about 3.6 million workers who were telecommuters paid for the hours they worked at home. A survey by Pratt for Telework America in 2001 reports that about 28 million, or one in five, U.S. employees participate in some form of telework at home, on the road, in telework centers or in satellite offices. This represents an increase of 17 percent from the 2000 figure of 16.5 million U.S. teleworkers. A report released by the Washington, D.C.-based Employment Policy Foundation projects that by 2003, up to 25 percent of the U.S. workforce might be telecommuting.[2] The International Telework Association and Council (ITAC) testimony in March 2000 claimed that the number of teleworkers climbed from 8.5 million in 1995 to 19.6 million near the end of 1999 and a predicted 137 million worldwide by 2003. The Hudson Institute projects that 90 million U.S. workers will be involved in telework by 2030.[3] Estimates vary widely due to the actual definitions of teleworkers used in surveys. However, it appears as though current numbers in the U.S. range between 15 percent and 25 percent of all workers using some type of telecommuting arrangements.

Telecommuting is not limited to the United States. For example, it has been reported that over one third of European employees now have a "Cyber Boss," where the boss is often working from home or a telecenter. Germany (50 percent), Austria (47 percent), and Slovakia

(41 percent) had the highest number of Cyber Bosses. The report also found that over 48 percent of European employers had implemented flexible working policies and solutions for employees.[4] In the United Kingdom, a survey by Henley Management Centre found that the number of employees working at home increased by 50 percent between 1992 and 1995, and reported that 70 percent of large- and medium-sized businesses plan to introduce teleworking in the next few years.[5]

Telecommuting is most likely to take place at very small or very large companies operating in information-intensive industries, such as banking, insurance and financial services, market research, data analysis, and telemarketing.[6] The continued shift to an information-based economy will result in a concomitant increase in jobs that are suitable for telecommuting. Occupations dealing primarily in information have grown to include 59 percent of workers by 1997.[7] In 1993, Handy and Mokhtarian estimated that at most 40 percent of the workforce might someday telecommute at least occasionally, based on Nilles' 1988 assumptions that half of all workers are (and will remain) information workers, of whom 80 percent are potential telecommuters.[8] Recent surveys suggest that 25 to 65 percent of jobs in North America and Europe are suitable for telecommuting on a part-time or full-time basis.[9]

Jobs suitable for telecommuting tend to have the following characteristics: a substantial portion of the work requires extended periods of high concentration and consists of creating, manipulating and disseminating information; some of the work results in measurable output and can be planned, and many tasks do not require face-to-face contact, physical access to fixed resources, or the use of high-security information.[10]

In addition to the growing reliance upon knowledge workers, there are other factors behind this growth in telecommuting arrangements. One major reason telecommuting has boomed in recent years is the rapid decline in prices of equipment and the simultaneous improvements in technology.[11] In addition, there are multiple organizational incentives, including the elimination of bureaucracy,[12] improved productivity and quality of work, the greater flexibility of work patterns, reduced labor costs, the necessity of telecommuting for meeting both recruitment and retention goals, and requirements of the new legal environment.[13]

Surveys of firms using telework arrangements are unanimous in the finding that teleworkers are more productive than their office counterparts.[14] The range of productivity improvement reported is anywhere from 15 percent, according to Goodrich, to 144 percent, as observed by Weiss. These productivity improvements are attributed to the reduced commuting time, reduced distractions from the workplace and improved around-the-clock use of computer facilities as well as the opportunity for employees to work at personal peak times, manage their work more effectively, and become more organized.[15]

A significant additional benefit to employers is reduced operating cost.[16] The primary source of cost savings is the reduction in office space required to maintain operations.

Cost savings are also achieved indirectly by the influence that telework has upon worktime lost.[17] Teleworkers also tend to be more satisfied with their jobs than their office-bound counterparts, leading to a lower turnover rate, and thus savings in recruitment and training costs.[18] A recent survey found that more than two-thirds of telecommuters express greater job satisfaction, with almost 80 percent feeling a greater commitment to their organization, most saying that they plan to stay with their employer, and almost three-quarters reporting a major increase in productivity and work quality.[19]

A significant challenge currently faced by organizations is the changing nature of the U.S. labor market. This is particularly the case for high-technology companies facing tight labor markets.[20] In recent years overall labor market growth has declined to 25-year lows. At the same time, the mean age in the workforce has risen, and the growth rate in the youngest age group of workers (18 to 25), has declined, leading to greater competition among employers for entry-level workers.[21] In the long-run, this shortage of qualified workers is expected to increase reliance upon telework as a strategy to attract and retain talented new employees.

In the United States, additional incentives for implementing teleworking arrangements can be found in the legal environment. The Clean Air Act's 1990 revisions require the reduction of employee trips to work, thus indirectly promoting telework. The Americans with Disabilities Act requires reasonable accommodation to be made to "qualified individuals with disabilities." Such "reasonable accommodations" for disabled employees may well include the option of telecommuting. Finally, the 1993 Family and Medical Leave Act requires that employers allow employees to take emergency time-off to care for dependents or themselves. By allowing employees to work from home, employers can dramatically reduce the amount of lost work time due to family emergencies and extended illnesses.[22]

What motivates individual employees to participate in telecommuting? Research suggests that the greater potential for control over their work and work hours, reduced routine, reduced commuting time, escape from rigorous dress codes, and easier management of work-family conflict are all important motives for individuals.[23] Roderick and Jelley found that the principal reasons employees take work home are to meet deadlines, to avoid interruptions, and to make up for insufficient office time. A recent survey found that the typical teleworker works at least one full day per week away from the office, lives in the northeastern or western regions of the U.S, has a college education, and is 35 to 44 years of age and married.[24]

Cost savings to individuals arise from the reduction or elimination of traveling to and from the workplace, the cost of meals away from home, and the cost of work clothing.[25]

Employees also benefit psychologically from the reduced stresses associated with commuting, particularly in congested city areas.[26] As already noted, teleworking employees report greater job satisfaction than their office-bound counterparts.[27] The greater flexibility of work scheduling afforded by telework arrangements also allows individuals greater flexibility to handle work-family conflicts.[28]

Telecommuting also has societal benefits in the form of reductions in city traffic congestion and the associated reduction in transport-related pollution. Telecommuting arrangements also have the potential of revitalizing rural areas.[29] In addition, society indirectly benefits from the many advantages accruing to employers and employees; that is, by improving the productivity of individuals and competitiveness of firms, consumers benefit from lower-priced and better-quality products. The general social welfare is also improved by the better quality of life reported by those using telework arrangements.

The transportation implications of telework are very important at the individual and societal level as travel choices have serious implications for household and government budgets in terms of direct expenditures and indirect health costs. Although it has been hypothesized, and there is some evidence, that telework substitutes for work-related driving, the magnitude of this effect is not clear. Furthermore, it has been found that most telecommuters do not change their usual travel modes. [30]

Telework may also have long-term impacts on auto mobility through residential relocation and the associated reshaping of spatial form. With regard to relocation, the major concern is that telework will result in further decentralization/sprawl, which has serious financial implications because of the direct costs associated with municipal infrastructure provision and the indirect costs associated with the loss of high-quality farmland and increased travel/vehicle emissions. The empirical evidence, however, is scant and mixed.[31]

TELECOMMUTING IN THE CONTEXT OF TELECOMMUTER RAIL CARS

The previous section reviewed the societal, employer, and individual benefits of various aspects of telecommuting in its common forms, i.e., home-based and center-based telecommuting. This section discusses the implications of the above findings for a new form of telecommuting, namely telecommuting on a train during the journey to and/or from work.

The fact that telecommuting is widespread and still growing indicates that both employers and employees have found it a beneficial form of attaining their respective objectives. Therefore, it is expected that employers are likely to accept rail telecommute time as work time. The added benefit is that jobs that may not be suitable to telecommuting in its present form may be suitable for telecommuting during the work journey. For example, information-oriented jobs that require frequent face-to-face contact may not be telecommutable in the traditional sense but do become telecommutable with this new technology. Thus, although the chief disadvantages of telecommuting result from the physical separation of workers from the workplace, these disadvantages may be mitigated by telecommuting during the work journey, as the employee has to be at the office on a daily basis, although for shorter periods of time.

Employers are likely to experience reduced operating costs through a reduction in utility expenses rather than a reduction in office space requirements. Productivity increases are also likely to take place through higher job satisfaction on the part of employees who will experience less stress than they would with a congested commute. Employees are also likely to benefit from increased work flexibility that will allow them to better handle their work-family conflicts.

Given the anticipated labor shortages, especially for information and high-tech companies, the most significant anticipated benefit for employers with this new form of telecommuting will be access to a pool of labor from a larger geographic region. Allowing employees to telecommute on the train is likely to attract employees from distant labor pools who may not otherwise be available. Recruitment in this context will be limited only by the amount of rail telecommute time the employers will accept as work time. Finally, this new form of telecommuting will afford prospective employers another alternative for regulatory compliance, such as the Clean Air Act of 1990.

One of the most important impacts of telecommuting from a societal point of view is the reduction of work-related driving. The next section reviews empirical evidence on the impact of telecommuting on transportation.

TRANSPORTATION IMPACT OF TELECOMMUTING

The impact of telecommuting as a potential transportation control measure has also received attention in the literature. Most studies of the travel and emissions impacts of home-based telecommuting have found substantial reductions in distance traveled, trips, and, hence, emissions.[33] For example, Mokhtarian, in her 1998 article for *Urban Studies*, adopted a simulation approach to analyzing the effect of telecommuting on transportation demand. Her results suggest that 6.1 percent of the workforce may be telecommuting (at least in California), 1.2 days a week on average; i.e., 1.5 percent of the workforce may be telecommuting on any given day. She estimated that, consequently, the vehicle-miles eliminated by this level of telecommuting amount to at most 1.1 percent of total household vehicle travel.

