Residential Area-Based Offices Project: Final Report on the Evaluation of Impacts

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ABSTRACT

The Residential Area-Based Offices (RABO) Project, sponsored by the Federal Highway Administration and the California Department of Transportation, was designed to evaluate the effectiveness of telecommuting centers as an institutional work arrangement and as a transportation demand management strategy. The program, operated by the University of California, Davis, established a total of 16 telecenters, and evaluation data were collected from an additional 5 centers from outside the project. In this volume, the impacts of these telecenters on work performance, job satisfaction, and travel behavior are evaluated using data from four survey instruments: an attitudinal survey, a travel diary, an attendance log, and an exit interview. Data collected through June 1996 are included in the final report. A companion volume, *Residential Area-Based Offices Project: Project Overview and Telecenter Operations*, describes results from the implementation and operation of telecenters in the RABO Project.

Despite efforts to locate centers close to residential areas in order to make walking and biking more attractive, most commuting to the telecommuting centers took place by driving alone. Interestingly, there was a small, but significant, increase in the number of commute trips apparently largely due to telecommuters returning to the center after a trip home for lunch. Most importantly, the number of vehicle-miles of travel decreased by an average of more than 53% for telecenter users on telecommuting days while the total number of trips remained relatively constant. This resulted in reductions of 15% for total organic gas emissions, 21% for carbon monoxide, 35% for nitrogen oxides, and 51% for particulate matter. When the average reduction in VMT is weighted by the average frequency of telecommuting, there is a reduction of more than 11.5% in average weekday VMT compared with the no-telecommuting alternative.

As of June 30, 1996, the sites established under the RABO Project had been open an average of 1.3 years, with a minimum operation of 3.8 months and a maximum of 2.7 years. Average site occupancies ranged between 10 and 20% of available workspace days. The average telecommuting frequency was 28.2% (or 1.4 days per week) at RABO sites, compared to 17.3% (less than one day a week) at the non-RABO sites.

On the organizational side, 79% of the managers of telecenter users rated their level of satisfaction with telecommuting centers as high or very high. A selection bias in these results must be noted, as managers who were dissatisfied with telecommuting would be less likely to remain in the program long enough to complete an after survey. However, the exit interviews from managers indicated that even those managers whose employees quit telecommuting had a high or very high satisfaction with center-based telecommuting (66%). The perceived advantages of telecommuting (customer service and productivity) are difficult to quantify, while other more easily quantifiable factors (office space and parking costs) were not perceived to be advantages. While nearly half (48%) of the manager respondents indicated that their organization was likely to offer center-based telecommuting to its staff, more than a third cited lowering the cost, being able to quantify the benefits, and increased manager acceptance as factors that needed to change before center-based telecommuting was likely to be offered.

Overall, the employee experience with telecommuting centers has been positive. Employee reactions to center-based telecommuting have been favorable, and no adverse impacts on productivity and job satisfaction were measured. There may be a selection bias in these results as these data were obtained only for employees remaining in the program. Attrition at the telecenters was high: half

of the telecenter users quit within nine months. Primary reasons for leaving relate to changes in job circumstances and supervisor desires rather than to employee dissatisfaction with telecommuting centers.

In summary, while transportation, air quality, and other impacts are unequivocally positive for those who telecommute as long as they are telecommuting, concerns remain about high attrition among telecenter users and about the perceived cost-effectiveness of center-based telecommuting to organizations and their management.

ACKNOWLEDGEMENTS

This report is an update to the Interim Findings Report (UCD-ITS-RR-96-11) of November 1996. It pools data analyzed in the Interim Report with an additional year of data collected from July 1, 1995 to June 30, 1996. The structure of this report is based on the Interim Report and considerable debt is owed to those original authors: Narayan Balepur, Michelle Derr, Chaang-Iuan Ho, David Stanek, and Krishna Varma. We would also like to acknowledge Dennis Henderson and Brett Koenig who assisted in the creation of the research instruments; Michelle Derr, Francisca Mar, and Michael Heins who coordinated the data collection and cleaning efforts; Carol Buckinger, who directed the operations side of the project; David Fleming, the former program manager; Ilan Salomon for input to the survey design and interpretation of results; Toan Lam and Michael Bagley who placed the Interim Report on the ITS Web page at (http://www.engr.ucdavis.edu/~its/tcenters/tc.stm); and Ravikumar Meenakshisundaram who is placing the final reports on the Web. Finally, we acknowledge the support shown in many ways by Caltrans staff John Wolf, Michael Seaman, Bruce de Terra, and Michele Fell.

DISCLAIMER

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Stanek, David. *Modeling Perceptions and Preference of Home-Based and Center-Based Telecommuting.* Master's Thesis. UCD-ITS-RR-95-12. September 1995. 116 pp. $15.

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* Periodic reports on the status of California telecommuting centers outside the Neighborhood Telecenters Program, largely superceded by Buckinger *et al., Telecommuting Centers in California: 1991 - 1997.*

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Stanek, David M. and Patricia L. Mokhtarian (1998). Developing models of preference for home-based and center-based telecommuting: Findings and forecasts. *Technological Forecasting and Social Change* **57(1/2)**, 53-74.

Varma, Krishna V., Chaang-Iuan Ho, David M. Stanek, and Patricia L. Mokhtarian (1998). The duration and frequency of telecenter use: Once a telecommuter, always a telecommuter? Forthcoming, *Transportation Research C.*

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EXECUTIVE SUMMARY

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The Residential Area-Based Offices (RABO) Project, known informally as the Neighborhood Telecenters Project, is a multi-year program conducted by the Institute of Transportation Studies, University of California, Davis. This research program, sponsored by the Federal Highway Administration and the California Department of Transportation, was designed to evaluate the effectiveness of telecommuting centers as an institutional work arrangement and as a transportation demand management strategy in California. The program established a total of 16 telecenters, and evaluation data were collected from an additional 5 centers from outside the project.

In this volume, the impacts of telecommuting center use on work performance, job satisfaction, and travel behavior are evaluated using data collected from four survey instruments: an attitudinal survey, a travel diary, an attendance log, and an exit interview. The survey and diary were administered to participants once before and once after the start of telecommuting, the attendance log was used throughout the study period, and the exit interview was conducted with participants who left the program. This report provides an analysis and discussion of the travel impacts, telecommuter and manager attitudes, telecommuting retention, and telecommuting patterns associated with telecommuting center use. Data collected through June 30, 1996 were included in the analyses for this final report. A companion volume, *Residential Area-Based Offices Project: Project Overview and Telecenter Operations*, describes results from the implementation and operation of telecenters in the RABO project.

Overall, the employee experience with telecommuting centers has been positive. Employee reactions to center-based telecommuting have been favorable, and no adverse impacts on productivity and job satisfaction were measured. There may be a selection bias in these results as these data were obtained only for employees remaining in the program. (The attitudes of employees who quit the program and their reasons for leaving are discussed below.) On average, telecenter users preferred to work from the regular workplace and the telecommuting center for approximately equal amounts, or about 40% of their time each. However, they reported actually telecommuting only about one-third of the time. Attendance log data (discussed below) suggest even lower frequency of telecommuting.

The transportation impacts of center-based telecommuting were complex. On one hand, there was an increase in drive-alone trips and a decrease in trip chaining on telecommuting days. Most commuting to the telecenter took place by driving alone, despite efforts to locate centers sufficiently close to residential areas that walking and biking would be attractive commute modes. Interestingly, there was a small increase (of 0.6, significant at $p = 0.00$) in the number of *commute* trips made on telecommuting days, apparently due to telecommuters making trips home for lunch and returning to the center in the afternoon. The transportation impacts of this behavioral change are outweighed by the societal benefits of increased time being spent with families and in communities.

Positive transportation impacts included the finding that telecommuting did not adversely affect commute mode choices on non-telecommuting days. And most importantly, the number of person-miles traveled (PMT) decreased by an average of nearly 58% on telecommuting days, while the *total* number of trips made remained relatively constant. Additionally, the 53%

reduction in vehicle-miles traveled (VMT) on telecommuting days resulted in a 15% reduction for total organic gas emissions, 21% for carbon monoxide, 35% for nitrogen oxides, and 51% for particulate matter.

To place the PMT reduction in the proper perspective, it is important to realize two things. First, the reduction represents a comparison between travel on non-telecommuting weekdays and telecommuting weekdays for center-based telecommuters. Thus, the overall impact on travel will be a function of the frequency of telecommuting. When travel indicators on telecommuting and non-telecommuting days were weighted by the average frequency with which each type of day occurs, an average reduction of more than 11.9% in average work-week PMT and 11.5% in average work-week VMT was found (when compared to the no-telecommuting alternative).

Second, the telecommuters in this sample lived farther from work, and hence had a much greater average non-telecommuting day PMT, than the non-telecommuting control group members (87.8 vs. 48.7 miles). Although on telecommuting days the telecommuters traveled less than the control group, in the aggregate (telecommuting and non-telecommuting days combined) they still traveled more. If, in the future, telecommuting continues to be adopted primarily by long-distance commuters, the per capita reductions in travel will be considerable, but this change will be achieved by a limited segment of the market. If, on the other hand, the adoption of telecommuting is more universal, the per capita reductions in travel will be smaller, albeit achieved by a wider segment of the market. In either case, the specific reductions measured in this study will not be representative of the impacts for the population as a whole.

On the organizational side, managers of telecenter users were generally supportive, with 89% having a positive attitude toward telecommuting in general, and 79% rating their level of satisfaction with center-based telecommuting as high or very high. A selection bias in these results must be noted, as managers who were dissatisfied with telecommuting would be less likely to remain in the program long enough to complete an after survey. However, the exit interviews from managers indicated that even those managers whose employees quit telecommuting had a positive attitude toward telecommuting in general (91%) and had a high or very high satisfaction with center-based telecommuting specifically (66%). Opinions of upper management tended to be more neutral according to the immediate supervisors of telecommuters. The perceived advantages of telecommuting were those for which the benefit is difficult to quantify (customer service and productivity), while telecommuting is not perceived to offer advantages on "hard" money items, such as office space and parking costs. This will continue to make center-based telecommuting difficult to justify in purely economic terms. Indeed, while nearly half (48%) of the manager respondents indicated that the organization was likely to offer center-based telecommuting to its staff, more than a third (37%) cited lowering the cost, being able to quantify the benefits, and increased manager acceptance as factors that needed to change before the organization would be likely to offer center-based telecommuting.

Managers continued to view the regular workplace as the primary work location for their employees, to be used for at least three days per week on average. This expectation of part-time telecommuting may act to inhibit the adoption of the center-based form, as there will be little opportunity for the organization to re-use the telecommuter's space in the regular workplace.

Average site occupancies ranged between 10 and 20% of available workspace days, with a generally upward trend. As of June 30, 1996, the RABO telecenters had been open an average

of 1.3 years, with a minimum operation of 3.8 months and a maximum of a little more than 2.7 years. For those who used the centers at least twice, telecommuting frequencies averaged 28.2% (1.4 days per week) at RABO sites and 17.3% at non-RABO sites.

Attrition at the telecenters was relatively high, with 50% of all telecommuters quitting within the first nine months. Although little comparative data are available, this attrition rate appears to be higher than for home-based programs. Results of exit interviews, conducted with the participants who quit after the program began and who could be reached, suggested that primary reasons for quitting were job-related (37.7%), followed by supervisor-related (14.9%), rather than due to employee dissatisfaction with telecommuting. Nevertheless, the frequency and duration of telecommuting are crucial factors to consider in any forecast of levels and impacts of telecommuting.

In summary, while transportation and other impacts are unequivocally positive on net for those who telecommute, on the days they are telecommuting and for the duration of their telecommuting experience, concerns remain about high attrition among telecenter users and about the perceived cost-effectiveness of center-based telecommuting to organizations and their management.

The high-quality and multi-faceted data set provided by this study is expected to yield new insights into telecommuting for some time to come. Possible studies include the modeling of telecommuting preference and choice that can be used to identify key factors in the decision to telecommute and to predict the frequency of future telecenter use, and the use of travel diary data in investigations of the impact of telecommuting centers at the household level.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 Objectives

This final findings report on the Residential Area-Based Offices (RABO) Project focuses on the measurement of the impacts of telecommuting centers. The survey instruments employed in the evaluation process both measured telecommuting activity and assessed its impacts on work performance, job satisfaction, and travel behavior. The assessment presented here provides valuable information about the effectiveness of center-based telecommuting as a work option and as a travel demand management strategy. A companion volume to this report, *Residential Area-Based Offices Project: Project Overview and Telecenter Operations*, provides a detailed description of the implementation and operation of all of the RABO telecenters. The Project was sponsored by the Federal Highway Administration and the California Department of Transportation and was conducted by the Institute of Transportation Studies at the University of California, Davis.

The RABO Project was contracted to evaluate not only the 16 telecenters it established, but also five non-RABO telecenters already in existence (see Table 2-1 for a list of telecenters evaluated in this report). The non-RABO centers that were opened separately from this project did not necessarily locate near residential areas, a criterion in the siting of most RABO centers. As a result, the impacts of these non-RABO centers are likely to differ from the RABO centers in some ways, and these differences are noted where appropriate. In addition to the formal data collection from, and evaluation of, these telecenters, all known telecommuting centers in California (a total of 46) were also informally monitored through periodic status tracking reports. The final report in that series, *Telecommuting Centers in California: 1991 - 1997*, compiles and updates the information in the previous reports.

1.2 Evaluation Methodology

To investigate the impacts of telecenter use, a complex evaluation plan was developed that involved the administration of four data collection instruments, three groups of project participants, and three types of respondents within each participant group (see Tables 1-1a and b). The four survey instruments that were used to measure telecommuting behavior and its impacts were an attitudinal survey, a travel diary, an attendance or sign-in log, and an exit interview. The project participants included the telecommuting center users and two control groups: home-based telecommuters and non-telecommuters. In addition, for each group of employees telecommuting, the employee's manager and household members were also surveyed as part of the investigation. As a result, the surveys were tailored to each group, where appropriate. In addition, the attitudinal survey and travel diary were administered at two points in time (before and after telecommuting began) so as to measure changes related to the implementation of telecommuting from a center.

Monetary incentives were offered to participants to motivate the completion of attitudinal surveys and travel diaries. The primary incentive was a drawing for cash prizes of $100, $150, and $250. Two drawings were held: one in December 1994 for before survey instruments and one in July 1995 for after survey instruments. Each attitudinal survey or travel diary returned by a telecenter user, a control group member, or a household member counted as one entry in the drawing. Later in the evaluation process, when recruiting control group members proved difficult, an

incentive of five dollars per completed survey was offered to members of that group. This stimulated participation somewhat, but control group sample sizes remain substantially smaller than those for center-based telecommuters.

Table 1-1: Evaluation Plan

a. Before Telecenter Use Began

Study Group	Attitudinal Survey (Once)	Travel Diary (3 Consecutive Days)
Center-based telecommuters	Employee & Manager	Employee & Household
Home-based telecommuters	Employee & Manager	Employee & Household
Non-telecommuters	Employee & Manager	Employee & Household

b. After Telecenter Use Began

Study Group	Attitudinal Survey (Once)	Travel Diary (3 Consecutive Days)	Attendance Log (Continuously)	Exit Interview (When Necessary)
Center-based telecommuters	Employee & Manager	Employee & Household	Employee	Employee & Manager
Home-based telecommuters	Employee & Manager	Employee & Household	---	---
Non-telecommuters	Employee & Manager	Employee & Household	---	---

The attitudinal survey is a sixteen-page questionnaire that asked about participant characteristics and their attitudes toward telecommuting. Prior to the commencement of telecommuting from the center, the prospective telecenter user completed the before-wave version of the attitudinal survey. Approximately six months after the start of telecenter use, the center-based telecommuters were again surveyed (a copy of the "after" survey is included as Appendix A). Although the after-wave version of the attitudinal survey contained some new questions about experiences at the telecommuting center, most questions remained the same as in the initial version. Consequently, comparisons between the two survey waves can be used to show changes in attitudes related to work and telecommuting. However, any measured changes are not necessarily caused by telecommuting from a center, but they may in fact be due to other events occurring independently of this project. As a hypothetical example, a negative change in attitudes toward work and productivity may be caused by the downsizing of the respondent's organization rather than by the ineffectiveness of telecommuting.

To control for these potential confounding factors, two comparison groups, home-based telecommuters and non-telecommuters, were identified. The data from the non-telecommuters

capture effects due to changes other than telecommuting, which are (on the whole) common to all participants. Thus, the changes observed in the telecenter users are controlled for, allowing the identification of the effects related specifically to telecommuting center use. Additionally, the home-based telecommuting group provides the opportunity to distinguish attitudes and impacts common to both forms of telecommuting from those specific to the center-based form. The control group members (up to six per telecenter user from each of the two groups) were recruited from the same organization and chosen to have a position similar to that of the telecenter user, where possible. While the attitudinal survey differed slightly among the three study groups, the majority of the questions were identical or had a parallel structure in order to facilitate the comparison of responses. For the most part, the home-based and non-telecommuters were surveyed at approximately the same time as their associated telecenter user for both waves.