Analyses of the effect of center-based as opposed to home-based telecommuting show some differences across these forms. For example, analysis of participants in the California Neighborhood Telecenters Project showed that person-trips did not change significantly between telecommuting and non-telecommuting days, while vehicle trips increased by about one trip on telecommuting days. However, miles traveled were found to decrease significantly (65 to 74 percent) on telecommuting days. Although non-commute travel did not increase, there was a significant shift from other modes to driving alone on telecommuting days. Participants were also found to perform higher numbers of return home, eat meal, shopping, and social/recreational trips on telecommuting days, while the number of mode-change trips was reduced to zero.[34]

In their 1998 study, Mokhtarian and Varma found that the per capita vehicle miles traveled decreased significantly (53 percent) as a result of center-based telecommuting. On the other hand, they found that the number of commute personal vehicle trips increased significantly (58 percent) because of trips home for lunch and back to the telecenter in the afternoon. However, this study further showed that the number of non-commute personal vehicle trips decreased significantly, resulting in an overall insignificant increase in the total number of personal vehicle trips. Moreover, the increase in the number of cold starts was insignificant. The net impact of these effects on emissions was that the pollutants most closely tied to distance traveled showed the greatest reductions: a 51 percent decrease in particulate matter and a 35 percent decrease in oxides of nitrogen for telecommuters on their telecommuting days. Smaller reductions were also found in the pollutants most closely tied to the number of cold starts: a 15 percent decrease in total organic gases and a 21 percent decrease in carbon monoxide.

In summary, the empirical evidence on the impact of home-based or center-based telecommuting is that, although there is a significant reduction in miles traveled on telecommute days, there may be an increase in vehicle trips, and a modal shift from other modes to driving alone. In contrast, the anticipated effect of telecommuting on rail cars during the work journey is a shift from personal vehicle trips/miles to public transit. This shift would be expected to carry even greater benefits from the perspective of emissions reduction than the shift to more traditional telecommuting methods. Furthermore, if employers accept telecommute time during the work journey as work time, then travel time is effectively reduced by this telecommute time. This results from the shift from travel time that is unpaid (and therefore a cost born by employees) to travel time that becomes a part of the remunerated work day. How much of a shift in transportation will result from this reduction in travel time can be answered using a disaggregate demand model analysis as reviewed in the following section.

TRANSPORTATION MODAL CHOICE

Research into demand for passenger transportation in the economics literature has been focused mainly on estimating important parameters of the users of various transportation modes, such as their elasticities with modal price or service time and their values of travel time. These parameter estimates have been used to assess intermodal competition, to forecast the demand for new modes of transportation, and to assess the impact of policy issues such as investment, pricing, and regulation. For example, they have been used to assess alternative pricing schemes for urban highways, which require estimates of travelers' value of time.

Unlike many other economic services, individual consumers of transportation services have been reported to have a very high valuation of service quality as a percentage of their wage rate (see Table 1). Thus, in transportation demand analysis, the various components of service quality, such as travel time, comfort, and reliability, are treated as important attributes of a transportation mode. How much transportation users value each of these attributes depends on their tastes and the activity to be performed at the destination of travel. Thus, consumers face a choice among various combinations of attributes when they try to decide which mode of transportation to use.[34]

Table 1 Value of transportation time estimates

Type of Travel Time	Value of Time as Percentage of Wage Rate
Urban Passenger, Auto On-Vehicle Time	178%
Urban Passenger, Transit On-Vehicle Time	74%
Urban Passenger, Walk Access Time	338%
Urban Passenger, Transfer-Wait Time	165%
Intercity Passenger, Auto	6%
Intercity Passenger, Bus*	79%–87%
Intercity Passenger, Rail**	54%–79%

Source: Winston, 1985 based on McFadden et al. (1977), estimates for work trips; Morrisson and Winston (1985), estimates for vacation trips in the U.S.
*Lower value applies to low-income passengers and the higher value applies to high-income passengers.

**Lower value applies to high-income travelers and higher value applies to low-income travelers

Although aggregate modal split models were first developed in the economics literature, for example, Boyer in 1977 and Levin in 1978, behavioral disaggregate demand analysis models became more popular both for theoretical and empirical reasons.[35] First, disaggregate models are grounded in a theory of individual behavior. Second, the disaggregate approach allows a richer empirical specification capturing important characteristics of the decision-maker. Third, disaggregate models are better suited for the analysis of intermodal competition because both the consumers' characteristics and the attributes of the transportation modes are studied simultaneously. Furthermore, the parameter estimates from disaggregated choice models can be used to forecast the demand for a new mode of transportation.[36]

In the disaggregate transportation demand models, the decision-maker, usually identified as the head of household and/or principal driver, is modeled as making the discrete choice of one of J particular modes, such as auto, bus, or train. The chosen mode is assumed to maximize the decision-maker's utility, where, given the attributes of the J modes of transportation and the decision-maker's characteristics and tastes, the individual will select the mode, i, that results in the highest utility. Depending on the assumptions regarding the error term in the empirical specification, one then estimates a multinomial logit model or a multinomial probit model. Thus, the multinomial logit model has been used to explore urban passenger mode choice,[37] household automobile-type choice,[38] and intercity passenger transportation.[39] Estimates of key parameters based on disaggregate demand analysis are included in Table 2.

The basic disaggregate mode choice model has been further developed to include analysis of joint choices, such as mode choice and destination choice.[40] Thus, these models characterize mode choice in the context of other choices that either affect or are affected by the transportation choice. For example, in intercity passenger vacation travel, the choice of destination and of transportation mode are interrelated.

The parameters of a transportation choice model can be used to calculate estimates of price and service-time elasticities of demand and a decision-maker's value of travel time. As can be seen from Table 2, the cost and on-vehicle time elasticity estimates for the main urban transportation modes tend to have similar magnitudes, indicating that reducing on-vehicle time will have the same effect as reducing fares in increasing public transit ridership. However, the small magnitude of these elasticities suggests that neither increasing automobile tolls nor decreasing on-vehicle time in public transit is likely to significantly change urban travelers' work-trip modal choices. On the other hand, service-time elasticity estimates for intercity rail and bus transportation tend to be larger than the price elasticity estimates. Moreover, their large magnitude (higher than 1.50) suggests that reducing service time on public transit could significantly increase rail and bus ridership.

The value of travel time represents the amount of money decision-makers are willing to sacrifice for a reduction in the amount of time they spend traveling. This value depends on the disutility travelers attach to the time spent in a particular mode and the opportunity cost of travel.[41] Thus, a high value placed on travel time indicates that travelers derive a great amount of disutility from the time spent in the mode and/or that they attach a high value to travel time, given their activity at the destination of their trip.

Table 2 presents some values of travel-time estimates for the main forms of transportation. Winston, in the *Journal of Economic Literature,* interprets these magnitudes as follows. The finding that the value of transit on-vehicle time is lower than the value of auto on-vehicle time may be a result of the benefits of traveling by public transit such as being able to read and not suffering automobile commuter congestion. This estimate, however, does not include wait time and transfer wait time, which are more onerous than on-vehicle time. Thus, the high value of transfer wait time results from the disutility of having to interrupt a trip by transit and spend time waiting in a station for a connection. The high value of walk-access time appears to reflect the disutility involved in time spent walking to a bus stop or rail station before gaining access to either mode of transportation.

Winston further argues that, for intercity passenger transportation, the value of travel-time estimates indicates that the value of time associated with travel on auto, bus, or rail is not very high, suggesting that these travelers do not perceive that time spent on these modes is particularly onerous, nor do they attach a high value to their travel time in terms of the time foregone from activities at their travel destinations.[42]

In the context of the models reviewed above, if employers accept telecommute time on telecommute rail cars as work time, then, from the employees perspective, this is equivalent to a reduction in on-vehicle time during the journey to and/or from work. Thus, the implications of the parameter estimates in the disaggregate transportation mode choice models for the impact of telecommuter rail cars on modal choice are twofold. First, given the low on-vehicle time elasticity estimate for urban passengers using rail (-0.6), we can expect that the use of telecommute rail cars for urban transit will have a minimal impact on increasing rail ridership. Second, however, the high magnitude of on-vehicle time elasticity estimate for intercity rail passengers (-1.58) indicates that the use of telecommute rail cars on intercity rail (provided of course that the telecommute time is accepted as work time by employers) is likely to have a significant impact on modal shift from personal auto to public transit. This is especially important if the use of telecommuter rail cars is supposed to be effective in helping employers reach distant labor pools. These time elasticity estimates, however, are old and need updating. This is the first step in the empirical study described next.

Table 2 Transportation price and service time

Travel Mode	Cost Elasticity	On-vehicle Time Elasticity
Urban Passenger, Auto	-0.47	-0.22
Urban Passenger, Bus	-0.58	-0.60
Urban Passenger, Rail BART	-0.86	-0.60
Intercity Passenger, Auto	-.045	-0.39
Intercity Passenger, Bus	-0.69	-2.11
Intercity Passenger, Rail	-1.20	-1.58

Source: McFadden (1974), multinomial logit mode choice model for work trips in San Francisco Bay Area; Morrisson and Winston (1985), multinomial logit mode choice model for vacation trips in the U.S.