In addition to the survey of telecommuting employees, a parallel attitudinal survey was developed to measure manager characteristics and perceptions. This twelve-page survey was administered to the manager of each prospective telecenter user and control group member before the start of telecenter use. The managers were again surveyed in the after wave (a copy of the after-wave survey is included as Appendix B). A description of the contents and results of the employee and manager surveys for the telecenter users can be found in Chapter 3 of this report; comparisons with the control groups await future analysis.

The travel diary was used to record the transportation activities of study group employees and their household members during three consecutive days (a copy of key elements of the diary is provided in Appendix C). All three study groups were included in the sample studied using the travel diary. The home-based and non-telecommuter households serve both as controls for background effects and as comparisons to the travel activities of center-based telecommuter households. The travel diary was also administered in two survey waves, before and approximately six months after telecenter use began. There were no day-of-the-week restrictions for the control groups or for the prospective telecenter users on the before travel diary. However, on the after diary the telecenter users were requested to include at least one telecenter use in their three-day period. The discussion of the travel diary results in Chapter 6 is based on a combined before- and after-wave data set and focuses primarily on the differences in travel for telecenter users on days they worked from the telecenter versus days they did not work from the telecenter. It also provides some comparison of the travel characteristics of home- and center-based telecommuters.

The sign-in logs captured the use of the telecommuting centers on a daily basis. For each telecommuting occasion, project participants were asked to sign an attendance log to record their presence. Besides their name, telecenter users were also asked to give the time spent at different work locations and the means of travel to the center (a copy of the sign-in log is provided in Appendix D). The data from the sign-in sheets provide measures of telecommuting frequency, duration, center occupancy, and travel behavior. Chapter 4 covers the tabulation and analysis of the attendance log data.

Finally, those who quit telecommuting from a center, as well as their managers, were given an exit interview to determine the reason(s) for leaving. The administration of an exit interview was prompted by one of two occurrences. In some cases, participants informed their site administrator of their intention to quit. Other participants were contacted about their project status if they had failed to sign the attendance log for an extended period. The interview itself asked primarily

about the motivation for quitting and the current preferences for work locations. The responses to the employee and manager exit interviews are analyzed in Chapter 5.

1.3 Comparison to the Interim Report

The analyses in this report were performed using a combined data set that included the data collected for the Interim Report (Mokhtarian, *et al.*, 1996) plus an additional year's worth of data collected from July 1, 1995 through June 30, 1996. The Final Report replicates the analyses of the Interim Report on the larger combined data set, but includes a few new additions. The videoconference analysis of Chapter 2, the manager exit interview analysis of Chapter 5, and the air quality and emissions analysis of Chapter 6, for example, are all new additions to the Final Report. The comparison of employee and manager attitudinal responses in Section 3.4 is conducted on a matched sample in the Final Report, resulting in stronger inferences than were permitted by the unmatched sample analysis of the Interim Report. The findings of the Final Report do not differ in any meaningful manner from those of the Interim Report. The larger data set does, however, increase the validity of some of the statistical tests and has allowed for more complex analyses. In the Final Report we generally used a standard of $p = 0.05$ or lower for judging a result to be statistically significant, compared to the more relaxed standard of $p = 0.10$ used in the Interim Report.

1.4 Report Outline

This report is organized into seven chapters. Following the introduction, some procedural issues involved in conducting the evaluation of telecenter impacts are discussed. The third chapter describes the results of the attitudinal surveys administered to the telecenter users and their managers. In Chapter 4, the patterns of telecommuting use are examined at the site and the individual levels. Next, factors in the retention of center-based telecommuters are addressed in Chapter 5. The sixth chapter investigates the travel and emissions impacts of telecenter use by comparing telecommuting to non-telecommuting days. Finally, the conclusions in Chapter 7 summarize the major findings of this report and describe some directions for future research.

CHAPTER 2

PROCEDURAL ISSUES IN THE EVALUATION PROCESS

2. PROCEDURAL ISSUES IN THE EVALUATION PROCESS

2.1 Administration of the Project Evaluation

Although the focus of the Residential Area-Based Offices (RABO) Project was to investigate the organizational acceptability and travel impacts of telecommuting centers, some interesting lessons were learned from the project evaluation process. Measurement of telecenter operation, as required by the project, necessitates constant communication with site administrators, who provide information on the status of project participants. As a result, a RABO Project member, referred to here as the Evaluation Manager, was assigned to keep in contact with the site administrators to monitor the progress of telecenter use. The duties of the Evaluation Manager included tracking the status of telecommuters, providing survey materials to the sites, collecting returned survey materials, and conducting exit interviews by phone.

A number of issues arose in the process of conducting the evaluation of the RABO Project, and these issues are described more fully in the later sections of this chapter. These issues included both policy decisions as well as unforeseen events that increased the effort required to conduct the evaluation properly. These issues of evaluation procedure can be divided into compliance with contractual obligations (Section 2.2), measurement of site usage (Section 2.3), and modifications to the survey process (Section 2.4).

2.2 Contract Administration

As part of the RABO Project, the university sought applications from developers interested in establishing telecommuting centers. The site developers were required to sign contracts with the university which had provisions requiring the implementation of telecenters and the collection of data from the telecenter users. In addition, site developers were required to have employers interested in utilizing the center sign a memorandum of understanding (MOU) that described telecenter procedures and the evaluation requirements of the university (see Appendix E). Unfortunately, problems arose with the collection of data from project participants that necessitated changes to the site developer contracts. These problems included indirect contractual arrangements, insufficient motivation for users to participate in the evaluation, and inefficient survey administration.

2.2.1 Contractual Arrangements

For some site developers, contractual arrangements hampered the communication link between the RABO evaluation team and the site administrator. Lower-level subcontractors and independently established telecenters were not tied to the evaluation as closely as the majority of the centers, and as a result, data collection from these sites was adversely affected.

In one particular case, a site developer, who was subcontracted under the RABO Project to open and operate a telecommuting center, subcontracted, in turn, with a private company to manage the site. The lack of direct leverage with the company managing the center and interacting with the telecommuters made the evaluation process more difficult. Several months passed before the private firm responded to the data collection needs of the project. Consequently, the baseline surveys were administered after telecommuting had begun (instead of prior to the start of telecommuting) which resulted in poor quality data. For future projects, it is recommended that

the contractual relationship be directly with the entity managing the site and performing the evaluation services. Where this is not possible, special contract provisions need to be made to ensure proper compliance with evaluation procedures.

In addition to the 16 RABO sites, five telecommuting centers from outside the project (non-RABO) were included in the evaluation (see Table 2-1). While three of the five non-RABO centers also received funding from the California Department of Transportation (Caltrans), they received no direct funding from the RABO Project. The other two sites, Concord and San Jose, were evaluated under an MOU between Caltrans and the Metropolitan Transportation Commission, but yielded very little usable data. None of these non-RABO sites had a direct contractual relationship with the university and, therefore, they lacked an immediate incentive to provide data. It was not until Caltrans used its funding leverage that cooperation from the non-RABO sites was obtained.

Even after cooperation of the sites was assured, the telecommuters themselves were not always willing to participate in the evaluation. Unlike the RABO sites, the center users at non-RABO sites did not sign any type of MOU. Thus, survey completion was not a requirement for telecenter use. While the non-RABO sites have been included in the analysis in this report to the extent possible, the quality of the data collected and the response rate of the telecommuters is poorer than that for the RABO sites.

Table 2-1 provides a list of the opening and closing dates of the RABO and non-RABO sites that participated in the evaluation process. Five of the RABO sites left the project prior to the conclusion of RABO funding support on June 30, 1996, three of which (Auburn, Citrus Heights, and Davis) closed with less than a year of operation and two of which (Roseville, Anaheim) are still currently operating, but independently of the project.

2.2.2 Ensuring Compliance

Even with a direct link established between the Evaluation Manager and the site administrator, problems arose in the measurement of center activity. Although all but one developer included a provision in their MOU specifying user participation in the evaluation process, at least two developers described this process as "voluntary". This was, in part, a reflection of a faulty understanding of university policy regarding the use of human subjects in behavioral studies, and in part, an attempt on the part of the developer to secure as many users as possible by minimizing program requirements. Developers were concerned that too rigorous an application of evaluation requirements would further jeopardize the already-difficult marketing situation: employers could perceive the evaluation process as overly burdensome and refuse to use the center altogether. As a result, telecenter users and their managers who were originally unaware of the need to complete surveys were less willing to participate in the evaluation in exchange for their use of the telecommuting center. Since compliance with the evaluation process relied only on the goodwill of the participants to return their surveys and travel diaries, the response rate was much less than one hundred percent.

In an effort to address this problem, the university policy regarding behavioral studies was re-examined. State law requires that participation in studies such as the RABO Project must be voluntary. After consulting with the university's Human Subjects Review Committee, the evaluation team determined that while participation in the project is voluntary, once signed up

for the project, the completion of survey materials could be made mandatory in order to remain a participant. Hence, for telecenter users and their managers, references describing the completion of surveys as voluntary was removed from survey cover letters and other materials. Those references were retained for the home-based telecommuter and non-telecommuter groups.

Table 2-1: Telecenters Monitored in the Evaluation (status as of June 30, 1997)

a. RABO Sites

Site	Opening Date[1]	Closing Date	Site	Opening Date[1]	Closing Date
Roseville[2]	9 / 93	---	Davis[2]	8 / 94	7 / 95[3]
Coronado	10 / 93	7 / 96	Modesto	8 / 94	11 / 95
Grass Valley	2 / 94	---	Chula Vista - H St.	9 / 94	---
Auburn[2]	3 / 94	1 / 95[3]	Chula Vista - F St.	11 / 94	4 / 97
Citrus Heights[2]	3 / 94	1 / 95[3]	Ventura	12 / 94	---
Vacaville - Alamo	4 / 94	---	Moorpark	2 / 95	7 / 96
Vacaville - Ulatis	4 / 94	7 / 95	La Mesa	3 / 95	11 / 95
Anaheim[2]	6 / 94	---	San Juan Capistrano	4 / 95	---

b. Non-RABO Sites

Site	Opening Date[1]	Closing Date	Site	Opening Date[1]	Closing Date
Ontario	10 / 91	6 / 96	San Jose	9 / 93	2 / 94
Highland	12 / 92	---	Antelope Valley Fair	8 / 94	4 / 96
Concord	9 / 93	2 / 94			

[1] The opening date corresponds to the official opening date of the telecenter.
[2] These sites left the RABO Project before June 30, 1996.
[3] Estimated.

The decision to exclude participants based on failure to complete surveys prompted a number of changes to the project evaluation. Perhaps most importantly, the funding of telecenter sites was linked to survey response rate. One provision of an amendment to the project contract stated that if a survey were more than 30 days delinquent, the participant would no longer be counted in the center's occupancy rate (see Section 2.3) in terms of contract compliance (attendance and other evaluation data already collected were retained and analyzed for such a participant, however). The telecenter would not be able to recover the money it would have otherwise received, even if the overdue surveys were returned at a later date. After the implementation of this provision, a regular procedure was set up whereby site administrators would be informed on a bimonthly basis of outstanding survey instruments.

2.2.3 Survey Administration

Originally, the site administrator at each center was to handle the distribution and collection of survey materials provided by the Evaluation Manager. The rationale behind having the center as intermediary was ease of contact for the participating employees. With the start of telecommuting, it soon proved difficult to track the distribution of survey materials by the site administrators. Much of this problem was due to the turnover among site personnel that many sites experienced (while some site administrators were temporary employees only, other site personnel left due to low pay for the work involved and/or inadequate job performance). Replacement administrators often received little, if any, training from the site developer. Much time was spent by the evaluation staff in acquainting the new site administrators with the evaluation process. Occasionally, materials and valuable data were lost due to an inexperienced administrator.

In an attempt to solve the problems with survey administration, site administrators were offered the option of distributing materials themselves or allowing the Evaluation Manager to handle the process directly. Although the latter method makes it more difficult for participants to return materials or ask questions, the surveys are much more likely to be distributed and collected efficiently. Meanwhile, a form for all sites was developed to help the Evaluation Manager keep track of new telecommuters. For the sites that continued to administer the surveys directly, the new form ensured that the evaluation team was aware that surveys were being distributed. In the cases where the Evaluation Manager handled the process (which happened at a majority of the sites), the tracking data provided the information needed to distribute survey materials.

2.3 Measuring Site Occupancy and Usage

To measure the use of telecommuting centers for both funding and evaluation purposes, certain criteria were developed. The analyses presented in this report distinguish between site occupancy and site usage. The formula for the monthly *site occupancy rate* is the number of telecommuting occasions by registered telecommuters that lasted *at least four hours* divided by the number of workstation-days (the product of the number of workstations and the number of work days) in the month. The monthly *site usage rate* is similar but instead considers the number of all telecommuting occasions of any length in the calculation (see Section 4.3.1).

Compliance with contractually-set occupancy targets was based on the occupancy rate rather than the usage rate. The criterion for the time spent at the center was arbitrarily set at four hours in an attempt to screen out occasions where the user spent most of the day at the regular workplace. If the telecommuter visits both the center and the main office on the same day, there would be no reduction in vehicle-miles traveled (VMT) for that telecommuting occasion. Nevertheless, it is important to see how usage of the center evolves naturally. If the telecenter is most often utilized on a part-time basis, either on the way to or from work locations or as an occasional supplement to home-based telecommuting, that knowledge would affect how the center is operated, priced, and marketed. Accordingly, both site usage and occupancy rates are analyzed in the evaluation presented in Chapter 4.

However, in one special case, telecommuting occasions of less than four hours were included in the site occupancy rate. Some telecenter users with field jobs found it more convenient to use either of two centers in the area depending on which was closer to the field location. In some

cases, the total telecommuting time at both centers may have exceeded four hours on a given day. More importantly, these participants were working at the telecenter instead of returning to the regular workplace to complete paperwork. Therefore, they reduced their daily VMT and for this reason are included in the occupancy rate.

In fact, the centers were utilized in many ways that fell outside the strict definition of telecommuting, some of which had potentially important travel-reduction benefits. Uses that were not formally evaluated included drop-in use by non-participants and leasing of space to large companies. Although some sites excluded those who would have used the telecenter as a primary place of business for small businesses, other sites allowed these workers to work from their centers. Videoconferencing, a non-telecommuting use that was formally tracked, is discussed in Section 2.4.2.

2.3.1 Drop-in Use and Single-company Leasing

To bring in additional revenue, all of the telecenters experimented with drop-in programs. Drop-in use allowed customers to walk into the center and rent a workstation for their use. These telecenter users were not participants in the RABO Project since they did not sign an MOU or complete any surveys, and therefore, they were not counted as part of the occupancy rate. The registered telecommuters had priority for use of the workstations. However, conflicts between project participants and drop-in users were rarely a problem because most centers had unoccupied workstations.

In addition to drop-in programs, some telecenters leased workstations to companies looking for supplemental office space. Since the company itself was in charge of the use of the space, it was unclear whether the workstations would be used for telecommuting or as a branch office (in fact, some of the rented center space was used as classrooms and teaching facilities). Consequently, these tenants were not required to participate in the evaluation and were also not counted in the occupancy rate. Although these participants were not involved in the evaluation, some centers measured the travel by the employees of these companies and found significant savings.

2.3.2 The Telecenter as a Primary Place of Business

Defining a "true telecommuter" for the purpose of this study proved to be difficult because many different types of employees used the centers. Additionally, telecommuting centers formulated different criteria for the admission of prospective users. While some telecenter users were employees at a large firm who had a main office elsewhere, others were self-employed or employees of small businesses who used the telecenter as their primary place of business. Both non-RABO and RABO sites had telecommuters who fell into the latter category of telecenter users, some of whom were included in the evaluation process. In one respect, small businesses represent a desirable target market for telecenters. Small businesses have fewer layers of authority to go through than large organizations, so it is usually easier to obtain agreement to participate in a telecommuting program. The desire to fill telecommuting centers will likely lead to more participation by these types of employees. However, the use of the telecommuting center as a primary place of business has some negative implications for the evaluation process.

First, small business workers may have difficulty complying with all elements in the survey process. While some small business employees have a manager, sole proprietors or independent

contractors do not, by definition. Additionally, these workers may lack any co-workers or may have only a few. Since both manager and co-worker surveys are part of the evaluation process, using small business employees reduces the size of these comparison groups.

Secondly, one of the goals of the RABO Project was to demonstrate the advantages of an alternative work location for employees who would otherwise have no choice over their work location. Sole proprietors already have the choice to work at whatever location best suits them. For small businesses that use the center as a primary place of business, the employees do not have any other alternative besides the center. Thus, in these cases, the advantages of alternative work locations cannot be evaluated, nor are employees being given any choices which they did not already have.

Thirdly, the transportation impacts for those who use the telecenter as their primary place of business are indeterminate. For other employees, it is easy to see that travel is reduced if the commute trip is longer to the regular workplace than to the center (assuming that only one commute trip is made that day). But for small business workers, it is not clear what the alternative work location is. There may be no alternative location, or the alternative location may be home, in which case travel is generated, not reduced.