EMPIRICAL STUDY

The most important characteristic of the behavioral disaggregate analysis models reviewed previously is that they allow one to forecast the demand for a new mode of transportation such as telecommuter rail cars. Transportation via telecommuter rail cars can be viewed as rail transportation with shorter commute times than traditional rail transportation. Thus, behavioral disaggregate models can be used to forecast the demand for such a new mode of transportation. However, this requires an estimate of the amount of time by which the work journey will be reduced. This in turn depends on whether employers will accept commute time on telecommute rail cars as work time, how much time they will in fact accept, and for which types of professions. Thus, our empirical study includes two parts: updated estimates of service-time elasticities derived from secondary data, and an employer survey to obtain information on: the extent to which area employers will accept commute time on telecommuter rail cars as work time; whether there are limits as to how much time they will accept; and which types of jobs they will consider as candidates for this new form of telecommuting. The combined results of these two analyses allow us to forecast the demand for transportation on telecommuter rail cars. We first describe the analyses of the secondary data. This is followed by the analyses of the primary data and the combined results of the study.

Service Time Elasticity Estimates–Sample and Data

The Bay Area Travel Survey (BATS) 2000, commissioned by the California Metropolitan Transportation Commission, provided the source data for our analysis of service-time elasticities. This database is most appropriate for this analysis since it covers travel patterns specifically of the people in the Bay Area of Northern California, as opposed to the travel patterns of the U.S. population covered in the National Household Travel Survey.

BATS 2000 collected data on the activities and travel patterns over two-day periods of all members of 18,068 Bay Area households totaling 41,609 persons. 14,563 households were from a random Bay Area sample stratified by county; 503 households were from an ongoing transportation panel; and 3,002 households were from a sample of users and potential users of the Bay Area Rapid Transit (BART). The survey included an activity diary completed by participants, and a Computer Assisted Telephone Interview (CATI) recruitment and retrieval survey instrument. The survey collected travel data from February 2000 through February 2001.

The survey collected information on household characteristics (number of persons in the household; household income; number of cars owned or leased by the household; bicycle, moped, and motorcycle ownership; home ownership), person characteristics (age, sex, race, income, marital status, employment, schooling, disability, ability to drive) and vehicle characteristics (model, make, mileage). It also collected data on activities and trips from each member of a household for a two-day assigned recording period. Respondents could report more than one activity taking place within one period of time, thereby capturing multitasking (such as working while riding the bus). Respondents were asked to report on start time, end time, and sequence of travel activities (driving, riding, walking, biking, flying), as well as other activities such as household chores, personal care, meals, recreation and entertainment, sleep, work or work-related, school, shopping, etc. Over the two reporting days, there were a total of 328,834 travel activities, amounting to 35 percent of the reported activities. Eighty-two percent of the travel activities were through private car, while 4 percent were through public transit (rail or bus).

Since the analysis concerns work-trip behavior, the data were restricted to those trips whose purpose was work (i.e., trips for shopping, schooling, eating, or any other type of non-work activity were eliminated). Further, since the analysis forecasts the diversion of employed drivers from car to public transit, the sample was restricted to those households who owned at least one car, and those individuals who were able to drive (i.e., no driving disability, and licensed to drive). The final sample, consisting of 23,261 person-trips for the purpose of work, found that 23,045 (99 percent) of these trips are made through private car, and 216 (one percent) through public transit.

Service Time Elasticity Estimates–Variables and Method

The dependent variable in the analysis is the choice of work-trip transport mode, set to 1 if public transit is chosen, and zero if private car is chosen. Since this is a discrete choice model, probit analysis was undertaken.

Independent variables:

- The value of relative time, or the value of time difference between public transit and private car (*vtimediff*). This variable is calculated as the difference between the duration of the work trip and the duration of the alternative mode trip times the wage rate times 42 percent. This is based on the assumption that the value of time is 42 percent of the wage rate.[43]

Since data on the duration of the alternative mode trip is not available in the database, it was assumed that the alternative mode trip duration for each individual would be the average of that mode trip duration for individuals in the same census tract.

- Age (*age*) and age squared (*agesq*). These variables are usually included in this equation for fitting consideration, i.e., to prevent their non-inclusion from possibly negatively affecting the coefficients of main interest. It is postulated that a nonlinear relationship exists because the very young and the very old tend to ride public transit.
- Household size (*hhsize*) and number of household vehicles (*hhveh*). These variables take into consideration the constraints placed on a driver by his family's alternative uses for the car (*hhsize*) counterbalanced by the availability of other cars (*hhveh*).
- Sex (*female*). Similarly to age, this variable is usually included for fitting considerations.
- Flexibility in work time (*smflex*). It is postulated that workers with some flexibility in arrival to work time may be more likely to ride public transit.
- Race (*white*). Similarly to age and sex, this variable is usually included for fitting considerations.
- Home ownership (*rent*), and household income (*hhincome*). These variables reflect both wealth and income, and are assumed to reflect preferences for comfort, and to allow for influence of income on a commuter's sensitivity to the total cost of transport.

Although cost savings data should be included as well, the only cost data available in BATS 2000 is parking costs. The main coefficient of interest for the variable *vtimediff* will thus be biased. However, since the main purpose of this study is to forecast ridership rather than to obtain a specific point estimate, it is sufficient that the model be specified so as to predict the actual modal choices as accurately as possible.

Service Time Elasticity Estimates–Results

Table 3 presents summary statistics of the indirect and direct variables included in the analysis. For the final sample, the average work trip duration is 45 minutes, the average household size is 2.7 persons, and the average number of household vehicles is 2.22 cars. Forty-six percent of the sample is female; 75 percent is white; 72 percent own their home, and the average household income is $94,000 per year. Furthermore, 64 percent have some flexibility in work time. The sample consists mainly of officials and managers and professionals (60 percent). These sample characteristics are not surprising given that the sample was restricted to those commuters who were employed, owned at least one car, and were able and licensed to drive.

Table 3 Descriptive statistics for individual trip data

Variable	Mean	S.D.	Minimum	Maximum
Work trip duration	45.6	32.89	1	202
Car trip duration	43.9	32.29	0	202
Transit trip duration	44.0	5.28	0	160
Age	43.06	11.67	15	99
hhsize	2.70	1.28	1	11
hlveh	2.22	0.95	1	8
Female	0.46	0.49	0	1
smflex	0.64	0.46	0	1
White	0.75	0.43	0	1
Rent	0.27	0.44	0	1
Own	0.72	0.44	0	1
hhincome	94.39	40.41	5	150
Wage rate	47.19	20.20	2.5	75
Officials and managers	0.23	0.42	0	1
Professionals	0.36	0.48	0	1
Technicians	0.05	0.21	0	1
Sales	0.06	0.24	0	1
Office clerical/administrative	0.11	0.31	0	1
Craft workers–semiskilled	0.05	0.23	0	1
Operatives–semiskilled	0.01	0.10	0	1
Laborers–unskilled	0.02	0.11	0	1
Service workers	0.10	0.15	0	1

Table 4 presents the results of the probit analysis. The model is highly significant (model P value is 0.000). The coefficient of prime interest, that of the variable *vtimediff* is of the correct sign and also highly significant (P value=0.000). Household size, the number of household vehicles, sex, and household income are also highly significant. Household size appears to act as a constraint on car ridership, and thus encourages public transit ridership. On the other hand, the availability of more cars discourages transit ridership. Females are also more likely to use public transit than males, and those who rent their homes are more likely to ride public transit than those who own their homes and are thus wealthier. It may be surprising to observe that the coefficient for household income is positive, since higher incomes should reflect a higher preference for comfort and thus for car use. However, since a relative cost variable was not included in the analysis due to lack of data, this variable might be capturing relative cost effects.

To test its predictive power, the estimated model was used to predict the modal choice of the individuals in the sample. The sample consists of 23,045 (99 percent) trips made through private car, and 216 (1 percent) made through public transit. The estimated model predicted 23,026 (roughly 99 percent) trips made through car, and 173 (roughly 1 percent) trips made through public transit. Thus, the estimated model has very good predictive power and is a good fit.

Table 4 Probit analysis results for individual trip data

Variable	Coefficient	Standard Error	P Value
Vtimediff	0.000067	3.27E-06	0.000
Age	-0.021934	0.023585	0.352
Agesq	0.000089	0.000281	0.750
hhsize	0.099920	0.036583	0.006
hlveh	-0.442810	0.072704	0.000
Female	0.249046	0.086247	0.004
smflex	0.221974	0.099613	0.026
White	-0.138783	0.091814	0.131
Rent	0.033988	0.097790	0.728

Variable	Coefficient	Standard Error	P Value
hhincome	0.011393	0.001104	0.000
Constant	-1.370079	0.503013	0.006

Number of observations = 23,199
chi2 = 1464.06
Prob > chi2 0.0000
Log likelihood = -493.10155
Pseudo R2 = 0.5975

Employer Survey

The population of interest in this analysis is San Francisco Bay Area employers. Therefore, the sample for this study was all public and private employers in San Francisco and its surrounding counties (San Mateo, Alameda, Santa Clara, Contra Costa, and Marin). Survey participants were identified using the *Dunn and Bradstreet Million Dollar Directory*. This directory lists all public and private businesses with more than 20 employees, branch locations with more than 50 employees across the U.S. and Canada, or sales of one million dollars per year or more. The directory is therefore a very comprehensive source for U.S. employers, and holds current information on 1.5 million companies in the U.S. and Canada. The total sample thus identified was 3,069 unique business addresses (San Francisco, 634; San Mateo, 354; Alameda, 731; Santa Clara, 932; Contra Costa, 295; Marin, 123). Surveys were mailed along with pre-paid return envelopes to the senior human resources executive at these organizations.

The survey instrument was designed to assess the average percentage of a work day that Bay Area employers would accept as part of paid work time. We defined telecommuting in the survey as "working from home (or a hotel) for total time equivalent to at least one day per week (i.e., eight hours) using some form of telecommunications equipment (e.g. telephone, fax, or home computer)" and we defined telecommuting while traveling to or from work as "work performed on the train, bus or other mode of transportation during the normal journey to the work-site." As the last question in a larger survey about telecommuting practices, we asked, "Now consider those occupational categories whose work requires at least some 'face-time' or 'on-site time' each day, yet other aspects of work may be conducted off-site. For example, for employees engaged in sales or service, a significant portion of the day may involve administrative tasks rather than sales or customer service activities. For employees in each occupational category, what percentage of the work day would you be willing to accept telecommute time as a part of their work time?"