Finally, equity issues are also a concern for small business participation in the telecenter study. As part of the RABO Project, telecommuters are typically provided with workstations at below-market rates in order to stimulate interest in the concept. As a result, sole proprietors and small businesses who do not have an office other than the center could be unfairly subsidized in relation to their competitors who must pay full value for work space. Nevertheless, some level of experimentation is appropriate for a demonstration project, and it may be expected that a rent subsidy would not continue indefinitely for any user.

Despite the problems with those who use the center as a primary place of business, the complete exclusion of these users is not recommended. In fact, they may ensure stability for center operation and, therefore, be a key factor in the long-run success of the telecommuting center concept. A diversity of users and uses appears to be a critical element in the success of telecenters (Bagley, *et al.*, 1994). However, to control for the negative effects on the evaluation process, the following recommendations are suggested for future demonstration projects of this nature. First, since these users cannot provide the full data requirements and have no demonstrable transportation benefits, the proportion of workers of this type should be limited (for example, a limit of 25% of occupied workspace-days). Second, site developers should charge the businesses using the center as a primary workplace the full-market rent in order to prevent inequitable subsidization of these businesses.

2.4 Changes to the Survey Process

Although the survey process as described in Section 1.2 generally followed the original evaluation plan, some modifications were made during the course of the RABO Project evaluation. The two most important changes are discussed in this section: the removal of focus groups from the evaluation plan (Section 2.4.1), and the measurement of the use of videoconferencing equipment that was available at some centers (Section 2.4.2).

2.4.1 Focus Groups

Originally, focus groups were slated to be held in order to identify problems in the early stages of telecenter use. For all sites, both telecenter users and their managers would have had a separate session to discuss early experiences with the telecommuting center concept and any difficulties they might be having. Once the problems were exposed, they could be effectively addressed by the university and the site developer. Although focus groups have been used effectively in evaluating home-based telecommuting programs in the past, there are some important differences between those programs and the RABO project that hindered their use here.

The first key difference is timing the start of telecommuting. In previous studies involving a single organization, telecommuting was scheduled to begin for all participants at roughly the same time. Thus, the participants experienced the same problems together. For the RABO Project, the entry of participants into the program was staggered according to when each signed up. So, if focus groups were held too soon after a center opened, there would not be enough participants. On the other hand, waiting too long after the start of telecommuting may let problems remain unsolved, thereby damaging the telecommuting experience.

A related scheduling problem further hindered the use of focus groups in the RABO project. In previous home-based programs, managers and telecommuters usually participated in separate but consecutive sessions held at the work site during normal business hours. In the RABO case, multiple employers were involved at each center, making it difficult to identify a suitable time and place for the focus group. Even for the employees, where the telecenter may seem a natural location, work schedules are likely to differ considerably as not everyone telecommutes on common days. For the managers, the somewhat remotely located center is probably not ideal, and scheduling the time of the meeting is likely to be at least as difficult as for the employees.

Due to the problems with timing and scheduling, alternatives for exposing early problems were investigated. Although professionally-conducted focus groups are costly in terms of money and time, they provide impartial moderators and foster a certain synergy through the group discussion. Telephone interviews conducted by the university are less impartial but are more affordable and allow for asynchronous administration, such that everyone would not need to be in the same place at the same time. Non-aggressive monitoring would let minor problems be resolved at the site level and have only major problems reported to the university. The drawback here is that certain problems may go unreported without direct contact with the telecenter users. Finally, although complete site administrator monitoring would allow for personalized contact, the impartiality of the site personnel is compromised since they may be part of the problem.

After careful consideration, the final decision was to have the Evaluation Manager conduct informal monitoring by contacting project participants three months after telecommuting began to identify any difficulties they might be having. It was felt that since the Evaluation Manager had established contact with most of the participants and was seen as a neutral party, this method of monitoring would be most effective.

2.4.2 Use of Videoconferencing Facilities

A number of the telecommuting centers provided videoconference rooms to both project participants and outside users as part of their facilities. Because videoconferencing has the

potential to reduce the travel required to attend meetings, a simple survey form was developed to log each use (see Appendix F). The form requested information on the videoconference start and end times, the location of other sites participating in the meeting, the number of people involved at each site, the purpose of the meeting, and the relationship of the participants. Since the survey was developed late in the evaluation process, results are not necessarily representative of all videoconference occasions. A few of the surveys were discarded due to large amounts of missing data.

All six of the RABO telecenter locations that possessed videoconference technology provided data to the study. The six participating sites are shown in Table 2-2, producing a total of 33 videoconference occasions. Only two sites were involved in each of the videoconferencing occasions. Overall, an average of 4.2 people from the telecenter site attended each videoconference and an average of 9.1 attended the meeting from both sites involved. The standard deviation for the number attending from the telecenter site, 3.77, is relatively high due to a small clump of extreme values. More than three-fourths (77%) of the occasions involved four or fewer people at the telecenter and the median value was three. The high standard deviation for the total number of people attending each session, 8.7, is due to one extreme instance of 47 people. When this outlier is removed, the mean drops to 8.0 with a standard deviation of 5.4. About three-quarters of the occasions involved eight or fewer people at all sites.

Videoconference duration varied across the sites, but the mean value for all occasions was about an hour and a half. About one-third (34.4%) of the videoconferences lasted one hour, the most commonly reported duration. Nearly all of the one-hour sessions occurred at either the Moorpark or Ventura Community College centers, correlating mainly to teaching/instruction as the purpose. This result is not a surprise due to the approximate one-hour length of most classes.

The primary purposes of the meetings documented were information exchange (45.5%) and teaching/instruction (42.4%). The two other less frequent purposes were "other" (9.1%) and negotiation/persuasion (3.0%). There was no specific trend for the "other" selection. The participants were co-workers from the same organization 36.4% of the time, but the relationship was more often classified as "other" (39.4%). All of the "other" responses were specified to be students, corresponding to the teaching/instruction uses of the systems. The remaining selections were client/contractor (12.1%) and peers from multiple organizations (3.0%). Five sites had missing data for this question and two sites provided more than one response. The location and purpose of the site also played an important role in determining the purpose for the meeting. Both community college sites, Moorpark and Ventura, not surprisingly listed teaching/instruction as the most common reason for the videoconferences. Cross-tabulations showed that small groups (seven or fewer people attending from both sites) were 3.3 times more likely to meet for information exchange purposes than for teaching/instruction. Conversely, meetings with larger groups (more than eight people attending from both sites) were 3.7 times more likely to be for teaching/instruction purposes than for information exchange. The chi-squared test of independence shows that these differences are significant at a p-value of 0.004.

Geographically, the two participating sites for each videoconference were both located within California about 87% of the time. On four occasions the sessions included meeting sites outside of California (Texas, Ohio, Maine). Of those meetings occurring entirely within California, 71.4% involved sites less than 30 miles apart. Overall, 62.5% of the videoconferences were held less than 30 miles apart. Four-fifths of the videoconferences that were less than 30 miles apart

were for exchanges of teaching/instruction between Moorpark and Ventura Community Colleges. Many of the remaining uses are likely to be local business meetings or telecommuters meeting with people at their regular workplace. The technology at the centers does not yet seem to be used regularly on a national or international basis, which is not surprising in view of the relative novelty of the technology and the profile of the center users.

Table 2-2: Summary of Videoconferencing Usage

Site	Number of Videoconference Occasions	Mean Number of People at Telecenter Site[2]	Mean Number of People at All (Both) Sites[3]	Mean Length of Meeting (Hours)[3]
Chula Vista - F St.	4	6.75	21.75	3.5
Grass Valley	3	2.33	5.67	0.93
Highland	5	1.75	3.80	1.0
Moorpark	13	3.67	8.39	1.35
San Juan Capistrano	3	2.33	3.67	0.53
Ventura	5	8.25	12.75	1.55
Total	33	4.17 (3.77)[1]	9.12 (8.73)[1]	1.48 (1.08)[1]

[1] Standard deviations.
[2] N = 30 [3] N = 32

2.5 Summary of Procedural Issues

The RABO Project not only provides information on the practice of telecommuting center use, it also provides valuable lessons in the process of evaluating the use of telecommuting centers. The procedural issues related in this chapter dealt with contractual compliance, site usage measurement, and modification of the survey process. Since telecommuting centers are a relatively new concept, the lessons learned here will help later evaluation programs be more effective..

Changes to the contracts with site developers were necessitated by problems with data collection. Some contracts did not directly tie the university to the administrators of the telecenter which resulted in poor communication and inadequate survey response rates. At all centers, survey response rates that were lower than desired led to modifications of the center funding policies. Telecommuters were only counted in funding invoices if they had completed the required surveys. This new policy also emphasized that, while participation itself was voluntary, survey completion was a mandatory element of participation. Additional methods for improving survey collection included shifting the duties of survey distribution and collection from the site administrator to the Evaluation Manager for those centers which did not want to handle these activities.

A specific definition of telecenter occupancy was developed to ensure that the measured rate of telecommuting reflected the goals of the study. The monthly site occupancy rate calculated to assess compliance with contractual targets included only the telecommuting occasions by project

participants that lasted at least four hours. However, there were other meaningful (in terms of travel reduction) uses of the center that fell outside this narrow definition. As a result, uses by telecommuters for any length of time were documented and evaluated. Further, most sites set up at least some of their workstations for use by drop-in customers, and others specifically leased work space to particular companies (neither of those types of center users participated in the evaluation). Some participants who used the center as their primary place of business were included as project participants even though their situation was quite different from the typical telecommuter from a large organization. These participants may not have had managers or co-workers to participate in surveys, may not have had travel reduction benefits, and during the demonstration period, may have been unfairly subsidized in terms of office space costs in relation to similar businesses. It is recommended that a screening process be used to give highest priority to those who are truly telecommuting while still allowing other uses to continue at the site since a diversity of clients is a key to long-term operation.

Other issues involved in the evaluation process included changes to the survey procedure. Originally, focus groups were to be used to identify any initial problems and concerns of both the telecommuters and their managers with the use of telecommuting centers. However, problems with timing and scheduling caused the focus groups to be replaced by individual telephone interviews.

Additionally, the availability of a videoconferencing room at some telecommuting centers led to the development of a usage log for these facilities. The analysis of this data illustrates that the two most popular purposes for videoconferences were information exchange and teaching/instruction. Only two sites were involved with each videoconference and the average total attendance at each session was 8.0 people (neglecting a single occasion with 47 people). The smaller-group sessions (less than eight) were centered around information exchange and the larger-group sessions (greater than or equal to eight) were used for teaching/instruction purposes. The mean duration for videoconference sessions was approximately one and a half hours. About one-third of the sessions lasted one hour, mostly occurring at the Moorpark and Ventura Community College sites, corresponding to teaching/instruction purposes and the approximate one-hour length of most classes. Videoconference use was also mainly limited, geographically, to California. The technology at the centers does not yet seem to be used regularly on a national or international basis, which is not surprising in view of the relative novelty of the technology and the profile of the center users.

CHAPTER 3

ATTITUDINAL SURVEY ANALYSIS

3. ATTITUDINAL SURVEY ANALYSIS

3.1 Quasi-Experimental Design Structure

The data collection process was designed to make comparisons along three dimensions. First, both employees and their managers were polled on their attitudes about telecommuting. Both surveys focus on job performance and satisfaction of the employee, perceptions of telecommuting, and feasibility of telecommuting for the employee. Identical or parallel wording was used between employee and manager surveys to the extent possible. The manager surveys also include a section on the organization's opinions about telecommuting.

Three study groups comprise the second survey dimension: center-based telecommuters, home-based telecommuters, and non-telecommuters. The center-based telecommuters surveyed in this study come both from the RABO telecenters and from two southern California non-RABO telecenters which the University was contracted to evaluate. Members of the other two groups (including both employees and their managers) were recruited from the same organizations through the telecenter users or their employers and were chosen, where possible, to have a position similar to that of the telecenter user or the user's manager, respectively. The control groups were included to see how center-based telecommuting differed from more familiar work arrangements. Where changes in attitude and behavior over time are noted in the telecenter group, the control groups help to determine whether those changes are a result of telecommuting from a center, common to telecommuting in general, or a consequence of background changes affecting all workers. Thus, the control group surveys were designed to parallel the telecenter group surveys as closely as possible, with the obvious exception that the latter surveys contained some questions about the telecenter experience that were not applicable to the other groups.

Finally, the surveys were administered in two waves. In the first wave, the prospective telecenter user and the associated study group employees and managers were to be given surveys before telecommuting from the center began. Although this was the ideal situation, in some cases the surveys did not reach the respondents until soon after center use had already begun. The second, or after, wave was administered in May 1995 to all participants who had begun telecommuting before December 1994. Thereafter, new participants were surveyed one by one after they had been telecommuting 5-6 months. The two survey waves allow for an analysis of how perceptions of center-based telecommuting change with actual experience since the before wave benchmarks job satisfaction and performance levels. Although some modifications were made between the before and after versions, the surveys are essentially the same containing many identically worded questions.

The number of surveys received in each of the categories is shown in Table 3-1. The before surveys were completed during the period of July 1993 to February 1996, and the after surveys from May 1995 to September 1996.

This final report focuses only on the attitudinal surveys for telecenter users and their managers (see Appendices A and B). Comparisons to the other study groups will be conducted in the future as resources permit. Key findings for the employee telecenter user surveys are discussed in Section 3.2, which describes the characteristics of the telecenter users and compares certain characteristics before and after the beginning of telecommuting. (Section 5.2 compares the traits of those who continued to telecommute from a center to those who dropped out of the program.)

Section 3.3 covers information similar to that of the previous section, but for managers of telecenter users. In addition, this section analyzes managers' perceptions of the organizations' views of telecommuting. Finally, the responses of employees and managers are compared in Section 3.4.

Table 3-1: Number of Surveys Received

Type	Wave	Study Group			Total
		Center-based Telecommuters	Home-based Telecommuters	Non-telecommuters	
Employees	Before	150	20	36	206
	After	69	11	17	97
Managers	Before	107	14	12	133
	After	62	6	3	71

3.2 Employee Survey Results

Unless otherwise specified, the findings reported below are derived from the 69 after surveys (see Appendix A) returned by the center-based telecommuters (see Table 3-1). Where changes over time are of particular interest, before and after responses are compared for the 54 respondents who completed both waves of the telecenter user survey.

The response rate for center-based telecommuters can be calculated as follows. Of the 150 before surveys received from this group, an estimated 36 respondents quit before the after surveys were distributed. (Many more participants ultimately quit, but not before receiving the after survey. However, soon-to-be quitters who received the survey were probably less likely to return it. Quitters as a group are analyzed in Chapter 5.) Of the remaining 114 respondents, 54 completed the after surveys (the remaining 15 after surveys came from non-RABO respondents who were telecommuting from a center prior to the start of the RABO project and hence could not complete before surveys). In addition, 38 respondents telecommuted and were eligible to receive the before and after surveys but declined to return either survey. Thus, the before-wave response rate was 79.8% (150/188*100%). The after-wave response rate was 35.5% (54/152*100%) in absolute terms or 47.4% (54/114*100%) in terms of those who completed the before survey and were eligible to receive the after survey.

The employee survey contains six sections: job characteristics, job performance and satisfaction, work environment characteristics, the amount of telecommuting, travel characteristics, and demographic information. Findings from each of these sections are discussed below, although in a different order from their appearance in the survey. In particular, demographic information is presented first in order to characterize the nature of the sample.

3.2.1 Demographic Characteristics

Demographic data were collected for the full after-survey sample of 69, either from the final section of the before survey or, for those who did not complete a before survey, from a special supplement to the after survey designed for that group of respondents. The sample had more females (41, or 60.3%) than males. Almost half the sample (48.5%) fell into the median age category of 35 to 44 years. The adjacent categories, from 25 to 34 and from 45 to 54 years of age, were the next largest at 23.5% and 20.6% each. The remainder, 7.4%, fell into the category of 55 to 64 years of age (see Table 3-2).

Table 3-2: Employee Demographic Characteristics (N = 69)

Characteristic	Number (Percent)	Characteristic	Mean (Std. Dev.)
Female[1]	41 (60.3%)	Household size[1]	2.74 (1.25)
Age 25 to 34 years[1]	16 (23.5%)	Full-time workers	1.54 (0.66)
Age 35 to 44 years[1]	33 (48.5%)	Part-time workers	0.16 (0.37)
Age 45 to 54 years[1]	14 (20.6%)	Vehicles per household	2.17 (1.08)
Age 55 to 64 years[1]	5 (7.4%)	Vehicles per worker	1.50 (0.88)
Dependent care[1]	7 (10.3%)	Vehicles per licensed driver	1.10 (0.41)
Children less than 6	19 (27.5%)	Licensed drivers per household	1.99 (0.65)
Children less than 16	43 (62.3%)		

[1] N = 68

In the full data set, the average household size was 2.7 persons. Seven (10.3%) of those sampled had a household member who needed special care. More than a quarter (27.5%) had children under the age of six, and almost two-thirds (62.3%) had children under the age of 16. Each household had, on average, 1.5 full-time and 0.2 part-time workers. Between the before and after survey waves (based on the reduced sample of 54 cases common to both waves), the number of full-time workers increased slightly (from 1.52 to 1.54), and the number of part-time workers fell slightly (from 0.19 to 0.16). No one in the sample was without a driver's license. There were 2.0 licensed drivers per household and 2.2 vehicles available to the household for trips. Finally, there were 1.1 vehicles per licensed driver.

The respondents on the whole were very well educated. Using the full data set, 36.8% held college degrees, an additional 14.7% had taken some graduate school, and another 27.9% had completed at least one graduate degree (see Table 3-3). Of the remaining respondents, most had some college education (19.1%), and only 1.5% had simply a high school diploma.

Annual household income before taxes was skewed towards the higher categories. The most frequent annual household income bracket was $75,000 or more (40.9%). The next two

categories, $55,000 to $74,999 and $35,000 to $54,999, contained 28.8% and 24.2% of the sample, respectively. Only 6% of the sample had household incomes less than $35,000 per year.

3.2.2 Job Characteristics

The first section of the survey asks questions about the type of work the respondent does (see Table 3-4). Using the full after data set, the majority of the sample (55.9%) classified their current position as professional/technical. The other categories are manager/administrator (20.6%), sales/marketing (10.3%), and administrative support (8.8%). Although there is a wide range in responses, respondents tended to have job longevity: they had worked for their immediate supervisor for 3.2 years on average, for their present employer for 8.2 years, and in their present occupation for 10.5 years. The respondents reported working an average of 81.5 hours in a two-week period.

Table 3-3: Employee Education and Household Income

Education Category (N = 68)	Number (Percent)	Household Income (N = 66)	Number (Percent)
High school graduate	1 (1.5%)	Less than $25,000	2 (3.0%)
Some college	13 (19.1%)	$25,000 to $34,999	2 (3.0%)
College degree	25 (36.8%)	$35,000 to $54,999	16 (24.2%)
Some graduate school	10 (14.7%)	$55,000 to $74,999	19 (28.8%)
Graduate degree	19 (27.9%)	$75,000 or more	27 (40.9%)

Table 3-4: Employee Job Type and Work Duration (N = 69)

Job Type	Number (Percent)	Work Duration	Mean (Std. Dev.)
Manager / administrator[1]	14 (20.6%)	Years worked for supervisor[2]	3.18 (2.95)
Professional / technical[1]	38 (55.9%)	Years worked for employer[3]	8.17 (6.09)
Administrative support[1]	6 (8.8%)	Years worked in occupation[1]	10.48 (7.96)
Sales / marketing[1]	7 (10.3%)	Hours worked in two weeks	81.50 (16.32)

[1] N = 68 [2] N = 65 [3] N = 66

The respondents worked under a variety of schedules (see Table 3-5). Flexible schedules such as flextime and compressed work week were the norm rather than the exception; only 13.2% of the full sample worked a conventional schedule. Additionally, some respondents worked part-time (5.9%).

It is of interest to analyze the impact of telecommuting on the type of work schedule. One might expect more flexible schedules to become more popular with the use of telecommuting centers.

However, in some programs, employees have been required to choose between telecommuting and other forms of flexible work, which suggests that an increase in telecommuting may result in a decrease in other flexible schedules. The reduced data set containing paired before and after surveys shows that respondents did change their work schedules between survey measurements. The number of part-time, fixed flextime, and compressed work week workers dropped slightly (by 1-2 respondents each), while the number of variable flextime workers went up (by 5 respondents). Thus, in this sample, telecommuting appears to accompany a shift among various forms of schedule flexibility, but did not change the number of workers on a conventional schedule. It is noteworthy, however, that telecommuting appeared to permit two people to change from part-time to full-time status.

Table 3-5: Employee Work Schedule

Work Schedule	Reduced (N = 53)		Full (N = 68)
	Before	After	After
Part-time	6 (11.3%)	4 (7.5%)	4 (5.9%)
Conventional	9 (17.0%)	9 (17.0%)	9 (13.2%)
Fixed flextime	10 (18.9%)	8 (15.1%)	11 (16.2%)
Variable flextime	16 (30.2%)	21 (39.6%)	24 (35.3%)
Compressed work week	12 (22.6%)	11 (20.8%)	20 (29.4%)

The survey asked each respondent to classify the time spent on the job into five categories, based on the degree of location independence (see Table 3-6). Respondents reported that they spent approximately 44% of their time working independently. They split the time working with others evenly (about 20% each) into face-to-face and remote communication. Work which had to be performed at a specific location (9.0%), work-related travel (6.8%), and "other" (0.8%) accounted for the rest of their work time. Although there may be variations at the individual level, the two sets of responses for the 51 who answered both survey versions show that the aggregate percentages remained essentially the same between the two survey waves, aside from a slight drop in work-related travel after telecommuting began.

Table 3-6: Employee Work Activity Proportions (Mean and Standard Deviation)

Nature of Work Activity	Reduced (N = 51)		Full (N = 67)
	Before	After	After
Independent	42.5% (25.6)	43.8% (27.0)	43.9% (25.5)
Face-to-face	16.5% (9.0)	17.1% (12.1)	19.9% (13.2)
Remote	22.1% (19.7)	21.3% (21.1)	19.7% (19.4)
At a specific location	8.4% (12.1)	9.5% (12.1)	9.0% (11.4)
Travel	10.4% (12.9)	7.3% (9.1)	6.8% (8.3)
Other	0.2% (1.4)	1.0% (7.0)	0.8% (6.1)

3.2.3 Job Performance and Satisfaction

Respondents were asked a number of questions on their perceptions regarding their job, the first of which asks for a rating of job performance according to four aspects. The averages for the four aspects all fall higher than 4.0 (that is, "good") on a five-point scale, with small standard deviations (indicating little variability across the sample). The telecenter users rated their amount of work done as 4.25, work quality as 4.42, ability to meet deadlines as 4.23, and productivity as 4.30 (see Table G-1, Appendix G). The balanced data set shows minimal change between before and after measurements, indicating that telecommuting did not significantly affect the respondents' opinions of their work performance (see Table H-1, Appendix H). However, all four aspects were rated slightly higher on the later survey.

The second question asked respondents how their supervisor would rate them on the same four work aspects. The average scores were very similar to the respondents' own self-perceptions, with the quality of work and overall productivity being slightly lower at 4.34 and 4.25, respectively (see Table G-1, Appendix G). Comparison of before and after measurements for the reduced data set shows that after using the telecenter, the respondents thought their supervisor would rate them slightly lower on three of the four aspects. However, none of the changes were significant according to a t-test of the means (see Table H-1, Appendix H).

The final question in the section asked the respondent to give an opinion on various job satisfaction components, again on a five-point scale. Looking at all the questions in order, the following observations may be made (although there were both positively- and negatively-oriented questions, the average scores reported below have all been changed to a positive orientation so that a high rating is always favorable; see Table G-1, Appendix G). On average, respondents felt they communicated well with their supervisor (4.0), had a good opportunity for promotion (3.6), had sufficient resources to do the job (3.5), were part of an effective work team (3.7), and worked well with their supervisor (4.0). Most respondents found their job to be not tedious or boring (4.2), working gave them a sense of accomplishment (4.0), and they had appreciative supervisors (3.9). The telecenter users also were very confident of their work ability (4.5), got along very well with their co-workers (4.4), and were unlikely to look for a new job (3.8). In addition, those respondents who supervised others (41%) worked well with those they supervised (4.0). Overall, the respondents who had clients (67%) were not particularly bothered by their demands (3.4). The average response for overall satisfaction was 4.0.

The average responses from the before and after surveys for the balanced data set showed some variation, with the after responses being lower than the before responses for 10 out of the 14 statements. However, only for supervisor appreciation was the difference significant according to a t-test of the means (see Table H-1, Appendix H). Respondents rated their supervisor's appreciation of their (the respondents') work lower on the after survey than on the before survey, but the average after rating was still rather high at 3.9.

3.2.4 Work Environment Characteristics

In the third section of the survey, the respondent was asked to agree or disagree with a series of statements regarding characteristics of the work environment at three different work locations (see Table G-2, Appendix G).

For the full after data set, the means for each statement are graphed by each of the three workplaces (regular workplace, telecommuting center, and home) in Figure G-1 of Appendix G. A one-way analysis of variance was conducted for each statement to test for significantly differing means among workplaces. All statements except one show significant differences across workplaces (see Table G-3, Appendix G). Having work judged by the results was unaffected by a change in workplace location.

Table 3-7 classifies each statement under the workplace for which it had the highest mean rating. The results are very logical. Respondents perceived that their supervisors would be more comfortable if they worked in the regular workplace, as opposed to the telecenter or home. Having social interaction, being visible to management, having needed equipment, requiring little self-discipline, having professional interaction, and having supervisor communication were characteristics on which the regular workplace was perceived to be superior to the other two locations. Respondents felt more strongly that they would be easily motivated, would have less work stress, would have a professional-appearing workplace, and would not have distractions from others when they worked at the telecenter rather than at the regular workplace or home. Not overeating or indulging, having relative independence, having convenience to run errands, having enough space, keeping home and work separate, not costing too much, not having household conflicts, balancing responsibilities, and working effectively were other characteristics on which the telecenter was rated superior to the other two locations (or, in two cases, equal to home). Respondents felt more strongly that they would have relative independence and convenience to run errands if they worked at home than at the regular workplace (these two ratings were tied between home and center). Having free time, benefitting the environment, having control over equipment, not having a commute hassle, working while sick or disabled, having scheduling freedom, handling dependent care, saving money, and dressing the way they liked were also characteristics on which home was rated superior to the other two locations.

To examine how the employee's attitudes toward different work environments may have changed with the introduction of center-based telecommuting, two-way ANOVA tests were performed on the same attitudinal statements for the 54 respondents common to both survey waves. Table H-2, Appendix H presents the p-values for the main and interaction effects. Table H-3 provides the mean rating on each attribute by workplace and wave. The main effect of the workplace factor was again significant for all statements except having one's work judged by the results. For the wave main effect, only two statements indicated statistical significance (at a 0.05 level): having enough opportunities for social interaction with fellow employees and others (C8), and not having communication problems with supervisor (C29). After the employees started telecommuting from the center, the mean ratings on these two statements declined *for all three workplaces*. On the social interaction statement, the decline was greatest for the telecenter (but not significantly so, since the interaction effect was not significant), but on the supervisor communication statement, the decline was approximately equal for regular workplace and telecenter, and much greater for home. Hence, these results are inconclusive as far as indicating a problem with center-based telecommuting *per se*.

The before survey included a section in which respondents were asked to rate the importance of the same work environment characteristics on a four-point scale (see Table H-4, Appendix H). Using the balanced data set, the characteristics that had the highest and lowest average importance rankings overall are shown in Tables 3-8 and 3-9 respectively. The prospective telecenter users felt that working effectively, having the needed equipment, and having their work judged by its

results were very important. They also rated supervisor level of comfort with their work and having independence in day-to-day work activities as important characteristics. The lowest average importance scores are not as extreme as the highest scores since the lowest score is still above 2.3, which corresponds to a rating of slightly important. The respondents rated being visible to management as the least important.

Table 3-7: Perceived Strengths of Each Work Environment (N = 69)

Regular Workplace	Telecommuting Center	Home
Supervisor comfortable	Easy to be motivated	Free time
Social interaction	Not stressful to work	Relative independence[1]
Visible to management	Professional appearance	Convenient to run errands[1]
Have needed equipment	Distractions from others not a problem	Good for the environment
Would not require self-discipline	Would not overeat or indulge	Control over equipment
Professional interaction	Relative independence[1]	Commute is not a hassle
Supervisor communication not a problem	Convenient to run errands[1]	Work while sick or disabled
	Enough space	Scheduling freedom
	Easy to keep home & work separate	Can handle dependent care
	Would not cost too much	Save me money
	Household conflicts not a problem	Dress the way I like
	Balance responsibilities	
	Work effectively	

[1] Mean ratings tied for the telecenter and home locations.

Table 3-8: Most Important Work Characteristics (N = 54)

Rank	Characteristic	Score
1	Working effectively	3.91
2	Having the equipment and services needed to work effectively	3.80
3	Having work judged by its results	3.76
4	Having supervisor be comfortable with my work	3.69
5	Having independence in day-to-day work activities	3.56

Table 3-9: Least Important Work Characteristics (N = 54)

Rank	Characteristic	Score
1	Being visible to management	2.35
2	Running errands while commuting to or from work	2.41
3	Having the ability to care for a dependent(s)	2.46
3	Working while sick or disabled	2.46
5	Interacting socially at work	2.63

Looking at Table 3-7 and Figure G-1, the most important work characteristic was one on which the telecommuting center was superior (working effectively). Another characteristic (having independence in day-to-day work activities) was rated equally high for the home and telecommuting center locations, and a third (having my work judged by its results) was statistically equal across all three locations. The remaining two characteristics (having the needed equipment and having supervisor be comfortable with work) rated highest for the regular workplace. For the least important work characteristics, being visible to management and interacting socially at work were rated more highly for the regular workplace than for the telecommuting center or home. Running errands while commuting rated equally high for the home and telecommuting center locations. Having the ability to care for dependents and working while sick or disabled were rated more highly for the home than for the regular workplace or center. Thus, fortunately, it appears that the center tends to be viewed positively on the characteristics most important to the respondents, and that characteristics on which it is viewed less favorably are those which are less important. However, the comparisons of sample averages may mask some important individual differences. If, for some individuals, the center is perceived negatively on some important characteristics, then these individuals would be more likely to quit telecommuting.

3.2.5 Amount of Telecommuting

At the time of the after survey wave, the center-based telecommuters had, on average, a little more than a year's experience (median of 9.0 months' experience) with telecommuting from the center. (This estimate includes both the RABO and non-RABO telecenter users, the latter of whom had been telecommuting more than twice as long, on average, as the former). More than one-third of the full sample of 68 (35%) reported that they had also telecommuted from home, for an average (across those with prior home-based telecommuting experience) of 29.9 months. In the initial survey, 112 out of 149 (75%) had not telecommuted before participating in the study.

When asked about the ideal distribution of work time among various locations (see Table 3-10), the respondents, on average, allocated nearly equal amounts of their time to both the regular workplace (43.0%) and to the telecommuting center (40.6%). Home was a distant third at 7.6%, with other locations, such as site visits and sales meetings, comprising the remaining 4.8%. Although the variation within the data was quite high, the averages themselves remained basically the same for both versions of the survey (for those who answered both). Respondents were also

asked to distribute their work hours if the telecenter were unavailable. In this case, they would spend about two-thirds of their time at the main office (63.2%), 25.2% at home, and 7.9% at other locations, which almost evenly divides the time allocated to the center in the previous question between the regular workplace and home.

Table 3-10: Employees' Ideal Distribution of Work Time
(Mean and Standard Deviation)

Work Location	Reduced (N = 52)		Full (N = 69)
	Before	After	After
Regular workplace	41.6% (26.3)	39.7% (26.8)	43.0% (28.3)
Telecenter	45.7% (24.9)	45.8% (26.1)	40.6% (26.6)
Home	8.4% (13.7)	8.9% (14.9)	7.6% (13.8)
Other	4.3% (15.0)	5.6% (14.5)	4.8% (13.3)

The ideal distribution of time at the various workplaces can also show which combinations of work locations are preferred. Table 3-11 shows the frequency of selecting the possible workplace combinations from the after survey data. Not surprisingly, the most preferred alternative was to work at both the regular workplace and the telecenter (42.0% of the sample) with the work time at the regular workplace (56% of the time) being higher than at the telecenter (44%). However, the next most preferred alternative was to work at home in addition to the previous two locations (offered by 27.5% of the sample). So, even though the sample is composed of telecenter users, a sizeable percentage are still interested in doing some telecommuting from home. If the "other" work locations are included with the regular workplace (both of which can be considered essential to the job), then nearly all participants fall into two work arrangement categories: regular workplace/telecenter (50.7% of the sample) and regular workplace/telecenter/home (34.7%).

It is interesting to note that only one person out of 67 expressed an exclusive preference for home-based telecommuting – i.e. wanted to telecommute from home some amount but not at all from the center. In the before-wave data, 4% of the 150 respondents expressed an exclusive preference for home-based telecommuting. Perhaps several of those telecommuted from a center because it was the only or best option available to them (whether because of manager's desire, job constraints, or personal circumstances), but they are obviously more likely to drop out of center-based telecommuting than those who are more positively pre-disposed toward the option. On the other hand, perhaps some of those respondents who "had" to use a center instead of home changed their view of center-based telecommuting after having a positive experience with it.

The survey included a question designed to find out what the telecommuter did with the time saved by telecommuting. The most frequently checked responses (more than one response could be marked) were: spending time with family or friends (66.7%), getting more sleep (53.6%), and doing housework or yardwork (49.3%). Other important activities included exercising (46.4%) and relaxing by oneself (42.0%). This is followed by working (34.8%), shopping (27.5%), cooking (23.2%), spending time on a hobby (21.7%), participating in an outdoor activity (20.3%), and attending a class (15.9%). Only 4 respondents (5.8%) said there was no significant time

saved. When asked which one of the previously-checked activities they did most frequently during the time saved by telecommuting, the largest portion of the respondents cited spending time with family or friends (37.7%). Other "most frequent" activities included working (cited by 15.9%), doing housework or yardwork (8.7%), and getting more sleep (8.7%).