This information was gathered for each of the standard occupational classifications used by the U.S. Department of Labor (officials and managers, professionals, technician, sales workers, office clerical/administrative, craft workers–semiskilled, operatives–semiskilled, laborers–unskilled, and service workers). These distinctions were used for two reasons. First, it was anticipated that willingness to accept travel time as work time would vary systematically with the type of work being conducted. Second, these classifications are required for compliance with Equal Employment Opportunity legislation and are therefore used consistently across employers. They also indicate whether an employee may be expected to be exempt from the Fair Labor Standards Act (officials and managers, and professionals) or not (all others). Since the type of work performed as well as the employee's exemption from wage and hour laws are both likely to exert a predictable influence upon employer treatment of travel time as work time, we followed the Department of Labor classifications. Although the preliminary sample was over 3,000 employers, a very low response rate of 61 usable responses was received (2 percent). However, since this data is used to generate average estimates for employer acceptance only, and these estimates serve as input into the final analysis, the low response rate does not compromise the statistical power of the final analysis. The statistical power of this analysis is a function of the sample size (23,261 person-trips), the alpha level ($p<.05$), and the effect size in the population. Power is reduced when sample size decreases, as the estimate of sampling error is a linear function of sample size. In the present case, the very large sample size from the BATS data gives us confidence that the final analysis has sufficient statistical power to avoid false negatives (type 2 error). The low response rate does suggest that the results need to be interpreted with caution as it is possible that these results may either over- or underestimate the true value of the employers' willingness to accept travel time as work time. A summary of these data are presented in Table 5.

Table 5 Employer acceptance of travel time as work time (by industry and occupational category)

For employees in each occupational category, what percentage of the work day would you be willing to accept telecommute time as a part of their work time?					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	58	0	75	17.7586	18.35164
Professionals	38	0	80	22.1842	22.86134
Technicians	34	0	90	13.3824	24.33107
Sales workers	44	0	100	43.2045	36.85899
Office clerical/administrative	50	0	80	5.6	13.22336
Craft workers–semiskilled	19	0	20	1.5789	5.0146
Operatives–semiskilled	19	0	10	0.5263	2.29416
Laborers–unskilled	27	0	10	0.3704	1.9245
Service workers	23	0	5	0.3043	1.10514
Agriculture, forestry, mining					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	3	10	20	16.667	5.7735
Professionals	1	40	40	40	
Technicians	1	0	0	0	
Sales workers	2	80	90	85	7.07107
Office clerical/administrative	2	0	30	15	21.2132
Craft workers–semiskilled	0				
Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	2	0	0	0	
Service workers	1	0	0	0	
Automobile and other repair services					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	2	10	25	17.5	10.6066

Professionals	0				
Technicians	1	0	0	0	
Sales workers	2	20	100	60	56.56854
Office clerical/administrative	2	0	10	5	7.07107
Craft workers-semiskilled	1	0	0	0	
Operatives-semiskilled	1	0	0	0	
Laborers-unskilled	0				
Service workers	0				
Business services					
Occupation classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	10	0	50	23	17.82632
Professionals	5	0	50	27	22.2486
Technicians	3	10	90	36.6667	46.18802
Sales workers	6	25	90	59.1667	25.77143
Office clerical/administrative	9	0	30	9.333	12.12436
Craft workers–semiskilled	0				
Operatives–semiskilled	0				
Laborers–unskilled	1	0	0	0	
Service workers	1	0	0	0	
Communications					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	3	20	75	55	30.41381
Professionals	2	50	75	62.5	17.67767
Technicians	3	0	75	41.6667	38.18813
Sales workers	3	50	100	66.6667	28.86751
Office clerical/administrative	3	0	10	3.3333	5.7735
Craft workers–semiskilled	1	0	0	0	

Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	1	0	0	0	
Service workers	1	2	2	2	
Construction					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	3	0	10	4	5.2915
Professionals	2	0	5	2.5	3.53553
Technicians	1	10	10	10	
Sales workers	2	0	10	5	7.07107
Office clerical/administrative	1	0	0	0	
Craft workers–semiskilled	1	0	0	0	
Operatives–semiskilled	0				
Laborers–unskilled	1	0	0	0	
Service workers	2	0	5	2.5	3.53553
Educational services					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	1	0	0	0	
Professionals	1	0	0	0	
Technicians	1	0	0	0	
Sales workers	0				
Office clerical–administrative	1	0	0	0	
Craft workers–semiskilled	1	0	0	0	
Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	1	0	0	0	
Service workers	1	0	0	0	

Entertainment and recreation					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	2	0	10	5	7.07107
Professionals	1	20	20	20	
Technicians	1	0	0	0	
Sales workers	2	25	25	25	0
Office clerical/administrative	2	0	0	0	0
Craft workers–semiskilled	0				
Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	1	0	0	0	
Service workers	1	0	0	0	
Finance, insurance and real estate					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	7	0	30	17.8571	12.53566
Professionals	6	0	50	19.1667	18.55173
Technicians	5	0	30	6	13.41641
Sales workers	5	0	50	20	27.38613
Office clerical/administrative	7	0	15	3.5714	6.26782
Craft workers–semiskilled	4	0	20	5	10
Operatives–semiskilled	2	0	0	0	0
Laborers–unskilled	3	0	0	0	0
Service workers	2	0	0	0	0
General government services					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	6	10	60	23.3333	19.66384
Professionals	6	10	80	25.8333	26.91034
Technicians	6	0	80	23.3333	29.4392

Sales workers	3	0	100	33.6667	57.44853
Office clerical/administrative	4	5	80	26.25	35.91077
Craft workers–semiskilled	2	0	10	5	7.07107
Operatives–semiskilled	2	0	10	5	7.07107
Laborers–unskilled	3	0	10	3.333	5.7735
Service workers	3	0	0	0	0
Health services					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	1	10	10	10	
Professionals	1	0	0	0	
Technicians	1	0	0	0	
Sales workers	1	0	0	0	
Office clerical/administrative	1	0	0	0	
Craft workers–semiskilled	1	0	0	0	
Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	1	0	0	0	
Service workers	1	0	0	0	
Manufacturing					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	9	0	60	20	20.76656
Professionals	8	0	80	18.75	25.87746
Technicians	6	0	10	1.6667	4.08248
Sales workers	8	15	100	64.375	35.60071
Office clerical/administrative	8	0	1	0.125	0.35355
Craft workers–semiskilled	4	0	0	0	0
Operatives–semiskilled	5	0	0	0	0
Laborers–unskilled	5	0	0	0	0

Service workers	7	0	0	0	0
Retail					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	7	0	10	5	5
Professionals	3	0	30	10	17.32051
Technicians	2	0	0	0	0
Sales workers	7	0	100	22.8571	38.49861
Office clerical/administrative	7	0	0	0	0
Craft workers–semiskilled	3	0	0	0	0
Operatives–semiskilled	3	0	0	0	0
Laborers–unskilled	5	0	0	0	0
Service workers	2	0	0	0	0
Biotechnology					
Occupational classification	n	Minimum	Maximum	Mean	S.D.
Officials and managers	1	0	0	0	
Professionals	1	33	33	33	
Technicians	1	0	0	0	
Sales workers	1	50	50	50	
Office clerical/administrative	1	0	0	0	
Craft workers–semiskilled	1	0	0	0	
Operatives–semiskilled	1	0	0	0	
Laborers–unskilled	1	0	0	0	
Service workers	1	0	0	0	

As shown in Table 5, employers from several industries (agriculture/forestry/mining; automobile and other repair services; business services; communications; construction; educational services; entertainment and recreation; finance, insurance and real estate; general government services; health services; manufacturing; retail; and biotechnology) provided data on their willingness to accept travel time as paid worktime for each of the occupational groups. However, the numbers of respondents for each industry group varied significantly, and as these numbers were relatively small, we calculated the final results only for the Bay Area employers as a whole. Our final analysis is based upon this total group of Bay Area employers. The data show that sales workers were considered most appropriate for this form of paid telecommuting, with an average of 43 percent of work time and a maximum of 100 percent of work time spent telecommuting being acceptable to these employers. This is consistent with prior studies of jobs that are most appropriate for telecommuting. Also consistent with this prior research is the resulting observation that operatives, laborers, and service employees are not considered appropriate for telecommuting. On average, these employers rated less than 1 percent of total work time as acceptable for telecommuting on the journey to or from work for these occupational categories.

The next step was to predict public transit ridership, given the data on telecommute time that would be accepted by employers as work time. Each individual in the sample was assigned a time savings in public transit commute time equal to the average of the time that would be accepted by the employer as work time for the occupational classification to which the individual belongs. Then, the modal choice was predicted using the estimated model and the hypothetical public transit time savings. Public transit ridership increased from the original predicted 173 (without telecommute time savings) to a predicted 276, i.e., an increase of 60 percent in public transit ridership. This result is consistent with the literature[44] that found that a time savings of 25 minutes in public transit commute would result in a 30 percent increase in public transit ridership. Given that the weighted average time savings for this sample is 70 minutes as opposed to 25 minutes, a 60 percent increase is a reasonable estimate.

A sensitivity analysis was undertaken with respect to the amount of time that would be accepted by employers as work time. Sensitivity analysis provides estimates based upon the assumption that our observed data from employers is not representative of the population mean. We therefore offer estimates of modal choice based upon the values one and two standard errors around the sampling distribution of the means (estimated from the sample means and sample standard deviations). Drawing on central limit theorem, we can assume that 68 percent of the time, the true population means will fall within two standard errors of the observed mean, and 95 percent of the time, the true population means will fall within two standard errors of the observed mean. Thus, sensitivity analysis provides a range of estimates based upon the high and low values of the 68 percent and 95 percent confidence limits of the estimated sampling distribution.

Table 6 shows the mean for each occupational category as well as one and two standard errors around the mean for the percent of the work day that would be accepted by the employers as work time, as well as what this translates into in minutes (based on an 8-hour work day). It can be seen that, even allowing for sampling error, the time savings remain practically significant for white-collar jobs (sales workers, professionals, and officials and managers) and rather insignificant for blue-collar jobs. Note that for the sensitivity analysis, if one or two standard errors below the mean results in negative commute time accepted as work time, then this value is set to zero; i.e., there would be no time savings for that group of employees.

Table 6 also shows the results of the sensitivity analysis. Thus, at the mean, public transit ridership would increase by 60 percent, and it would vary between 58 percent and 65 percent at two standard errors below to two standard errors above the mean. Thus we can state with 95 percent confidence that the true impact of the implementation of telecommuter rail cars on modal choice is an increase in ridership that ranges between 59 percent and 65 percent. This estimate explicitly accounts for the modest sample size from which the employer preferences were estimated in this study.

Note that there is more responsiveness as the commute time allowed as work time increases than as it decreases. This is because most of the response comes from the exempt occupational classifications, for these groups, the time savings are quite large, even at two standard errors below (one-to two-hour time savings); therefore, they still have an incentive to switch to public transit. On the other hand, increasing the time savings to two standard errors above the mean induces more members of exempt occupational classifications to switch to public transit ridership. These results indicate that employers are likely to allow exempt employees enough commute time as work time to induce these types of workers to switch to public transit ridership.

Table 6 Sensitivity analysis

Occupational classification	mean	standard error (SE)	1 SE below	1 SE above	2 SE below	2 SE above	2 SE below (minutes)	1 SE below (minutes)	mean (minutes)	1 SE above (minutes)	2 SE above (minutes)
Officials and managers	17.7586	2.410	15.349	20.168	12.939	22.578	62	74	85	97	108
Professionals	22.1842	3.708	18.476	25.893	14.767	29.601	71	89	106	124	142
Technicians	13.3824	4.173	9.210	17.555	5.037	21.728	24	44	64	84	104
Sales workers	43.2045	5.557	37.648	48.761	32.091	54.318	154	181	207	234	261
Office clerical/ administrative	5.6	1.870	3.730	7.470	1.860	9.340	9	18	27	36	45
Craft workers-semiskilled	1.5789	1.150	0.428	2.729	-0.722	3.880	0	2	8	13	19
Operatives-semiskilled	0.5263	0.526	-0.000	1.053	-0.526	1.579	0	0	3	5	8
Laborers-unskilled	0.3704	0.370	0.000	0.741	-0.370	1.111	0	0	2	4	5
Service workers	0.3043	0.230	0.074	0.535	-0.157	0.765	0	0	1	3	4
			New N of Public transit users				273	275	276	282	286
			Original N of Public Transit Users				173	173	173	173	173
			Percent change				58	59	60	63	65

CONCLUSION

As our literature review has demonstrated, telecommuting has a number of important benefits for society, employers, and employees. However, due to its recent development, knowledge about telecommuting while traveling is very limited. This study was designed to assess the potential impact of telecommuting technologies installed in rail cars upon the transportation modal choice of the working population of the San Francisco Bay Area. In order to achieve this goal, we re-estimated the service-time elasticities of alternative transportation modes, a key parameter that had not been examined for 30 years. In addition, we surveyed Bay Area employers about their willingness to accept travel time spent telecommuting as paid work time. The rationale for this question is that by compensating employees for their time spent working while traveling, employers reduce the personal costs of travel by employees.

The sample used to estimate the value of time spent traveling was dominated by white (75 percent), home-owning (72 percent) managers and professionals (60 percent) earning an average annual household income of $94,000. Out of over 23,000 person trips included in this sample, we found just 1 percent of trips were made through public transit. When surveyed, the Bay Area employers reported that they would find it acceptable to reward a number of occupational categories for working while traveling. The occupational categories considered most acceptable were officials and managers, professionals, technicians, and sales workers. The occupational categories considered least acceptable for paid work while traveling were craft workers, operatives, laborers, and service workers. These findings are highly consistent with the existing literature on jobs appropriate for traditional forms of telecommuting.

By combining the data on employer acceptability for each job category and our estimate of the relative value of time spent on alternative travel modes we have estimated that person-trips on intercity rail forms of public transit will increase by 60 percent. Sensitivity analysis reveals that this finding is quite robust, even subject to the increased sampling error that is possible given the relatively small size of the sample from which employer preferences are estimated. The results of the sensitivity analysis reveal that we can be 95 percent confident that the expected possible shift in modal choice is between 58 and 65 percent. Therefore, the results are both statistically and practically significant and indicate that investments in telecommuter technology will raise the ridership of intercity rail forms of public transit services.

These results have significant practical implications. First, investments in telecommuting technology by intercity rail service providers can be expected to dramatically increase ridership by individuals using such services to commute to and from work. Second, this result is observed even while employers have limited knowledge about such opportunities. It is anticipated that many Bay Area employers are unaware of the potential for rail car telecommuting technologies to assist in the attraction and retention of qualified labor from beyond their traditional geographic labor pool. However, were such technologies considered to be widely available and their power for recruiting and retaining qualified employees recognized, it is possible that acceptance rates would increase further toward the maximal values observed. This would be expected to significantly increase modal shift toward public transit beyond the 60 percent estimate that we observed.

In order to obtain maximum benefit from these technologies for society, employers and employees, stakeholders such as local government, environmental agencies, transit authorities, and public interest groups should consider both encouraging their adoption and educating employers and employees about the potential benefits of this form of telecommuting. From the perspective of employers, the benefits are expected to result from the expanded labor pool and enhanced recruitment and retention possibilities. For employees (current and potential), the reduced travel costs, improved quality of life, and lower costs of living associated with moving outside of the traditional labor catchment area for the Bay Area will be of significant interest. One potential negative consequence of the implementation of this new telecommute option, and its more widespread adoption by employers and employees, is that urban employees will be more inclined to move to suburban and rural areas served by rail services with these technologies. We have examined how the modal choices of existing commuters may be influenced. Future research may also consider the impact that these technologies may have upon home location choices and the consequent urban sprawl that may result.

APPENDIX A: SURVEY

New Options

in

Telework:

Employer Practices

Survey

Sponsored by the

Mineta Transportation

Institute,

San Jose State University

Dear Senior Human Resource Professional

We are conducting a large-scale research project to investigate the acceptability of alternative work-practices which are expected to have positive benefits for employers, employees and society at large. This short survey has been designed to assess the extent to which employers in the San Francisco Bay Area are currently using alternative work practices, particularly telecommuting.

Recent developments in telecommuter technology have opened up new avenues for working off-site. In particular, it is now possible for employees to work while traveling using telecommuting technology from intercity train carriages. The central motive for this project is to ascertain the extent to which employers in the S.F. Bay Area would consider accepting work conducted on these 'telecommuter railcars' as paid work time for each occupational category that they employ.

This project is funded by the Mineta Transportation Institute (MTI). This institute was established by an act of Congress in 1991 and is based on the campus of San Jose State University. The purpose of the institute is to promote research, education and technology transfer in the area of transportation policy. The results of this survey are of great importance to our understanding of employer practices and preferences with regard to telecommuting and other alternative work practices.

We anticipate that it will take approximately 15-20 minutes to complete the survey. Once complete, please return the survey in the prepaid envelope provided. Please be assured that responses will be treated with absolute confidentiality. Individual data from companies will not be revealed. Once the results are aggregated, we will provide you with a report on the practices and preferences of organizations in the S.F. Bay Area with respect to telecommuting practices.

The results of this research are expected to contribute to policy formation in the region. We thank you in anticipation for taking the time to participate.

Sincerely

James C. Hayton, PhD.
Assistant Professor of Management & Human Resources,
Utah State University & MTI

Saloua Sehili, PhD.
Economist
World Bank Group & MTI

Stan Malos, PhD.
Professor of Management & Human Resources
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Part I. Organizational Information

1. Organization Name ____

2. Organization type (Check one):
   __ Federal Govt; __ State/Local Govt; __ Publicly Traded Company; __ Privately Held Company

   2b: Is your organization a family firm? (circle one): Yes / No

3. Survey completed by (job title) ____

4. Number of employees (FTE) _____________ 5. Age of organization (years) _____________

6. Primary industry/Government sector (description) ___________________________________

7. Revenue range— If private sector (check one):
   __ < $10 million; __ $10-50 million; __ $50-100 million; __ > $100 million

8. Strategic orientation (for each item, circle the number which best describes your organization, where 1 = completely disagree; 2 = somewhat disagree; 3 = neither agree nor dis-agree; 4 = somewhat agree; 5 = completely agree):

	Completely Disagree				Completely Agree
A) This organization shows a great deal of tolerance for high risk projects……	1	2	3	4	5
B) This organization uses only "tried and true" procedures, systems, and methods……	1	2	3	4	5
C) This organization challenges, rather than responds to, its environment and/or major competitors……	1	2	3	4	5
D) This organization takes bold, wide-ranging strategic actions, rather than minor changes in tactics……	1	2	3	4	5
E) This organization emphasizes the pursuit of long-term goals and strategies……	1	2	3	4	5
F) This organization is the first its sector or industry to introduce new products or services……	1	2	3	4	5
G) This organization rewards taking calculated risks……	1	2	3	4	5