Table 3-11: Employees' Distribution of Workplace Combinations and Ideal Distribution of Work Time

Workplace Combination	Number (Percent)	Mean Ideal Distribution of Time[1]			
		Regular Workplace	Telecenter	Home	Other Location
R/T	29 (42.0%)	56.0%	44.0%	---	---
R/T/H	19 (27.5%)	47.2%	38.8%	14.1%	---
R/T/O	6 (8.7%)	38.3%	30.8%	---	30.8%
ALL	5 (7.2%)	31.0%	21.0%	17.0%	31.0%
T/H	3 (4.3%)	---	60.0%	40.0%	---
T	3 (4.3%)	---	100.0%	---	---
R/H	1 (1.4%)	80.0%	---	20.0%	---
T/H/O	1 (1.4%)	---	40.0%	50.0%	10.0%
Total	67 (97.1%)	44.6%	42.1%	8.1%	5.2%
Missing	2 (2.9%)				

[1] Workplace locations are the regular workplace (R), the telecommuting center (T), home (H), and other locations (O).

A set of five questions compared telecommuting frequencies from a center and from home. The first two questions asked about the possible frequencies of telecommuting based on job suitability and manager support, respectively, and the last three asked for the current, preferred, and predicted frequencies of telecommuting (see Table 3-12). The mean telecommuting frequencies given in Table 3-12 were calculated by averaging the categorical responses weighted by the midpoint of each frequency category as shown in the lower section of the table.

For the full data set, telecenter users thought their jobs were suitable for telecommuting from a center about 44% of the time, on average. They believed their supervisors would permit them to telecommute a similar amount, 43%. Interestingly, however, they only currently telecommuted from a center 33% of the time even though they wanted to use the center 52% of the time. Apparently constraints other than job unsuitability and manager unwillingness were preventing users from telecommuting as much as they would like. Nor did they believe the situation likely to change much: the expected frequency of telecommuting six months later (36%) was similar to the current frequency and still considerably lower than the desired frequency.

Table 3-12: Relative Telecommuting Frequency

a. Percent of Work Week - Mean and Standard Deviation (N = 69)

After	Job	Supervisor	Choice	Prefer	Expect
From a center	43.9% (30.5)	43.1% (32.5)[1]	32.9% (30.5)	51.6% (29.5)	36.1% (29.0)
From home	28.7% (32.1)	26.9% (33.1)[1]	12.6% (26.0)[2]	23.2% (31.2)[3]	13.5% (26.6)[2]

b. Percent of Work Week - Mean and Standard Deviation (N = 53)

Before	Job	Supervisor	Choice	Prefer	Expect
From a center	47.0% (27.0)[4]	47.0% (30.5)[5]	19.7% (25.4)[4]	54.2% (28.5)[4]	45.7% (29.9)[4]
From home	28.9% (30.7)[5]	22.6% (26.3)[6]	12.0 (22.8)[7]	17.8% (25.8)[8]	14.1% (23.7)[9]
After					
From a center[8]	48.6% (32.6)[4]	48.5% (34.5)[5]	**37.7% (31.2)**[4,10]	56.1% (30.1)[4]	39.5% (30.4)[4]
From home[8]	33.8% (34.9)[5]	**33.4% (35.4)**[6,10]	16.2% (29.0)[7]	27.7% (34.2)[8]	16.5% (29.4)[9]

[1] N = 68 [2] N = 66 [3] N = 67 [4] N = 53 [5] N = 52 [6] N = 51 [7] N = 49 [8] N = 48 [9] N = 50

[10] Significantly different from its before counterpart at $\alpha \leq 0.05$. See Table H-5, Appendix H for the test statistics.

Survey Question Definitions

Job	Considering the requirements of your current job, how much do you think **the nature of your job** would allow you to telecommute . . . ?
Supervisor	Considering the characteristics of your current supervisor, how much do you think **your supervisor** would let you telecommute . . . ?
Choice	How much do you **currently** telecommute . . . ?
Prefer	Assuming that there are no work-related constraints, how much **would you like** to telecommute . . ?
Expect	Six months from now, how much **do you expect** to be telecommuting . . . ?

c. Values Used in Frequency Calculation

Frequency Category	Definition		Assigned Value
Not at all	0 days per month	0/22 = 0	0
Less than once a month	0.5 day per month	0.5/22 = 0.0227	0.0225
About 1 - 3 days a month	2 days per month	2/22 = 0.091	0.09
1 - 2 days a week	1.5 days per week	1.5/5 = 0.30	0.30
3 - 4 days a week	3.5 days per week	3.5/5 = 0.70	0.70
5 days a week	5 days per week	5/5 = 1.0	1.00
Occasional partial days	Equated with "Less than once per month"		0.0225

Average frequencies of telecommuting from home were lower than from a telecenter for all five questions. Respondents felt that their jobs were suitable for telecommuting from home only about 29% of the time on average, suggesting that some parts of their jobs could be done remotely but required the context of a typical office environment. Accordingly, the telecenter users chose to telecommute from home much less frequently (13% of the time, on average) than from a center and also preferred to telecommute from home much less frequently (23%). (The levels of actual telecenter use based on the attendance logs are described in Section 4.4.2).

It is of interest to analyze how the responses to these five questions change with telecenter experience. For the reduced data set, the frequency of telecommuting was significantly different between the two waves for only two of the questions according to a pairwise t-test of the means (see Table H-5, Appendix H). Interestingly, the frequency of home-based telecommuting permitted by the supervisor (according to the employee's perception) increased from about one to one-and-a-half days a week, suggesting that an increased comfort-level with center-based telecommuting transferred to the home-based form as well. And not surprisingly, the frequency of telecommuting from the center increased significantly ($p = 0.000$). However, the change between the survey waves is not as great as might be expected due to a number of respondents who had already begun to telecommute from the center before completing the initial survey. Although the survey was to have been administered prior to the start of telecenter use, it was not always possible to reach a respondent or to have a survey ready before telecommuting actually began. In fact, 57% of the respondents (from the reduced data set) stated that they currently telecommuted from a center on the before survey, although most of those had probably been telecommuting less than a month.

Comparing the distributions of the categorical responses for the five questions shows some important differences between telecommuting locations (see Table 3-13). Although all respondents felt that the nature of the job allowed them to work from the telecommuting center for some amount of time, approximately 20% of the respondents considered themselves unable to telecommute from home for the same reason. Even more respondents (about 27%) felt that their supervisor was unwilling to let them work from home at all. Cross-tabulating these two results showed that the option of telecommuting from home was not available to a third of the telecenter users. Also, a sizable portion (31%) of the telecenter users did not want to work at home. Thus, centers may help spread the transportation and other benefits of telecommuting to a larger segment of the workforce.

Setting an arbitrary telecommuting frequency criterion at one day per month or more, the full after survey results show that 84% of the respondents meet this level of telecommuting at the center. Using the same marker, 29% currently telecommute from home. In fact, 23% spend one day per month or more working at each telecommuting location.

Finally, although most respondents expected to be telecommuting more often six months after completing the survey, 5 of the respondents (7.2%) planned to stop using the telecenter, as indicated by a response of "not at all" to the question: "Six months from now, how much do you expect to be telecommuting from a telecommuting center?" Again, nearly half of the telecenter users did not expect to be telecommuting from home (47.8%). Overall, the results from the choice, preference, and expectation questions indicate that combined home and center telecommuting appears to be a popular option for many but not all respondents. Synthesizing responses from Tables 3-11 and 3-13 suggests that at least 40% of the sample wanted to work

at home either not at all or very little (less than once a month, combining the first two columns of Table 3-13).

Table 3-13: Employee Telecommuting Frequency (Number and Percent)

	Not at All	Less Than Once a Month	About 1-3 Days a Month	1-2 Days a Week	3-4 Days a Week	5 Days a Week	Occa-sional Partial Days
From a Center (N = 69)[1]							
Job	0	0	12 (17.4%)	30 (43.5%)	16 (23.2%)	9 (13.0%)	2 (2.9%)
Manager[2]	0	1 (1.5%)	14 (20.6%)	30 (44.1%)	10 (14.7%)	12 (17.6%)	1 (1.5%)
Choice	1 (1.5%)	8 (11.6%)	19 (27.5%)	20 (29.0%)	14 (20.3%)	5 (7.2%)	2 (2.9%)
Prefer	0	1 (1.4%)	4 (5.8%)	28 (40.6%)	24 (34.8%)	10 (14.5%)	2 (2.9%)
Expect	5 (7.2%)	1 (1.5%)	16 (23.2%)	25 (36.2%)	17 (24.6%)	4 (5.8%)	1 (1.5%)
From Home (N = 69)[1]							
Job	14 (20.3%)	5 (7.2%)	10 (14.5%)	24 (34.8%)	5 (7.2%)	8 (11.6%)	3 (4.4%)
Manager[2]	18 (26.5%)	4 (5.9%)	10 (14.7%)	19 (27.9%)	5 (7.3%)	8 (11.8%)	4 (5.9%)
Choice[3]	35 (53.0%)	9 (13.6%)	4 (6.1%)	10 (15.2%)	1 (1.5%)	4 (6.1%)	3 (4.5%)
Prefer[4]	21 (31.3%)	7 (10.4%)	8 (11.9%)	17 (25.4%)	5 (7.5%)	6 (9.0%)	3 (4.5%)
Expect[3]	33 (50.0%)	6 (9.1%)	10 (15.2%)	8 (12.1%)	2 (3.0%)	4 (6.1%)	3 (4.5%)

[1] See Table 3-12 for the text of the survey questions.
[2] N = 68 [3] N = 66 [4] N = 67

3.2.6 Travel Characteristics

On average, for 68 after survey respondents, the commute to the regular workplace took 62.2 minutes to travel 42.3 miles. The average commute to the telecommuting center took about 10.8 minutes to travel 7.5 miles. Thus, on days that the participants used the center *instead of* going to the regular workplace, their commute travel was reduced, on average, by 34.8 miles. (This estimate includes five participants who traveled 0.5, 1.0, 5.0, 11.5 and 12.5 miles, respectively,

farther to the center than to the regular workplace. The differences for the first two cases are negligible. For the third case, no first-hand explanation is available, but it is believed that the employee used the center to work with her supervisor, a telecenter user, and/or to work at a nearby field site. In the fourth case, the employee could not be contacted for an explanation. In the last case, the employee was actually using the center temporarily before obtaining permanent space for a branch office near the center.)

On the before survey, respondents were asked to divide their total commute between miles on freeways and miles on other roads. For the sample of respondents who completed both surveys, the breakdown of commute distance is shown in Table 3-14. For the commute to the regular workplace, 36.3 miles were traveled on freeways compared to 6.9 miles on other roads, on average. The trip to the telecenter was composed of 3.8 freeway miles and 2.6 non-freeway miles. Interestingly, a larger portion of the travel to the telecenter was done on freeways than on surface streets.

Examining the difference between the ten RABO sites, which were established near residential areas for the most part, and the two non-RABO sites, one of which is located in a light-industrial park, provides some insights into the effects of telecenter location. Although RABO participants had shorter commutes to the telecenter (5.2 vs. 12.9 miles), non-RABO respondents had a slightly greater reduction in travel (38.8 miles vs. 36.2 miles) since their regular workplace was farther away, on average (51.7 vs. 41.4 miles). Non-RABO participants traveled much greater distances on freeways (10.1 vs. 2.6 miles) when commuting to the telecenter than RABO participants and approximately the same amount on other roads (2.8 vs. 2.6 miles).

Table 3-14: Average Distance to Work Locations (Before-wave Survey)

Location	Roadway Type	One-way Distance (Miles)		
		RABO (N = 44)	Non-RABO (N = 9)	Total (N = 53)
Regular workplace	Freeway	34.1	46.8	36.3
	Surface streets	7.3	4.9	6.9
	Total	41.4	51.7	43.2
Telecenter	Freeway	2.6	10.1[1]	3.8[2]
	Surface streets	2.6	2.8[1]	2.6[2]
	Total	5.2	12.9[1]	6.4[2]

[1] N = 8 [2] N = 52

The section of the survey covering travel characteristics also includes a series of questions about residential relocation. Of the 69 respondents, only 4 (5.8%) had moved in the past year: two moved closer to their regular workplace and the other two moved farther away. Contrary to expectation, the former respondents stated that telecenter use was, respectively, a somewhat important and very important factor in the relocation decision, while the latter respondents both stated that telecenter use was not a factor. A larger group of respondents was considering

residential relocation. Of these 12 (17.4%), 5 planned to move closer to work, one planned to move farther from work, and the remaining six would move either closer to or farther from work. However, a majority of those planning to move did not believe that telecommuting (8 of 12) or telecenter location (7 of 12) were important factors in the relocation decision. So, although telecommuting is sometimes hypothesized to facilitate residential relocation farther from work since the commute trip is made less frequently, there is little measurable impact for this small sample at this early point in the telecommuting experience.

In the after survey, respondents were asked what they did during their lunch break in a typical month (20 working days) on both the days they worked from the regular workplace and days on which they worked at the telecommuting center (Table 3-15). The purpose was to obtain some information on the likely local economic impacts of telecenters: to what extent do participants eat and shop in the vicinity of the center? The categories were not mutually exclusive, but represented a conscious compromise to reduce survey length and complexity.

For the full data set, the relative frequency of telecommuting which could be deduced from the responses to this question implies that respondents telecommuted on average seven working days out of a typical 20-day month (35.0%). This proportion of center-based telecommuting days is consistent with an earlier response where respondents from the full data set indicated that they currently telecommuted from a center about 33% of the time (Table 3-12a).

First examining only the days respondents worked at the regular workplace, the most frequent lunch break activities were to drive or ride someplace other than home to buy lunch and/or run errands (28.9%), to bring lunch from home (26.2%), to buy lunch at the workplace (15.7%), to skip lunch (13.7%), and to walk someplace other than home to buy lunch and/or run errands (10.6%). It is not surprising to see that the top two activities include driving/riding somewhere else for lunch and bringing lunch from home. It is not uncommon to have a variety of restaurants and shops near a conventional workplace in a commercial area. On the other hand, regardless of one's work location, there will be some proportion of people who would rather bring lunch from home than spend more money on lunch "out" or eat restaurant cooking.

For the days the respondents worked at the telecenter, they ate lunch at home (25.3%), brought lunch from home (19.9%), drove or rode to someplace other than home to buy lunch and/or run errands (18.2%), and walked someplace other than home to buy lunch and/or run errands (17.6%). Since the telecenters were relatively close to the respondents' homes, it is not surprising that respondents chose eating at home with the greatest frequency.

In terms of lunch break activities, the most notable difference between the regular workplace and the telecenter is that, proportionately, respondents ate lunch at home on days they worked at the telecenter (25.3%) far more often than on days they worked at the regular workplace (2.8%) – an observation borne out by the travel analysis in Chapter 6. This suggests that center-based telecommuting can increase the time spent with family and in the community. On the other hand, it also suggests that the economic impacts of telecommuting centers may not be substantial, at least for lunch break activities (there may still be an effect for activities chained to the morning or evening commute trip). However, traveling to someplace other than home to buy lunch and/or run errands remained a popular activity while working at either the regular workplace or telecenter (as did bringing lunch from home). Respondents indicated buying lunch at the workplace on a lower proportion of days when they were working from the telecenter, a

reflection of the fact that telecenters do not offer on-site cafeterias or restaurants to the extent that regular workplace locations do.

Table 3-15: Lunch Break Activities in a Typical Month (20 Working Days) (N = 69)

Activities	Regular Workplace			Telecommuting Center		
	Mean Days (S.D.)	Percent of All Days	Percent of RW Days	Mean Days (S.D.)	Percent of All Days	Percent of TC Days
Drive or ride to someplace other than home to buy lunch and/or run errands	3.75 (4.97)	18.77%	28.87%	1.28 (2.40)	6.38%	18.22%
Bring lunch from home	3.41 (4.72)	17.03%	26.20%	1.39 (3.59)	6.96%	19.88%
Buy lunch at the workplace	2.04 (3.30)	10.22%	15.72%	0.72 (1.86)	3.62%	10.35%
Skip lunch	1.78 (3.61)	8.91%	13.71%	0.49 (1.58)	2.46%	7.04%
Walk someplace other than home to buy lunch and/or run errands	1.38 (2.60)	6.88%	10.59%	1.23 (2.87)	6.16%	17.60%
Eat at home	0.36 (1.26)	1.81%	2.79%	1.77 (4.29)	8.84%	25.26%
Take public transit to someplace other than home to buy lunch and/or run errands	0.26 (1.82)	1.30%	2.01%	0.03 (0.24)	0.14%	0.41%
Take a taxi to someplace other than home to buy lunch and/or run errands	0	0	0	0.04 (0.36)	0.22%	0.62%
Other	0.01 (0.12)	0.07%	0.11%	0.04 (0.36)	0.22%	0.62%
Total	13.00 (22.40)	65.00%	100%	7.00 (17.56)	35.00%	100%

3.2.7 Summary of Employee Survey Results

In this final report, the analysis of the survey data is restricted to telecenter users only. Primarily, the data from the after-wave surveys were used to characterize center-based telecommuters (sample size of 69). However, where appropriate, data from both before and after waves were utilized to highlight changes related to the use of telecenters (a reduced sample size of 54). A summary of the results from the six parts of the survey is provided below.