9. Does your company employ an electronic Human Resource Information System of any kind? (circle one)
[Yes] / [No]

10. What broad categories of data are maintained in your HRIS? (check all that apply)
- □ Recruitment (e.g. applicant tracking)
- □ Selection (e.g. test scores)
- □ Equal Employment Opportunity information
- □ Compensation (e.g. payroll, variable pay information, stock option grants)
- □ Benefits (e.g. benefit plan enrollment data, retirement calculations)
- □ Performance data (e.g. subjective and/or objective performance data, MBO objectives)
- □ Job analysis data (e.g. job descriptions, job specifications)
- □ Skills inventory data (e.g. educational qualifications, training programs completed)
- □ Work time data (e.g., attendance, absence, scheduling)
- □ Accident and injury data (e.g. workers compensation, OSHA data)
- □ Employee handbook information
- □ Employee suggestions and/or attitudes and/or opinion survey data

Part II. Human Resource Management Practices

For each of the following statements, please circle the number that best applies. (Where 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree)

In this organization…	Strongly disagree				Strongly agree
1. We have formal job descriptions……	1	2	3	4	5
2. We have a formal performance appraisal process……	1	2	3	4	5
3. Pay levels are set with the help of formal salary surveys……	1	2	3	4	5
4. We have established a structured salary system……	1	2	3	4	5
5. We have a clearly defined incentive (variable) pay system……	1	2	3	4	5
6. We have a formal orientation program for new employees……	1	2	3	4	5
7. We organize socialization activities to enhance the sense of teamwork……	1	2	3	4	5
8. We have formal programs in place to encourage employee participation……	1	2	3	4	5
9. We take a structured approach to selecting the best employees……	1	2	3	4	5
10. We actively try to identify the best possible recruitment sources for our new job candidates……	1	2	3	4	5
11. The tasks, duties and responsibilities of all employees are clearly established…	1	2	3	4	5
12. We take a systematic approach to training and developing our employees……	1	2	3	4	5
13. Incentive pay is based upon the achievement of clearly understood goals……	1	2	3	4	5
14. Employees are empowered to make decisions that improve product quality, reduce cost, or enhance customer service……	1	2	3	4	5
15. Employee participation in decision making is encouraged and rewarded……	1	2	3	4	5
16. We have a policy of offering pay that is higher than the average for the industry……	1	2	3	4	5
17. Performance evaluations are used to determine base compensation and/or incentive compensation……	1	2	3	4	5
18. We measure employee attitudes and opinions on a regular basis……	1	2	3	4	5
19. We offer employees stock and/or profit sharing……	1	2	3	4	5
20. Performance evaluations rely on input from other people in addition to the immediate supervisor (e.g. coworkers)……	1	2	3	4	5
21. We have a commitment to developing our employees' skills and capabilities……	1	2	3	4	5
22. We take a structured approach to deciding and describing the content of jobs in this organization……	1	2	3	4	5
23. We maintain a record of the skills, knowledge, and qualifications of each of our employees……	1	2	3	4	5

Part III —Organizational Demographics

1. Please describe your employee population according to the following occupational classifications:

Occupational Classification	Number of employees in class	Percent of total employee population
Officials and Managers		
Professionals		
Technicians		
Sales Workers		
Office Clerical/Administrative		
Craft workers—skilled		
Operatives—semiskilled		
Laborers—unskilled		
Service workers		
Total		

2. On average, what percentage of total work-time are employees required to be on the organization's premises as a result of the work that they do (regardless of the reason—e.g. due top the need to interact with co-workers, customers, or site specific equipment/technology). Indicate a percentage for each of the following occupational categories.

Occupational Classification	Percentage of total work-time required to be on premises
Officials and Managers	
Professionals	
Technicians	
Sales Workers	
Office Clerical/Administrative	
Craft workers—skilled	
Operatives—semiskilled	
Laborers—unskilled	
Service workers	

Part IV —Telecommuting Practices

1. What proportion of your workforce uses each of the following forms of alternative work-schedule of telecommuting. Please indicate the *number* of employees in each occupational category using each alternative work practice:

Occupational Classification	**Flexible Schedules[a]**	**Compressed Workweek[b]**	**Telecommuting from Home[c]**	**Telecommuting from a Telecenter[d]**	**Telecommuting While Traveling To or From Work[e]**
Officials and Managers					
Professionals					
Technicians					
Sales Workers					
Office Clerical/					
Craft workers—skilled					
Operatives—semiskilled					
Laborers—unskilled					
Service workers					

Note:

a: Flexible schedules allow employees to choose their start and finish times from a range of options (e.g. 7am-3pm; 8am-4pm. Etc.) provided that they still complete a full work-week (e.g. 40 hours).

b: Compressed workweeks reduce the number of days that employees attend while increasing the number of hours worked in a single day (e.g., 4 days per week, 10 hours each).

c: Telecommuting refers to working from home *for total time equivalent to at least one day per* week (i.e., eight hours) using some form of telecommunications equipment (e.g. telephone, fax, or home computer).

d: Telecommuting from a tele-center is the same as c, except the work is performed in a remote office dedicated to the purpose of telecommuting rather than from home.

e: Telecommuting while traveling to or from work includes work performed on the train, bus or other mode of transportation during the normal journey to the work-site.

2. What are the most significant barriers to adopting telecommuting practices for each of the following occupational categories? Check each box that is a significant reason for NOT adopting telecommuting practices in each occupational category

Occupational Classification	Top Management Resistance	Supervisor Resistance	Employee Resistance	Cost/ budget limitations	Data Security Issues	Technology Issues	The Nature of the Work
Officials and Man-							
Professionals							
Technicians							
Sales Workers							
Office Clerical/							
Craft workers—							
Operatives—							
Laborers—unskilled							
Service workers							

3. Now consider those occupational categories whose work requires at least some 'face-time' or 'on-site time' each day, yet other aspects of work may be conducted off-site. For example, for employees engaged in sales or service, a significant portion of the day may involve administrative tasks rather than sales or customer service activities. For employees in each occupational category, what percentage of the work-day would you be willing to accept telecommute time as a part of their work-time?

Occupational Classification	Percentage of total work-time may be spent telecommuting
Officials and Managers	
Professionals	
Technicians	
Sales Workers	
Office Clerical/Administrative	
Craft workers—skilled	
Operatives—semiskilled	
Laborers—unskilled	
Service workers	

4. Now consider the possibility that employees may be able to perform some work while traveling to or from the company's premises or work-site. For example, assume that employees are able to perform certain administrative tasks while traveling on an intercity train or other form of public transportation. For each occupational category, rate your willingness to accept time spent telecommuting while on public transport and paid work-time. Circle the answer that best reflects your willingness to accept this form of work. Where 1 = unacceptable; 2 = neutral; 3 = acceptable.

Occupational Classification	Willingness to Accept Travel Time as Work Time		
Officials and Managers	1	2	3
Professionals	1	2	3
Technicians	1	2	3
Sales Workers	1	2	3
Office Clerical/Administrative	1	2	3
Craft workers—skilled	1	2	3
Operatives—semiskilled	1	2	3
Laborers—unskilled	1	2	3
Service workers	1	2	3

5. Please write the name and address of the recipient for the final report from this survey:

____

____

____

____

____

Thank you for your contribution to this research.

ENDNOTES

1. David G. Allen, "Telecommuting: A review of the literature with research propositions," Working Paper, Georgia State University, 1996.

2. Daniel M. Hrisak, "Millions Move to the Homeoffice," *Strategic Finance* (1999): 54-57.

3. Ronald B. Wilkes, Mark N. Frolick and Robert Urwiler, "Critical issues in developing successful telework programs," *Journal of Systems Management* (July 1994): 30-34.

4. Nextra eEurope Report, 2001, available www.nextra.co.uk.

5. Olga Aiken, "Your obligations to the staff who stay at home," *People Management* (September 1996); and David Littlefield, "Remote working has pleasures and perils," *People Management* (November, 1995).

6. Joanne H. Pratt, "1999 Telework America National Telework Survey: Cost/Benefit of Teleworking to Manage Work/Life Responsibilities," *International Telework Association and Council*.

7. Susan L. Handy and Patricia L. Mokhtarian, "Forecasting Telecommuting: An Exploration of Methodologies and Research Needs," *Transportation* v. 23 (1996): 163-190.

8. Susan Handy and Patricia L. Mokhtarian. *Present Status and Future Directions of Telecommuting in California: Executive Summary* (Davis, CA: Institute of Transportation Studies, 1993).

9. ECaTT (Electronic Commerce and Telework Trend) Survey, 1999. Empirica GmbH Consultancy, available www.ecatt.com/ecatt/surveys/results/nwwg90001.html; Pratt, "1999 Canadians and Telework," press release, Ekos Research Associates Inc. (November 4, 1998) available www.ekos.ca/nov98.HTM; and Thea Weijers, Rob Meijer, and Erno Spoelman, "Telework Remains 'Made to Measure': The Large Scale Introduction of Telework in the Netherlands," *Futures* v. 24 (1992): 1048-1055.

10. Jack M. Nilles, *Managing Telework: Strategies for Managing the Virtual Workforce (*New York, John Wiley & Sons, 1998); "Financial Issues of Telecommuting FAQ Telecommuting Tool," Gil Gordon Associates, 2000, available www.gilgordon.com/telecommuting/faq.htm; Yash P.

Gupta and Jahangir Karima, "A Study on the Usage of Computer and Communication Technologies for Telecommuting," *IEEE Transactions on Engineering Management* v. 47(1) (2000): 26-38; Weijers, Meijer and Spoelman.

11. Patricia Braus,"Homework for grownups," *American Demographics* (August 1993): 38-42.

12 David Littlefield, "Nationwide moves over to telework," *People Management* (September 1996).

13 Jonathan N. Goodrich, "Telecommuting in America," *Business Horizons* (July-August, 1990): 31-37; Norman A. Solomon and Andrew J. Templer, "Development of non-traditional work-sites: The challenge of telecommuting," *Journal of Management Development* v. 12 (5) (1993): 21-32; "The results of a 'Telework' study," *Association Management* (December 1995).

14. "The results of a 'Telework' study"; Trevor Bentley, "And this little piggy stayed home," *Management Accounting* (April 1994); Mark N. Frolick, Ronald Wilkes and Robert Urwiler, "Telecommuting as a workplace alternative: An identification of significant factors in American firms determination of work-at-home policies," *Journal of Strategic Information Systems* (September 1993): 206-222.; Goodrich; Paul Norman, Sylvie Collins, Mark Conner, Robin Martin and Janie Rance, "Attributions, cognitions,and coping styles: Teleworkers' reactions to work-related problems," *Journal of Applied Social Psychology* v. 25 (2) (1995): 117-128.; M.H. Olson, "Remote office work: Changing work patterns in space and time," *Communications of the ACM* v. 26 (1983): 182-187; Margarethe H. Olson, "Work at home for computer professionals: Current attitudes and future prospects," *ACM Transactions on Office Information Systems* v. 7 (1989): 317-338; Jean C. Roderick and Herbert M. Jelley, "Managerial perceptions of telecommuting in two large metropolitan cities," *Southwest Journal of Business and Economics* (1991): 35-41; Wilkes, Frolick and Urwiler; Cindy Froggatt, "New Work Directions: Creative Environments for the Future," Gil Gordon Associates (1999), available www.gilgordon.com; Vawn Himmelsbach, "Working at Home Given Top Marks by Employees," *ComputingCanada* v. 24(47) (1998): D29; Nilles, 1998.

15. Shari Caudron, "Working at home pays off," *Personnel Journal* (November 1992): 40-49.

16. Bentley; Frolick, Wilkes and Urwiler; Littlefield, 1995; Norman, Collins, Conner, Martin, and Rance; Roderick and Jelley; Wilkes, Frolick and Urwiler.

17. Frolick, Wilkes and Urwiler; Julian M. Weiss, "Telecommuting boosts employee output," *HRMagazine* (February 1994): 51-53.; Wilkes, Frolick and Urwiler.

18. Goodrich; Richard I. Hartman, Charles R. Stoner and Raj Arora, "An investigation of selected variables affecting telecommuting productivity and satisfaction," *Journal of Business and Psychology* v. 6 (2) (1991): 207-225; Roderick and Jelley; Wilkes, Frolick and Urwiler; Daniel B. Rathbone, "Telecommuting in the United States," *ITE Journal* (December 1992): 40-45; "Telecommuting Market Research-1999 Executive Summary," WestGroup Research, Regional Public Transportation Authority (1999), available http://www.valleymetro.maricopa.gov/99-tele.html; Pratt; Telecommute America.

19. Pratt

20. Kelly Dunn, "Telecommuting is a Tool of Millennial Business," *Workforce* v. 78(11) (1999):20; Mary Slepicka, "Remote Workforces Gaining in Strength," *America's Network*, Duluth (December 1, 1999): 16.

21. Howard N. Fullerton, Jr., "Labor Force Projections to 2008: Steady Growth and Changing Composition," *Monthly Labor Review* v. 122, n. 11 (November 1999).

22. Marc Hequet, "How telecommuting transforms work," *Training* (November 1994): 56-61.

23. Catherine Romano, "What's your flexibility factor?" *Management Review* (January 1994): 9; Braus.

24. Pratt

25. Bentley; Goodrich; Norman, Collins, Conner, Martin and Rance; Roderick and Jelley.

26. Wilkes, Frolick and Urwiler

27. Olson; Patricia L. Mokhtarian, "Telecommunications and Travel," in *Transportation in the New Millennium: State of the Art and Future Directions: Perspectives from TRB Standing Committees* (Washington, D.C., National Research Council, 2000).

28. Wilkes, Frolick and Urwiler; Elliott Levy, Patricia Flynn and Diane M. Kellogg, "Balancing Professional and Personal Lives: The Mantra for the Next Millennium," *CPA Journal*, New York (October 1998): 70-73; J. Greenwald, "Employers Warming Up to Flexible Schedules," *Business Insurance* v. 32 (June 15, 1998): 3-4.

29. Ilan Salomon and M. Salomon, "Telecommuting: The employee's perspective," *Technological Forecasting and Societal Change* v. 25 (1984): 15-28.

30. Tom Golob, "TravelBehavior.Com: Activity Approaches to Modeling the Effects of Information Technology on Personal Travel Behavior," resource paper for the 9th International Association for Travel Behavior Research Conference, Gold Coast, Queensland, Australia, July 2-7, 2000; Mokhtarian.

31. Nilles; Golob; Mokhtarian.

32. Patricia L. Mokhtarian and Krishna V. Varma, "The Tradeoff between Trips and Distance Traveled in Analyzing the Emissions Impacts of Center-Based Telecommuting," *Transportation Research* D 3(6) (1998): 419-428.

33. Prashant N. Balepur, Krishna V. Varma and Patricia L. Mokhtarian, "Transportation impacts of center-based telecommuting: Interim findings from the Neighborhood Telecenters Project." *Transportation* v. 25, n. 3 (August 1998): 287-306.

34. Kelvin Lancaster, "A new approach to consumer theory," *Journal of Political Economy* v. 74 (1996): 132-57.

35. Charles Lave, "The demand for urban mass transit," *Review of Economics and Statistics* v. 52 (1970): 320-23; Richard Quandt, *The Demand for Travel* (Washington, D.C.:Heath, Lexington, 1970); Mohse Ben-Akiva, "Structure of passenger travel demand models," Ph.D. Dissertation, Department of Civil Engineering, MIT, 1973; D. McFadden, "The measurement of urban travel demand," *Journal of Public Economics* v. 3 (1974): 303-28.; Thomas Domencich and Daniel McFadden, *Urban Travel Demand: A Behavioral Analysis* (Amsterdam, Holland: North Holland, 1974)

36. Clifford Winston, "A disaggregate model of the demand for intercity freight transportation," *Econometrica* v. 49 (1981): 981-1006.

37. Kenneth Train, "Work-trip mode-split models: an empirical exploration of estimate sensitivity to model and data specification," working paper No. 7602, Urban Travel Demand Forecasting Project, Institute of Transportation Studies, U.C. Berkeley, 1976.

38. Charles A. Lave, "Automobile choice and its energy implications," *Transportation Resources* 14A (5-6) (1980): 317-451.

39. Steven A. Morrison and Clifford Winston, "An econometric analysis of the demand for intercity passenger transportation," *Research In Transportation Economics* (1985): 192-207.

40. James Berkovec and John Rust, "A nested logit model of automobile holdings for one vehicle households," MIT working paper, 1981; Morrisson and Winston.

41. Conrad J. Oort, "The evaluation of traveling time," *Journal of Transportation and Economic Policy* v. 3(1969): 279-86; Gary S. Becker, "A theory of the allocation of time," *Economic Journal (*September 1965): 493-517.

43. Winston, 1985

43. Herbert Mohring, John Schroeter and Paitoon Wiboonchuikula. "The Values of Waiting Time, Travel Time and a Seat on a Bus." *Rand Journal of Economics*, v. 19, n. 1 (1987): 40-56.

44. Ibid.

ABBREVIATIONS AND ACRONYMS

agesq	Age squared
BART	Bay Area Rapid Transit
BATS	Bay Area Travel Survey
CATI	Computer Assisted Telephone Interview
DOL	Department of Labor
hhincome	Household income
hhsize	Household size
hhveh	Number of household vehicles
HRM	Human resources management
ITAC	International Telework Association and Council
S.D.	Standard deviation
smflex	Flexibility in work time
vtimediff	value of time difference between public transit and private car

BIBLIOGRAPHY

Aiken, Olga. "Your obligations to the staff who stay at home." *People Management* (September 1996).

Allen, David G. "Telecommuting: A review of the literature with research propositions." Working Paper, Georgia State University, 1996.

Becker, Gary S. "A theory of the allocation of time." *Economic Journal* (September 1965).

Balepur, Prashant N., Krishna V. Varma and Patricia L. Mokhtarian, "Transportation impacts of center-based telecommuting: Interim findings from the Neighborhood Telecenters Project." *Transportation* v. 25, n. 3 (August 1998).

Bateman, Thomas S. and Dennis W. Organ. "Job satisfaction and the good soldier: the relationship between affect and employee 'citizenship'." *Academy of Management Journal* v. 26 (4) (1983).

Ben-Akiva, Moshe. Structure of passenger travel demand models. Ph.D. dissertation. Department of Civil Engineering, MIT, 1973.

Bentley, Trevor. "And this little piggy stayed home." *Management Accounting* (April 1994).

Boyer, Kenneth D. "Minimum rate regulation, modal split sensitivities, and the railroad problem." *Journal of Political Economy* 85(3) (1977).

Braus, Patricia "Homework for grownups." *American Demographics* (August 1993).

Caudron, Shari. "Working at home pays off." *Personnel Journal* (November 1992).

Domencich, Thomas A. and Daniel McFadden. *Urban Travel Demand: A Behavioral Analysis*. Amsterdam, Holland: North Holland, 1975.

Dunn, Kelly. "Telecommuting is a Tool of Millennial Business." *Workforce* (78)11 (1999).

ECaTT (Electronic Commerce and Telework Trend) Survey, 1999. Empirica GmbH Consultancy, available www.ecatt.com/ecatt/surveys/results/nwwg90001.html.