In terms of demographics, there were half again as many female telecenter users as males, and nearly half the sample was between the ages of 35 to 44 years. The average household size of 2.7 persons was consistent with the fact that more than half of the respondents had children under 16 years of age. Vehicle availability was high among the respondents with 2.2 vehicles per household and 1.1 vehicles per licensed driver. The telecenter users were highly educated (about 43% had additional schooling after college) and relatively affluent (about 70% had annual household incomes greater than $55,000).

Job characteristics varied among the center-based telecommuters. Slightly more than half of the sample held professional/technical positions which are usually easily adapted to telecommuting, and as a whole, they were experienced in their field with an average length of time in the profession of 10.5 years. Flexible schedules were common among the telecenter users, with more than 80% of the sample having some form of flextime or compressed work week schedule. Finally, the respondents spent a high proportion of their workday working independently (44%) or remotely (20%), both of which are good indicators of positions with telecommutable tasks.

The responses from the attitudinal sections on job performance and satisfaction and work environment characteristics showed primarily positive results. Telecenter users rated their job performance and satisfaction positively, and there was little change in these characteristics between survey waves suggesting that working from a telecommuting center did not drastically change these factors. The ratings on the statements about work characteristics also remained approximately the same between survey measurements. Finally, the most important work characteristics to the respondents were working effectively, having needed equipment, and having work judged by the results. The telecenter was rated most favorably of the three workplaces (telecenter, home, regular workplace) on the most important characteristic of working effectively.

The survey also measured the amount of telecommuting the telecenter users had done, were currently doing, and planned to do in the future. The average experience with telecommuting from a center was about one year (median of 9.0 months) at the time of the after survey, and over one-third also had prior experience with home-based telecommuting. About a third of the respondents did not currently have the option to telecommute from home (based solely on job and manager considerations), which indicates that centers may help spread the transportation and other benefits of telecommuting to a larger segment of the workforce. With the time saved by telecommuting, the respondents most often spent time with family or friends, worked, got more sleep, and/or did housework/yardwork.

When distributing their work time in an ideal situation, the respondents preferred to work from the telecenter and the regular workplace about equal amounts, 41% to 43% of their time (each) on average. However, they reported actually telecommuting only about 33% of the time even though their jobs were suitable for telecommuting for about 44% of the time, on average (see Section 4.4.2 for actual telecommuting frequency based on attendance log data). The respondents predicted frequencies of future center-based telecommuting to be comparable to current levels (36%). Using the reduced data set, expected frequency of telecommuting from the center (40%) on the after survey was substantially lower than was reported on the before survey (46%). However, it was close to actual frequency (38%), suggesting that respondents had adjusted their expectations realistically. Supervisors were willing for their employees to telecommute from home more frequently in the after survey than in the before, suggesting that the supervisors became more comfortable with telecommuting in general through their telecenter experience.

Setting an arbitrary frequency criterion of one day per month or more, the full after survey results show that more than four-fifths meet this level of telecommuting at the center and that one-third currently telecommute from home at least this often. Almost a quarter of the respondents (of the full after survey) telecommute both at the telecenter and from home one day or more each per month. Overall, the results from the choice, preference, and expectation of telecommuting indicate that combined home and center telecommuting appears to be a popular option for many of the respondents. However, at least 41% of the respondents indicated that they did not want to work at home at all (31%) or wanted to work at home less than once a month (10%).

In the section on travel, the one-way commute to the regular workplace was reported as 42.3 miles in length, while the commute length to the telecommuting center was given as 7.5 miles, on average. The resulting average commute travel savings by using the center *instead of* going to the main office for the after survey respondents was 34.8 miles. Despite the reduction in travel, the majority of travel to the telecenter was on freeways, suggesting that the centers are far from the average participant's residence. This was especially true of the respondents from non-RABO centers who had longer commutes than RABO telecommuters, on average, to both the regular workplace (51.7 vs. 41.4 miles) and the telecommuting center (12.9 vs. 5.2 miles). Additionally, telecenter use was not found to have much effect on residential relocation decisions in this short time frame.

Comparing the lunch break activities of the full set of after survey respondents on regular workplace and telecenter days, the most significant difference is that, proportionately, respondents ate lunch at home on days they worked at the telecenter nine times more often than on days they worked at the regular workplace (25.3% vs. 2.8%, respectively). Driving or riding to someplace other than home to buy lunch and/or run errands and bringing lunch from home were both popular activities on regular workplace as well as telecenter days. Respondents indicated buying lunch at the workplace less often when they were working from the telecenter.

3.3 Manager Survey Results

Attitudinal surveys for managers targeted the supervisors of the employees who participated in the project. The number of returned manager surveys for the two waves and three study groups is shown in Table 3-1. There were a total of 133 responses for the before survey (107 from managers of center-based telecommuters; 26 from managers of home-based and non-telecommuters), and 71 for the after survey (62 center-based; 9 home-based and non-telecommuters). Attrition in the second wave was due both to employees dropping out of the study (in which case an "after" survey from the manager was not expected, although exit interviews with those managers were attempted; see Section 5.5) and to failure on the part of the manager of a still-telecommuting employee to return the questionnaire.

Similar to the previous section, this section focuses on analyzing the after survey for managers of telecenter participants, that is the perceptions of the supervisors after their employees had used the telecenter for several months. The survey response rate is calculated as follows. A total of 114 center-based telecommuting employees completed the before surveys and did not quit before the after surveys were distributed. Of the 114 employees, 9 were self-employed. Thus, 105 employees' managers were eligible to receive the after surveys. The 105 employees collectively had 98 managers, since 6 managers supervised more than one telecommuter (5 managers supervised 2 telecommuters and 1 manager supervised three telecommuters). However, managers

were to complete a different attitudinal survey for each of their employees, since their performance ratings and other attitudes might differ depending on the employee involved. A total of 62 after manager surveys were returned (completed by 56 different managers) of which 43 surveys were from the managers of the 105 employees (i.e. who were eligible to receive the after surveys). Twelve surveys were received from managers of employees who returned only the after employee surveys (generally because of joining the evaluation program after having already started telecommuting). The remaining seven surveys came from managers whose employees telecommuted from a telecenter but declined to return either the before or after employee surveys. In addition, an estimated 16 employees started telecommuting and did not quit before the after surveys were distributed but neither they nor their managers completed an after employee or manager survey. Thus, the survey-based response rate for managers who were eligible to receive both before and after surveys is 39% [(43+7)/(105+7+16)*100%]. The survey-based response rate based solely on eligibility to receive the after survey (i.e. including those who joined the evaluation while telecommuting was in progress) is 38% (62/(105+37+16+7)*100%), where the 37 in the denominator of the calculation represents employees who were only eligible for after surveys.

Of the 62 responses, 36 were from RABO sites and 26 were from non-RABO sites. In addition, a matched pair of before and after surveys was available in only 37 cases. When changes between the two survey waves are of interest, the analysis is based on these 37 responses. Of the remaining 25 supervisors who returned the after survey but not the before survey, 6 respondents were new managers for continuing telecommuters and the other 19 respondents were managers of new participants in the study. These new participants, who were from the non-RABO site at Ontario, had already been telecommuting for some time before joining the study, and hence neither they nor their managers could complete the before survey.

Although the surveys of the participating employees and their managers were conducted in parallel, due to non-response among both groups there is not necessarily a manager survey for each employee and vice versa. Among the telecenter participants, 69 employee surveys and 62 manager surveys were returned for the after wave. There are a total of 47 employee-manager pairs in the sample; thus, the average responses for the 62 manager surveys analyzed in this section may not completely correspond to the behavior of the 69 employees whose responses are presented in Section 3.2. Comparisons of the responses between managers and employees are discussed in detail in Section 3.4.

The questionnaire design for managers was similar for both survey waves, with the after survey obtaining additional information about telecommuting. The survey contains six parts:

- Part A: Job characteristics of the employee.
- Part B: Assessments of the employee's job performance and satisfaction.
- Part C: Attitudes toward the employee working at three different work environments: regular workplace, telecenter and home.
- Part D: Perceptions of the advantages of telecommuting.
- Part E: Perception of telecommuting as a work option, including general attitudes toward telecommuting within various management levels of the organization, information on the amount of time for the employee to telecommute, and intentions regarding continuing the telecommuting program.
- Part F: Demographic data, including gender, age, job tenure, education level, and frequency of computer usage.

The sections that follow describe the responses to each part of the survey in the order in which each part appears, except that the demographic information is presented first in order to describe the nature of the sample. The after survey for managers of telecenter users is attached to this report as Appendix B.

3.3.1 Demographic Characteristics

The demographics given below describe the 62 after survey responses. Slightly more than half (54.8%) of the responses were from males. The two largest groups, which accounted for 38.7% and 37.1% of the sample, were between the ages of 35 to 44 and 45 to 54, respectively. The next largest age group, which accounted for 16.1% of the sample, was 55 to 64 years of age. The remainder (8.1%) were in the category of 25 to 34 years old. On average, respondents had worked for their current organizations for 13.1 years and had worked as supervisors for more than 9 years.

The majority (69.4%) used a computer for several hours per day on the job. Only 4 persons did not use a computer at all while working. More than three-quarters of the sample held at least a four-year college degree: 29.0% had obtained a bachelor's degree and another 48.4% had completed one or more graduate degrees. Nearly one-third of the 62 responses (32.3%) came from organizations with more than 500 employees. Seventeen people (27.4%) worked for an organization with 10 to 49 employees, and 15 (24.2%) worked for an organization with 100 to 499 employees. Of the remainder, four and five responses came from organizations with 1 to 9 and 50 to 99 employees, respectively. Thus, in this sample, large organizations were the dominant participants in center-based telecommuting. This is in contrast to other, larger-sample studies of home-based telecommuting, where adoption has been found to be more prevalent among small-to-medium size employers.

3.3.2 Job Characteristics of Employees

In the first part of the survey, managers were asked to give some background information on their employees' jobs. Supervisors of the 62 telecenter users reported that their participating employees worked for 80.9 hours in two weeks on average. Table 3-16 shows the items or services which the supervisors thought that the employees would need to work as effectively at the telecenter as they did at the regular workplace. The most frequently-selected items were copier, personal computer, printer and fax machine. Other frequent responses (cited by half to three-quarters of the sample) included voice mail, software, modem, electronic mail and conference calling. Thus, the ability of center-based telecommuters to keep in touch with their supervisors, clients, and co-workers was important to most of the managers.

3.3.3 Assessment of Employee Performance

In Part B of the survey, supervisors were asked to evaluate their employees' performance in various ways. The average responses are shown in Table 3-17. The first question asked the supervisors to evaluate their employees (on a five-point scale from "terrible" to "excellent") regarding the amount of work completed, quality of work, ability to meet deadlines, and overall productivity. Most of the employees were rated as "good" (4) or "excellent" (5).

Table 3-16: Items or Services Thought to Help Employees Work Effectively at the Telecenter (N = 62)

Item/Service	Number (Percent)	Item/Service	Number (Percent)
Copier	56 (90.3%)	Overnight package pickup / delivery	20 (32.3%)
Personal computer	55 (88.7%)	Files or reference materials	19 (30.6%)
Printer	55 (88.7%)	Call forwarding	16 (25.8%)
Fax machine	54 (87.1%)	Private office	11 (17.7%)
Voice mail	48 (77.4%)	Videoconferencing	11 (17.7%)
Software	46 (74.2%)	Call waiting	10 (16.1%)
Modem	43 (69.4%)	Secretarial services	10 (16.1%)
Electronic mail	40 (64.5%)	Restaurant / cafeteria	8 (12.9%)
Conference calling	35 (56.5%)	Document production services	4 (6.5%)
Lockable storage area	27 (43.5.%)	Child care	1 (1.6%)
Additional phone line	26 (41.9%)	Other (Internet connection)	1 (1.6%)

Table 3-17: Supervisors' Ratings of Their Employees in the After Survey (N = 62)

Statements	Average Rating (Std. Dev.)
Amount of work completed	4.31 (0.69)
Quality of work	4.42 (0.64)
Ability to meet deadlines	4.37 (0.66)
Overall productivity	4.32 (0.70)
Employee communicates effectively[1]	4.31 (0.72)
Adequate resources are available[1]	4.03 (0.79)
Employee's work team is effective	3.90 (0.86)
Employee works well with supervisor[2]	4.18 (0.86)
Clients demand a reasonable amount of time[1, 3]	3.22 (0.86)
Supervisor is satisfied with employee's performance	4.37 (0.77)
Supervisor expresses enough appreciation[1]	3.08 (1.01)
Employee gets along well with co-workers[1]	4.34 (0.68)
Employee has ability to do the job	4.47 (0.62)
Employee is likely to stay at current job[1]	3.86 (0.83)
Employee works well with subordinates[4]	3.93 (0.81)

[1] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

[2] N = 60 [3] N = 51 [4] N = 15

The second question asked the respondents to express an opinion (on a five-point scale from "strongly disagree" to "strongly agree") regarding the work effectiveness of their employees along several dimensions. On the whole, the supervisors were satisfied with their employees' performance. Employees were believed to perform well on a team and to work well with the supervisor as well as with their own subordinates (where applicable). Also, they were still considered to communicate well with supervisors and their co-workers after the start of telecommuting.

To see if telecommuting had an impact on supervisors' assessments, responses in the before and after waves were compared for the 37 cases in which managers completed both surveys. The results of conducting paired t-tests on each statement are given in Table 3-18. None of the statements shows a significant change under a 0.05 level of significance (with the borderline exception of "clients demand a reasonable amount of time", for which the mean rating declined somewhat). Thus, for this sample, it appears that telecommuting did not alter the managers' perception of their employees' work abilities either for better or for worse.

Table 3-18: Change in Supervisors' Ratings of Their Employees (N = 37)

Statements	Before Mean (S. D.)	After Mean (S. D.)	P-value
Amount of work completed	4.38 (0.68)	4.38 (0.59)	0.272
Quality of work	4.41 (0.64)	4.46 (0.51)	0.286
Ability to meet deadlines	4.27 (0.69)	4.41 (0.60)	0.710
Overall productivity	4.30 (0.70)	4.35 (0.63)	0.960
Employee communicates effectively[1]	4.30 (0.70)	4.38 (0.59)	0.743
Adequate resources are available[1,2]	4.06 (0.65)	4.03 (0.90)	0.549
Employee's work team is effective[3]	3.94 (0.86)	3.94 (0.89)	0.981
Employee works well with supervisor	4.19 (0.66)	4.16 (0.83)	0.525
Clients demand a reasonable amount of time[1, 4]	3.44 (1.00)	3.32 (0.90)	0.053
Supervisor is satisfied with employee's performance	4.35 (0.72)	4.43 (0.60)	0.814
Supervisor expresses enough appreciation[1]	3.11 (0.99)	3.00 (1.00)	1.000
Employee gets along well with co-workers[1]	4.24 (0.80)	4.30 (0.66)	0.920
Employee has ability to do the job	4.46 (0.69)	4.41 (0.64)	0.147
Employee is likely to stay at current job[1]	3.59 (0.83)	3.78 (0.89)	0.619
Employee works well with subordinates[5]	4.20 (0.45)	4.40 (0.89)	0.534

[1] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

[2] N = 34 [3] N = 36 [4] N = 25 [5] N = 5

3.3.4 Attitudes toward Different Work Environments

In Part C of the survey, supervisors' attitudes toward their employees working in three different work environments (regular workplace, telecenter, and home) were investigated using a series of attitudinal statements with a five-point response scale (from "strongly disagree" to "strongly agree"). The average ratings on each statement for each of the three workplaces are provided in Table I-1 and graphed in Figure I-1, Appendix I. A three-level one-way analysis of variance (ANOVA) test was conducted for each statement to determine if supervisors' attitudes differed significantly across the three workplaces. Table 3-19 shows the results of the F-test for equality of means for each ANOVA, as represented by the p-values. Under a 0.05 level of significance, the effect of the workplace factor was significant for 16 of the 22 statements. The effect was insignificant for the employee indulging (C5), relative independence (C6), having the option to work when sick or disabled (C12), having the freedom to adjust the work schedule (C13), having work judged by the results (C15), and having high worker's compensation liability (C21).

In general, the supervisors favor working at home the least (see Table I-1 and Figure I-1, Appendix I). The mean rating for the telecenter typically falls between the average rating for the regular workplace and home. Despite this, the respondents rated the telecenter similarly to or better than the regular workplace on the following aspects: employee being easily motivated (C1), supervisor's level of comfort (C2), workplace having a professional appearance (C3), having fewer distractions from others (C4), being good for the environment (C7), supervisor feeling confident (C10), costing too much (C11), and employee working effectively (C18).

Meanwhile, center-based telecommuting had some relative disadvantages compared to the regular workplace, with the telecenter being rated less positively on statements such as the employee not being visible to management (C8), the employee not having needed equipment (C9), the employee being unavailable (C14), not having enough professional interaction (C16), poor communication with the employee (C17), telecommuting being an administrative burden (C19), security of confidential information (C20), and lower perceived security for the organization's property (C22). However, it is important to realize that the mean ratings on all of these statements were neutral or favorable, just less favorable than the ratings for the regular workplace. Hence, these attitudes toward the telecenter were not negative in the absolute sense. Further, these attitudes seem to apply to telecommuting in general since home-based telecommuting had even more unfavorable average responses than the telecenter in each of the above statements except the last two (C20 and C22), where both forms of telecommuting were rated approximately equally.

To examine how the supervisor's perceptions of the various workplaces may have changed with the introduction of center-based telecommuting, two-way ANOVA tests were performed on the same attitudinal statements for the 37 cases common to both survey waves. The results are shown in Table 3-20. The effect of the workplace factor is significant for most of the same statements as in the previous ANOVA. As to the effect of the wave factor, the mean ratings are statistically different across waves (at a 0.05 level of significance) for the following three statements: feeling confident in the employee (C10), costing too much (C11), and having the option available to work when sick or disabled (C12). In other words, the supervisors' attitudes on these statements changed significantly after their employees began telecommuting from the center.

Table 3-19: One-way ANOVA Results for Supervisors' Attitudes toward Different Work Environments in the After Survey (N = 62)

Statements	Workplace Factor[1]
C1. Employee is easily motivated	**0.000**
C2. Supervisor feels uncomfortable	**0.000**
C3. Workplace has professional appearance	**0.000**
C4. Employee is distracted by others	**0.000**
C5. Employee indulges	0.291
C6. Employee is relatively independent	0.086
C7. Beneficial to the environment	**0.000**
C8. Employee is not visible to management	**0.000**
C9. Employee does not have needed equipment	**0.000**
C10. Supervisor feels confident in employee	**0.000**
C11. Costs too much	**0.000**
C12. Offer option when sick or disabled	0.144
C13. Employee can adjust work schedule	0.230
C14. Employee is unavailable	**0.000**
C15. Employee's work is judged by results	0.691
C16. Employee does not have enough professional interaction	**0.000**
C17. Poor communication with employee	**0.000**
C18. Employee works effectively	**0.000**
C19. Administrative burden	**0.000**
C20. Security of confidential information	**0.002**
C21. High worker's compensation liability	0.324
C22. Organization's property relatively secure	**0.006**

[1] The numbers given are the p-values of the F-test for equality of means across workplaces. Values in boldface type are significant at $\alpha \leq 0.05$.

The average ratings for the three statements with a significant wave effect are shown in Figure I-2 of Appendix I. We see that first, supervisors' confidence that their employees would work a full day had changed. On average, respondents agreed more strongly on the after survey that their employees would work a full day at all three workplaces. Second, the perception that center-based telecommuting costs too much had changed. On average, respondents disagreed

more strongly on the after survey with the statement that telecommuting from a center would cost the organization too much. However, managers similarly changed their opinion about the costs of working from the regular workplace (and from home), suggesting that the change may not be simply caused by telecenter use. Third, it was found in the after wave that the supervisors were more likely to offer employees the option to work from any of the three workplaces when sick or disabled. It may be that telecommuting raised supervisors' awareness of the potential for accommodating such needs from a variety of locations. For the other 17 statements, there were no significant differences between survey waves.

Table 3-20: Two-way ANOVA Results for Supervisors' Attitudes toward Different Work Environments in Both Survey Waves (N = 37)

Statements[1]	Workplace Factor[2]	Wave Factor[3]	Inter-action[4]
C1. Employee is easily motivated	**0.000**	0.590	0.602
C2. Supervisor feels uncomfortable	**0.000**	0.826	0.773
C3. Workplace has professional appearance	**0.000**	0.769	0.548
C4. Employee is distracted by others	**0.000**	0.429	0.476
C5. Employee indulges	0.188	0.933	0.912
C6. Employee is relatively independent	0.098	0.646	0.644
C7. Beneficial to the environment	**0.000**	0.339	0.494
C8. Employee is not visible to management	**0.000**	0.172	0.706
C9. Employee does not have needed equipment	**0.000**	0.714	0.820
C10. Supervisor feels confident in employee	**0.000**	**0.013**	0.995
C11. Costs too much	**0.000**	**0.015**	0.984
C12. Offer option when sick or disabled	**0.013**	**0.003**	0.655
C13. Employee can adjust work schedule	0.245	0.196	0.486
C14. Employee is unavailable	**0.000**	0.308	0.994
C15. Employee's work is judged by results	0.805	0.438	0.976
C16. Employee does not have enough prof. interaction	**0.000**	0.329	0.994
C17. Poor communication with employee	**0.000**	0.692	0.855
C18. Employee works effectively	**0.000**	0.073	0.820
C19. Administrative burden	**0.000**	0.275	0.593
C20. Security of confidential information	**0.000**	0.200	0.880

[1] Statements C21 and C22 appeared only in the after survey, and hence cannot be tested across waves.

[2] The numbers given are the p-values of the F-test for equality of means across workplaces. Values in boldface type are significant at $\alpha \leq 0.05$.

[3] The numbers given are the p-values of the F-test for equality of means across survey waves. Values in boldface type are significant at $\alpha \leq 0.05$.

[4] The numbers given are the p-values of the F-test for the interaction between the workplace and wave factors.

3.3.5 Potential Advantages of Telecommuting

In Part D of the survey, the perceptions of the supervisors themselves and their perceptions of their organizations' official views on the advantages of implementing telecommuting were obtained through a series of attitudinal statements using a four-point scale ("no opinion", "not significant", "moderately significant", and "extremely significant"). The survey instructions specifically requested the respondent to distinguish between "no opinion" and "not significant", where the latter in fact represents a considered opinion. While acknowledging that the distinction may sometimes be difficult to make in practice, the belief is that a high proportion of "no opinion" ratings on a given characteristic may indicate an undervalued advantage of telecommuting. This suggests that marketing strategies emphasizing those characteristics may help to raise the perceived value of telecommuting to management.

Table 3-21 lists the proportion of supervisors and organizations having no opinion on each of the 11 advantages named in Part D. From 6.5% to 22.6% of the organizations did not have opinions on certain potential advantages of telecommuting. In contrast, most of the supervisors had their own opinions on these statements. Assuming that supervisors' direct contact with the telecommuters affords them greater experience with the benefits of telecommuting than upper management would have, and assuming that supervisors were offering their own opinions with the good of the organization as a whole in mind, it would appear that a full awareness of the business advantages of telecommuting had not filtered up to the top levels in the organization. Obviously, such awareness on the part of organization decision-makers will be important if telecommuting is to expand.

Table 3-21: Percentage of Supervisors and Organizations with "No Opinion" on Advantages of Telecommuting

Advantages	Manager (N = 61)	Organization (N = 56)
D1. Improve employee retention	0	9.7%
D2. Save office space costs	0	8.1%
D3. Offer better customer service	1.6%	9.7%
D4. Improve ability to recruit employees	4.8%	14.5%
D5. Increase productivity	1.6%	11.3%
D6. Save parking costs	8.1%	17.7%
D7. Improve disaster response capability	21.0%	22.6%
D8. Reduce absenteeism	1.6%	12.9%
D9. Reduce health costs	12.9%	17.7%
D10. Comply with environmental regulations	9.7%	11.3%[1]
D11. Improve employee relations	0	6.5%

[1] N = 57

However, even supervisors had a relatively high "no opinion" rate on four advantages of telecommuting: an improved disaster response capability (21%), reduced health costs (13%), compliance with environmental regulations (10%), and saved parking costs (8%). This suggests the need to raise awareness of the potential benefits of telecommuting in these areas.

The remaining three points on the scale ("not significant" to "extremely significant") have an ordinal relationship to each other and were assigned values of 1, 2, and 3, respectively. The mean ratings on each advantage *for those who had an opinion* are shown in Table 3-22. According to the supervisors' average rating, six potential advantages are viewed as being at least moderately important following the introduction of center-based telecommuting: improved employee retention (D1), improved ability to recruit employees (D4), increased productivity (D5), compliance with environmental regulations (D10), improved employee relations (D11) and (marginally) reduced absenteeism (D8). Five potential advantages are viewed as being unimportant: savings on office space costs (D2), improved customer service (D3), savings on parking costs (D6), improved disaster response capability (D7), and reduced health costs (D9). The mean ratings for the organizations were statistically equal to or lower than the managers' ratings on every statement. In three cases, the differences were statistically significant: improve employee retention (D1), improve ability to recruit employees (D4), and improve employee relations (D11). Supervisors view these three characteristics as more important advantages of telecommuting than they think their organizations do.

Table 3-22: Average Ratings and T-test Results for Potential Advantages of Telecommuting in the After Survey

Statements (Sample Sizes)	Supervisor	Organization	P-value[1]
D1. Improve employee retention (61, 50)	2.05	1.74	**0.013**
D2. Save office space costs (61, 51)	1.49	1.41	0.705
D3. Offer better customer service (60, 50)	1.52	1.46	0.656
D4. Improve ability to recruit employees (58, 47)	1.83	1.60	**0.053**
D5. Increase productivity (60, 49)	2.10	1.86	0.082
D6. Save parking costs (56, 45)	1.36	1.40	0.729
D7. Improve disaster response capability (48, 42)	1.31	1.21	0.370
D8. Reduce absenteeism (60, 48)	1.75	1.56	0.114
D9. Reduce health costs (53, 45)	1.40	1.33	0.584
D10. Comply with environmental regulations (55, 50)	1.96	2.04	0.597
D11. Improve employee relations (61, 52)	2.28	1.92	**0.001**

[1] The numbers given are the p-values for the unpaired t-test for equality of means across the two management levels. Values in boldface type are significant at $\alpha \leq 0.05$.

3.3.6 Telecommuting as a Work Option

In Part E of the survey, supervisors were asked about their experience with telecommuting, the extent to which telecommuting may be adopted by the organization, and how desirable it may be for the employee. To assess the general level of support for telecommuting within the organization, the survey asked about the existence of formal policies and general attitudes toward telecommuting on the part of responding managers themselves, their immediate supervisors, and the organization as a whole. Among the 62 responses, 67.7% of the telecommuter managers themselves, 53.2% of their supervisors, and 56.5% of the organizations had formal policies supporting telecommuting. Twenty-seven percent of the respondents, 37.1% of their supervisors, and 32.3% of the organizations did not have formal policies on telecommuting. Two respondents thought that the organization had a formal policy *against* telecommuting. Six respondents (9.7%) did not know if there was a formal policy on telecommuting in the organization, and five (8.1%) did not know if their immediate supervisor had a formal policy.

When asked about the general attitude toward telecommuting, 88.7% of the sample had a positive response. However, that percentage dropped to 58.1% for their supervisors and to 56.5% at the organizational level. Two (3.2%) of the respondents themselves had negative attitudes toward telecommuting. Nearly 10% of the respondents' supervisors and nearly 10% of their organizations also had negative attitudes. Eight percent of the respondents, 25.8% of the respondents' supervisors, and 30.6% of the organizations held neutral opinions on telecommuting. Thus, the higher the management level, the less positive was the attitude toward telecommuting. Indeed, it appears that some managers were supporting telecommuting for their staff in the face of actively negative attitudes on the part of upper management.

To ascertain the respondents' experience in managing telecommuters, they were asked how long they had supervised telecommuting employees. Interestingly, on average, respondents had supervised center-based telecommuters for 15.4 months (a median of 12.0 months) and home-based telecommuters for 12.5 months (a median of 0 months). The average experience level with home-based telecommuters is low because there were 30 managers who did not indicate any such prior experience. Thus, including only the 23 managers who noted some experience in home-based telecommuting (there were 9 missing responses), they had on average supervised center-based telecommuters for 15.6 months (a median of 12.0 months) and home-based telecommuters for 28.8 months (a median of 18.0 months). This suggests that, in these cases, managers' prior experience with home-based telecommuting opened the door for employees to exercise the option to telecommute from a center.

When asked about the proportion of the organization's workforce allowed to telecommute from a center and from home within the next two years, nearly half of the respondents thought that it would increase for each form of telecommuting (43.5% and 45.2%, respectively). However, approximately 37% of respondents expected no change in the proportion of telecommuters at their organization.

Overall, 79% of the supervisors had a high or very high level of satisfaction with center-based telecommuting. The other twenty-one percent were neutral; none had low satisfaction with center-based telecommuting. With the center in its current state, nearly half of the respondents (48.4%) believed that the organization would be likely to offer center-based telecommuting to other employees. Although only five (8.1%) respondents thought that other employees were

unlikely to be offered the opportunity to telecommute from a center, 41.9% of the sample was unsure whether it would be made available to others.

When asked what, if anything, would need to change to make the organization likely to offer center-based telecommuting, the most frequently selected response (33.9%) was that "nothing more is needed, we are already likely to offer it". Other common responses included obtaining manager acceptance (31%), lowering the cost (26%), and having the ability to quantify the benefits to the organization (26%). Collectively, these three responses were cited as most important by 37% of the respondents. At least two of these three responses relate to justifying the cost of the center. Even though rental costs for using the center were partially or completely waived for many participants during the demonstration, managers were likely responding both to existing costs of other kinds (monetary and non-monetary) and to expected future rental costs in a post-demonstration environment. Thus, it appears as though cost-justification is a critical issue in increasing the acceptance of center-based telecommuting. Manager acceptance may still be an issue apart from cost-benefit considerations (that is, even if telecenters were demonstrably cost-effective, managers may have other considerations); however, acceptance is likely to increase as proof of the benefits of telecommuting (relative to costs) becomes stronger. Only 6.5% of the respondents said "nothing would make the organization likely to offer it."

Supervisors were asked about the ideal distribution of their employees' work time among alternative work locations. On average, they wanted their employees to spend 62% of the time at the regular workplace, 28% at the telecenter, 5% at home, and 5% at other locations such as client offices. Table 3-23 shows the distribution of responses among various workplace combinations and, for each combination, the average ideal distribution of work time at each location. The most frequently-chosen workplace combination was regular workplace and telecenter, which accounted for just over half of the responses. On average, under this workplace combination, the managers preferred their employees to spend about three-quarters of work time at the regular workplace and one quarter at the center. The second most common combination (about 30% of the responses) was regular workplace, telecenter and home, where the average work time was distributed 57.5%, 28.6% and 13.9%, respectively. Collectively, the results of Table 3-23 suggest that (1) the manager still felt that the regular workplace is the primary work location, to be used three or more days out of the work week, (2) the manager was willing for the employee to spend much more time at the center than at home (more than five times as much, on average), and (3) for nearly one-third of the managers, some mixture of center and home-based telecommuting was considered ideal.

A series of questions asked the supervisor about several aspects of the employee's telecommuting frequency from a center and from home. In contrast to a previous question in which respondents filled in blanks for the "percent of time" an employee would ideally spend at each location, responses to this series of questions consisted of categories ranging from "not at all" to "5 days a week". The first question in the series related to the nature of the employee's job and its suitability for telecommuting. The other questions asked for the current amount, the allowable amount, and the predicted amount of telecommuting of the employee.

Table 3-24 shows the distribution of responses to the four questions. About 65% of the respondents reported that their employees telecommuted from the telecenter at least one to two days per week. The distributions of the responses are similar for the four questions, suggesting that the responses are consistent across all four indicators of possible and actual telecommuting

frequency. Notably, however, the supervisors indicated that they would allow their employees to telecommute more frequently than the employees actually did (as well as more frequently than the job would allow). Looking six months into the future, the supervisors also expect that the amount of center-based telecommuting will remain approximately equivalent to current levels except that two managers thought their employees would not be telecommuting from the center at all. It is noteworthy that few managers expected their employees to be telecommuting from the center nearly full time. This is consistent with the result for the question regarding the ideal distribution of time across work locations.

Table 3-23: Supervisors' Distribution of Workplace Combinations and Ideal Distribution of Work Time (N = 61)

Workplace Combination	Number (Percent)	Mean Ideal Distribution of Time[1]			
		Regular Workplace	Telecenter	Home	Other Location
R	3 (4.9%)	100.0%	---	---	---
R/T	31 (50.8%)	73.5%	26.5%	---	---
R/T/H	18 (29.5%)	57.5%	28.6%	13.9%	---
R/T/O	2 (3.3%)	45.0%	25.0%	---	30.0%
T	2 (3.3%)	---	100.0%	---	---
T/H	1 (1.6%)	---	50.0%	50.0%	---
ALL	4 (6.6%)	15.0%	13.8 %	6.3 %	65.0%
Total	61 (100.0%)	61.7%	27.7%	5.3%	5.3%

[1] Workplace locations are the regular workplace (R), the telecommuting center (T), home (H), and other location (O).

Table 3-25 shows the mean telecommuting frequencies for the four categories based on the managers' responses. The calculation follows the method described in Section 3.2. The nature of the job allows employees to telecommute from a center about 1.8 days per week (36% of work days), on average. Although the permitted frequency is 42% (more than two days a week), the current rate and the expected future rate for center-based telecommuting are 32% and 34% of work days, respectively. It appears that the supervisors feel that employees are constrained in the amount of time that they can telecommute due to the nature of the job rather than due to the restrictions imposed by management.