Ekos Research Associates, Inc. *Canadians and Telework*, Press Release, November 4, 1998, available www.ekos.ca/nov98.HTM.

Empirica GmbH Consultancy, *ECaTT (Electronic Comerce and Telework Trend Survey), 1999*, available www.ecatt.com/ecatt/surveys/results/nwwg90001.html.

Froggatt, Cindy. *New Work Directions: Creative Environments for the Future*. Gil Gordon Associates, 1999, available www.gilgordon.com.

Frolick, Mark N., Ronald Wilkes and Robert Urwiler. "Telecommuting as a workplace alternative: An identification of significant factors in American firms determination of work-at-home policies." *Journal of Strategic Information Systems* (September 1993).

Frone, Michael R., Marcia Russell and M. Lynne Cooper. "Relationship between job and family satisfaction: causal or noncausal variation?" *Journal of Management* v. 20 (3) (1994): 565-579.

Fullerton, H.N. Jr. "Labor Force Projections to 2008: Steady Growth and Changing Composition." *Monthly Labor Review* v. 122, n. 11 (November 1999).

"Financial Issues of Telecommuting: FAQ Telecommuting Tools." Gil Gordon Associates, 2000, available www.gilgordon.com/telecommuting/faq.htm.

Golob, Tom. "TravelBehavior.Com: Activity Approaches to Modeling the Effects of Information Technology on Personal Travel Behavior." Resource paper for the 9th International Association for Travel Behavior Research Conference, Gold Coast, Queensland, Australia, July 2-7, 2000.

Goodrich, Jonathan N. "Telecommuting in America." *Business Horizons* (July-August 1990).

Greenwald, Judy. "Employers Warming Up to Flexible Schedules," *Business Insurance* v. 32 (June 15, 1998): 26-38.

Gupta, Yash P. and Jahamgir Karima. “A Study on the Usage of Computer and Communication Technologies for Telecommuting.” *IEEE Transactions on Engineering Management* v. 47(1) (2000).

Handy, Susan L. and Patricia L. Mokhtarian. “Forecasting Telecommuting: An Exploration of Methodologies and Research Needs.” *Transportation* v. 23 (1996).

———. *Present Status and Future Directions of Telecommuting in California: Executive Summary.* Davis, CA: Institute of Transportation Studies, 1993.

Hartman, Richard I., Charles R. Stoner and Raj Arora. “An investigation of selected variables affecting telecommuting productivity and satisfaction.” *Journal of Business and Psychology* v. 6 (2) (1991).

Hequet, Marc. “How telecommuting transforms work.” *Training* (November 1994).

Himmelsbach, Vawn. “Working at Home Given Top Marks by Employees.” *Computing Canada* v. 24(47) (1998).

Hrisak, Daniel M. “Millions Move to the Homeoffice.” *Strategic Finance* (1999).

International Telework Association & Council (ITAC) testimony to MD Senate, March 4, 2000, Appendix 11.

Lancaster, Kelvin J. “A new approach to consumer theory.” *Journal of Political Economy* v. 74 (1966).

Lave, Charles A. “The demand for urban mass transit.” *Review of Economics and Statistics* v. 52 (1970).

———. “Automobile choice and its energy implications.” *Transportation Resources* 14A (5-6) (1980).

Levin, Richard C. “Allocation in surface freight transportation: does rate regulation matter?” *Bell Journal of Economics* v. 9(1) (1978).

Levy, Elliott S., P.atricia M. Flynn and Diane M. Kellogg. “Balancing Professional and Personal Lives: The Mantra for the Next Millennium.” *CPA Journal*, New York (October 1998).

Littlefield, David. "Remote working has pleasures and perils." *People Management* (November, 1995).

———. "Nationwide moves over to telework." *People Management* (September 1996).

Mason, Julie C. "Workplace 2000: The death of 9 to 5?" *Management Review* January 1993).

McFadden, Daniel. "The measurement of urban travel demand." *Journal of Public Economics* v. 3 (1974).

Mohring, Herbert, John Schroeter and Paitoon Wiboonchuikula. "The Values of Waiting Time, Travel Time and a Seat on a Bus." *Rand Journal of Economics*, v. 19, n. 1 (1987).

Mokhtarian, Patricia L. "Telecommunications and Travel." Transportation in the New Millennium: State of the Art and Future Directions: Perspectives from TRB Standing Committees." Washington, D.C., National Research Council, 2000.

———. "A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel." *Urban Studies* v. 35(2) (1998).

Mokhtarian, Patricia L. and Krishna V. Varma. "The Tradeoff between Trips and Distance Traveled in Analyzing the Emissions Impacts of Center-Based Telecommuting." *Transportation Research* D 3(6) (1998).

Moorman, Robert H. "The influence of cognitive and affective based job satisfaction measures on the relationship between job satisfaction and organizational citizenship behavior." *Human Relations* v. 46 (6) (1993).

Morrison, Steven A. and Clifford Winston. "An econometric analysis of the demand for intercity passenger transportation." *Research In Transportation Economics* (1985).

Nextra eEurope Report 2001, available www.nextra.co.uk.

Nie, Norman H. "Tracking Our Techno-Future." *American Demographics* v. 21(7) (1999): 50-52.

Nilles, Jack M. "Traffic Reduction by Telecommuting: A status review and selected bibliography." *Transportation Research* v. 22-A, 4 (1988).

———. "Telecommuting and Urban Sprawl: Mitigator or Inciter?" *Transportation* v. 18 (1991).

———. *Managing Telework: Strategies for Managing the Virtual Workforce*, New York, John Wiley & Sons, 1998.

Norman, Paul, Sylvie Collins, Mark Conner, Robin Martin and Janie Rance. "Attributions, cognitions, and coping styles: Teleworkers' reactions to work-related problems." *Journal of Applied Social Psycholog*y v. 25 (2) (1995).

Olson, Margrethe H. "Work at home for computer professionals: Current attitudes and future prospects." *ACM Transactions on Office Information Systems* v. 7 (1989).

———. "Remote office work: Changing work patterns in space and time." *Communications of the ACM* v. 26 (1983).

Oort, Conrad J. "The evaluation of traveling time." *Journal of Transportation and Economic Policy* v. 3 (1969).

Pratt, Joanne H. "1999 Telework America National Telework Survey: Cost/Benefit of Teleworking to Manage Work/Life Responsibilities." International Telework Association and Council.

Quandt, Richard E. *The Demand for Travel*. Washington, D.C.: Heath, Lexington, 1970.

Raghuram, Sumita. "Knowledge creation in the telework context." *IJTM, Special Publication on Unlearning and Learning* v. 11 (7/8) (1996).

Rathbone, Daniel B. "Telecommuting in the United States." *ITE Journal* (December 1992).

"The results of a 'Telework' study." *Association Management*, December 1995.

Roderick, Joan C. and Herbert M. Jelley, "Managerial perceptions of telecommuting in two large metropolitan cities." *Southwest Journal of Business and Economics* v. 35-41 (1991).

Romano, Catherine. " What's your flexibility factor?" *Management Review* (January 1994).

Salomon, Ilan and M. Salomon. "Telecommuting: The employee's perspective." *Technological Forecasting and Societal Change* v. 25 (1984).

Shamir, Boas and Ilan Salomon. "Work at home and the quality of working life." *Academy of Management Review* v. 10 (1985).

Slepicka, Mary. "Remote Workforces Gaining in Strength." *America's Network*, Duluth (December 1, 1999).

Smith, Raymond W. "Bell Atlantic's Virtual Workforce." *The Futurist* (March-April, 1994).

Solomon, Norman A. and Andrew J. Templer. "Development of non-traditional work-sites: The challenge of telecommuting." *Journal of Management Development* v. 12 (5) (1993).

———. "The use of telecommuting by large Canadian corporations: A preliminary analysis." Industrial Relations Issues for the 1990s: Proceedings of the 26th Conference of the Canadian Industrial Relations Association (1989).

Stanworth, John and Celia Stanworth. "Home truths about teleworking." *Personnel Management* v. 21 (1989).

Telecommute America. "Disasters Prompt Drive Toward Virtual Work." *The Futurist* (September-October, 1996).

Templer, Andrew J. "Human Resource managers and the new technology agenda." *Journal of General Management* v. 15 (2) (1989).

Tomaskovic-Devey, Donald and Barbara J. Risman. "Telecommuting innovation and organization: A contingency theory of labor process change." *Social Science Quarterly* v. 74 (2) (1993).

Train, Kenneth. "Work-trip mode-split models: an empirical exploration of estimate sensitivity to model and data specification." Working paper No. 7602, Urban Travel Demand Forecasting Project, Institute of Transportation Studies, U.C. Berkeley, 1976.

Trent, James T., Amy L. Smith and D.L. Wood. "Telecommuting, stress and social support." *Psychological Reports* v. 74 (1994).

Weijers, Thea, Rob Meijer and Erno Spoelman. "Telework Remains 'Made to Measure': The Large Scale Introduction of Telework in the Netherlands." *Futures* v. 24 (1992).

Weiss, Julian M. "Telecommuting boosts employee output." *HRMagazine* (February, 1994).

WestGroup Research. "Telecommuting Market Research-1999 Executive Summary." Regional Public Transportation Authority–Valley Metro, available http://www.valleymetro.maricopa.gov/99-tele.html.

Wilkes, Ronald B., Mark N. Frolick and Robert Urwiler. "Critical issues in developing successful telework programs." *Journal of Systems Management* (July 1994).

Winston, Clifford. "Conceptual developments in the economics of transportation: an interpretive survey." *Journal of Economic Literature* (March 1985).

———. "A disaggregate model of the demand for intercity freight transportation." *Econometrica* 49 (1981).

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