Home-based telecommuting was not perceived as positively as center-based telecommuting with respect to job suitability and permitted frequency: only 37% of the managers thought that the nature of the job allowed their employees to telecommute from home at least one to two days per week; a similar number were willing for the employee to telecommute from home that often. Slightly more than half of the managers reported that their employees did not telecommute from home currently, and 43.5% of the managers did not expect their employees to be telecommuting

from home within the next six months. The results are consistent with prior hypotheses that center-based telecommuting could be superior to home-based telecommuting in terms of job suitability and manager acceptance (e.g., Bagley, *et al.*, 1994) but are at odds with other researchers' findings that telecenters are not viewed favorably by managers (Bernardino and Ben-Akiva, 1996). Clearly, the self-selection bias of this sample should be kept in mind when interpreting these results; that is, managers who are willing to participate in this project are more likely to have a positive view of telecenters than the general population of managers.

Table 3-24: Supervisor's Perception of Employee Telecommuting Frequency (N = 62)

	Not at All	Less Than Once a Month	About 1-3 Days a Month	1-2 Days a Week	3-4 Days a Week	5 Days a Week	Occa-sional Partial Days
From a Center							
Job	2 (3.2%)	0	13 (21.0%)	34 (54.8%)	7 (11.3%)	6 (9.7%)	0
Permit[1]	0	1 (1.6%)	6 (9.7%)	36 (58.1%)	12 (19.4%)	6 (9.7%)	0
Choice[2]	1 (1.6%)	4 (6.5%)	13 (21.0%)	30 (48.4%)	5 (8.1%)	5 (8.1%)	1 (1.6%)
Expect[3]	2 (3.2%)	1 (1.6%)	15 (24.2%)	30 (48.4%)	7 (11.3%)	5 (8.1%)	0
From Home							
Job[1]	13 (21.0%)	6 (9.7%)	11 (17.7%)	16 (25.8%)	5 (8.1%)	2 (3.2%)	8 (12.9%)
Permit[3]	14 (22.6%)	6 (9.7%)	13 (21.0%)	15 (24.2%)	5 (8.1%)	2 (3.2%)	5 (8.1%)
Choice[2]	33 (53.2%)	5 (8.1%)	7 (11.3%)	7 (11.3%)	4 (6.5%)	0	3 (4.8%)
Expect[3]	27 (43.5%)	5 (8.1%)	11 (17.7%)	8 (12.9%)	5 (8.1%)	0	4 (6.5%)

[1] N = 61 [2] N = 59 [3] N = 60

Survey Question Definitions

Job Considering the requirements of your employee's current job, how much do you think **the nature of the job** would allow him/her to telecommute . . . ?
Permit How much **would you allow** your employee to telecommute . . . ?
Choice How much does your employee **currently** telecommute . . . ?
Expect Six months from now, how much **do you expect** your employee to be telecommuting . . . ?

Table 3-25: Relative Telecommuting Frequency – Mean Supervisor Responses[1]

After	Percent of Work Week - Mean and Standard Deviation (N = 62)			
	Job	Permit	Choice	Expect
From a center	35.9% (27.4)	42.2% (26.7)[2]	31.8% (27.2)[3]	33.8% (27.3)[4]
From home	19.0% (25.1)[2]	19.0% (25.2)[4]	9.7% (19.0)[3]	11.8% (20.3)[4]

[1] See Table 3-12 for the values used in the frequency calculation and Table 3-24 for the definition of the categories.
[2] N = 61 [3] N = 59 [4] N = 60

3.3.7 Summary of Manager Responses

This section summarizes the survey results from the supervisors of 62 center-based telecommuters. On the whole, the respondents reported an optimistic and positive attitude toward telecommuting. The analysis showed clearly that supervisors' opinions of the performance of their employees did not diminish with the introduction of telecommuting.

Characteristics dealing with the workplace atmosphere (such as motivation, professional appearance, and distractions) were considered to be similar at both the regular workplace and the telecenter. Areas in which the center was perceived less positively than the regular workplace concerned the supervisor-employee relationship (such as communication, availability, professional interaction, and administrative burden) as well as security of information and property. However, mean ratings for the telecenter on these characteristics were all neutral or better, indicating that the disadvantage is relative, not absolute. These attitudes seem to be generic to telecommuting in general since they tended to be even less favorable for home-based telecommuting.

Nearly all of the managers (89%) indicated having a positive attitude toward telecommuting in general, and 79% rated their level of satisfaction with center-based telecommuting as high or very high. A selection bias in these results must be noted, as managers who were dissatisfied with telecommuting would be less likely to have lasted long enough to complete an after survey. However, the exit interviews from managers indicate that even those managers whose employees quit telecommuting had a positive attitude toward telecommuting in general (91% of 90 responses) and had a high or very high satisfaction with center-based telecommuting specifically (66% of 89 responses) (see Section 5.4). Six potential advantages were viewed by managers to be at least moderately significant following the introduction of center-based telecommuting: improved employee retention, improved ability to recruit employees, increased productivity, compliance with environmental regulation, improved employee relations, and (marginally) reduced absenteeism. However, from 8% to 21% of the managers reported "no opinion" on the four following potential advantages of telecommuting: savings on parking costs, reduced health costs, compliance with environmental regulations, and improved disaster response capability. This suggests the need to raise awareness of the potential benefits of telecommuting in these areas.

It is an important result that the perceived advantages of telecommuting are those for which the benefit is difficult to quantify (customer service and productivity), while telecommuting is not perceived to offer advantages on "hard" money items such as office space and parking costs. This will continue to make center-based telecommuting difficult to justify in purely economic terms. Indeed, while nearly half (48%) of the respondents indicated that the organization was likely to (continue to) offer center-based telecommuting, more than a third (37%) cited reduced costs, the ability to quantify the benefits, and increased manager acceptance as factors that needed to change before the organization would be likely to offer center-based telecommuting.

About half of the managers expected that more of the organization's workforce would be telecommuting from a center in the future. However, from 8% to 23% of the organizations themselves did not have official opinions on various potential advantages of telecommuting according to the respondents. When opinions by the management levels above the supervisors were expressed, they tended to be less positive than those of the supervisors. Indeed, it appears that some managers were supporting telecommuting for their staff in the face of actively negative

attitudes on the part of upper management. This suggests the need for upper-level management to have increased exposure to the benefits of telecommuting.

Although the employees performed well at the telecenter and even better than they did at the regular workplace in some respects, managers still preferred telecommuting to be a part-time alternative for their employees. Very few managers expected their employees to be telecommuting from the center full-time. The managers' average ideal distribution of work time for their employees included nearly 62% at the regular workplace and 28% for center-based telecommuting. The current and the expected future telecommuting frequencies of 32% and 34% of work days, respectively (which is equivalent to 1.6 and 1.7 days per week) are consistent with the managers' ideal work time distribution. However, in the managers' perception, the appropriate telecommuting frequency for their employees was more constrained by job suitability (36% of work days on average) than by the managers' willingness (42% of work days). In any case, the managers still felt that the regular workplace is the primary work location, to be used three or more days out of the work week.

Home-based telecommuting was not perceived as positively as center-based telecommuting with respect to job suitability and permitted frequency, although the self-selection bias of the sample must be taken into account in interpreting this result. The managers were willing for the employees to telecommute more than five times as much from the center as from home. Also, some mixture of center and home-based telecommuting was considered ideal by nearly one-third of the managers.

This expectation of part-time telecommuting may act to inhibit the adoption of telecommuting centers. If employees are only using the center one or two days per week, there may be little opportunity for their space at the regular workplace to be used for other purposes. If an organization must continue to offer the same amount of space at the regular workplace as before, plus pay rent on space at the telecenter, other telecommuting advantages will have to be that much stronger to compensate for the added cost.

3.4 Comparison of Employee and Manager Results

As can be seen from the preceding sections, the employee and manager surveys were designed such that the responses to certain questions could be compared between the two groups. These questions include job performance and satisfaction, attitudes on work characteristics, and the amount of telecommuting. There are a total of 69 employees and 62 manager responses in the after telecenter data set (see Table 3-1) of which there are 47 employee-manager pairs (for which each telecenter user is matched with his/her supervisor). In this section we compare responses between groups for the 47 pairs.

3.4.1 Job Performance and Satisfaction

Similar questions were asked of both the employees and the managers about employee job performance and job satisfaction. For the characteristics of job performance, two comparisons can be made between the employee and manager results (see Table 3-26). A direct comparison of the employee's average assessment of his/her performance and the manager's average assessment shows only slight differences. For three of the four factors, the employees rated themselves higher than their managers did. For the remaining factor, the ability to meet

deadlines, the employees rated themselves lower than the managers did. Nevertheless, a t-test of the means showed that none of the differences were significant at the 0.05 level (see Table J-1, Appendix J). An additional comparison can be made between the employee's perception of the supervisor's assessment and the supervisor's actual assessment. Again, there were only slight variations between the two averages for each factor; however, the values were generally closer together than in the first comparison (meaning that employees had an accurate perception of their supervisor's assessment of them). None of the comparisons were significantly different at the 0.05 level according to a t-test of the means (see Table J-2, Appendix J).

Table 3-26: Comparison of Job Performance (N = 47)

Attribute	Rating (Mean and Standard Deviation)		
	Employee		Manager
	Assessment	Supervisor's Assessment	Assessment
Amount of work completed	4.35 (0.53)	4.30 (0.55)	4.28 (0.72)
Quality of work	4.50 (0.51)	4.41 (0.54)	4.43 (0.65)
Ability to meet deadlines	4.33 (0.79)	4.35 (0.64)	4.39 (0.65)
Overall productivity	4.39 (0.49)	4.33 (0.52)	4.33 (0.70)

The majority of the average ratings on the factors of job satisfaction are also similar between both telecenter users and managers of telecenter users (see Table 3-27). However, three factors show significant differences. First, managers were more pleased with the communication they have with their employees than vice versa. Second, managers were more likely to be satisfied with the availability of resources for completing tasks than employees were. The first result is not surprising since supervisors often perceive communication barriers to be less of a problem than their employees do. Likewise, the second result is not particularly startling given that employees must deal with resource availability problems more often than their supervisors have to. Third, surprisingly, employees had a higher average rating for the supervisor showing appreciation than the supervisors had. Perhaps supervisors feel they need to work at this part of their job more than they actually need to.

3.4.2 Work Environment Characteristics

Both the employee and manager versions of the survey contain a section about work environment characteristics. These two sections have 15 questions (on each of three locations: home, telecenter, and regular workplace) in common. The mean ratings for each set of questions are shown in Figure J-1, Appendix J. Rather than discuss the differences in the 45 means, this section will focus on a comparison of the ANOVA results.

A two-way analysis of variance was conducted for each set of work characteristic questions to determine if the response for each question differed significantly between employee and supervisor, and across the three work locations (see Sections 3.2.4 and 3.3.4). The results are shown in Table 3-28. Similar to the results for employees only in Section 3.2.4, the effect of the workplace factor is significant for most of the statements except for supervisor comfortable and

work judged by results. For the status factor, the mean ratings are statistically different at the 0.05 level for the following five statements: would not overeat or indulge, relative independence, work while sick or disabled, scheduling freedom, and work judged by results. That is, the employees' and supervisors' attitudes on these statements are significantly different according to an F-test for equality of the means.

Table 3-27: Comparison of Job Satisfaction Ratings (N = 47)

Statement	Rating (Mean and Standard Deviation)			
	Employee	Manager	T-statistic[5]	P-value[5]
Supervisor/employee communication[1]	4.04 (1.06)	4.40 (0.58)	**2.313**	**0.025**
No lack of resources for employee[1]	3.62 (1.11)	4.06 (0.67)	**2.605**	**0.012**
Employee's work team is effective[2]	3.78 (0.88)	3.84 (0.90)	0.358	0.722
Work well with supervisor/employee	4.11 (0.87)	4.23 (0.76)	0.799	0.429
Supervisor shows appreciation for employee[1]	4.02 (1.07)	3.15 (1.00)	**-4.393**	**0.000**
Employee works well with co-workers[1]	4.38 (0.85)	4.34 (0.67)	-0.269	0.789
Confidence in employee's ability to do the job	4.55 (0.50)	4.53 (0.55)	-0.206	0.837
Likelihood of employee to stay at the job[1]	3.81 (1.12)	3.79 (0.86)	-0.129	0.898
Employee works well with those supervised[3]	4.20 (0.63)	4.40 (0.70)	0.688	0.509
Client demands on employee's time[1, 4]	3.48 (0.77)	3.20 (0.76)	-1.572	0.129

[1] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.
[2] N = 45 [3] N = 10 [4] N = 25
[5] Significantly differing means at a level of significance of 0.05 are marked in boldface type.

Figure J-1, Appendix J shows the plots of the mean ratings for all statements, including the five that were statistically different for the status factor (statements 5, 6, 10, 11, and 12). Supervisors were more confident that the employees would not overeat or indulge in ways detrimental to their health than the employees themselves were. Both managers and employees believed, on average, that working at all three locations provided employees with relative independence, but a notable difference was seen at the regular workplace where employees felt that they would not have as much independence as their managers believed. Employees disagreed with their supervisors' views that they would be able to work from the telecenter or regular workplace while sick or disabled. Interestingly, employees rated their ability to work from home while sick or disabled more highly than did their supervisors. This seems to suggest that employees may be willing to work while in poor health as long as they do not have to deal with the commute to a workplace. In general, scheduling flexibility was rated more highly by managers (especially at the regular workplace) than by their employees. Whether employees worked at home, telecenter, or the regular worksite, they were less confident that their work would be judged by results than their

managers indicated. Supervisors' mean ratings for this statement were relatively close to one another across the three work locations, as were employees' ratings. This suggests that employees believe factors other than their work location are used by the managers to judge their work.

Table 3-28: Two-way ANOVA Results for Employees' and Supervisors' Attitudes toward Different Work Environments in the After Survey (N = 282)[4]

Statements	Workplace Factor[1]	Status Factor[2]	Inter-action[3]
1. Easy to be motivated	**0.000**	0.176	0.094
2. Supervisor comfortable	0.198	0.861	**0.000**
3. Professional appearance	**0.024**	0.432	**0.000**
4. Distractions from others not a problem	**0.000**	0.439	**0.000**
5. Would not overeat or indulge	**0.002**	**0.000**	**0.001**
6. Relative independence	**0.000**	**0.005**	0.074
7. Good for the environment	**0.000**	0.892	**0.000**
8. Visible to management	**0.000**	0.072	0.957
9. Have needed equipment	**0.000**	0.424	0.482
10. Work while sick or disabled[5]	**0.000**	**0.000**	**0.000**
11. Scheduling freedom	**0.000**	**0.023**	0.126
12. Work judged by results	0.500	**0.000**	0.448
13. Professional interaction[6]	**0.000**	0.788	0.147
14. Supervisor communication not a problem	**0.000**	0.468	0.341
15. Work effectively	**0.000**	0.881	0.473

[1] The numbers given are the p-values of the F-test for equality of means across workplaces. Values in boldface type are significant at $\alpha \leq 0.05$.

[2] The numbers given are the p-values of the F-test for equality of means between the employee group and the manager group. Values in boldface type are significant at $\alpha \leq 0.05$.

[3] The numbers given are the p-values of the F-test for the interaction between the workplace and status factors. Values in boldface type are significant at $\alpha \leq 0.05$.

[4] Ratings by each of 47 employees and their managers on each of three workplaces (47 x 2 x 3).

[5] N = 281 [6] N = 279

Five statements have significant interaction effects between the workplace and respondent factors, in conjunction with at least one significant main effect: professional appearance, distractions from others not a problem, would not overeat or indulge, good for the environment, and work while sick or disabled. The nature of the interaction can be discerned by examining Figure J-1. For example, perhaps naturally, employees were more concerned about distractions being a

problem at the regular workplace than at home, whereas the reverse was true for their managers. On the other hand, employees were significantly more concerned about overeating or indulging from home than from the other two locations, whereas managers were about equally confident it wouldn't be a problem at all three locations.

3.4.3 Amount of Telecommuting

Perhaps not surprisingly, employees and managers have different ideal distributions of the time spent at work. Although both groups chose the regular workplace as the most frequently-used worksite, telecenter users allocated only 45.5%, while managers assigned 58.5% of the work time. The telecommuting center received a much higher percentage, on average, from the employees (44.6%) than from the managers (31.4%), which suggests that managers restrict the employees from telecommuting as much as they would like. Home had similar proportions of work time at 6.9% from employees and 6.1% from managers, respectively. Finally, the percentage of time assigned to other locations was also similar between groups (3% from employees and 4% from managers).

The ideal distribution responses also give the combinations of workplaces preferred by respondents (see Table 3-29). There is remarkable agreement between the two groups at this level. Working at the regular workplace and telecenter is the most popular arrangement for both (51% and 49% of employees and managers, respectively) and working at home in addition to the previous two locations is the second most popular option for both (26% and 30%). Working at all the locations is more popular for employees than for managers (8.5% and 4.3%), as is working only at the telecenter (6.4% and 4.3%).

Table 3-29: Comparison of the Distribution of Workplace Combinations (N = 47)

Workplace Combination[1]	Employees	Managers
R/T	24 (51.1%)	23 (48.9%)
R/T/H	12 (25.5%)	14 (29.8%)
R/T/O	1 (2.1%)	2 (4.3%)
ALL	4 (8.5%)	2 (4.3%)
R	0	2 (4.3%)
T	3 (6.4%)	2 (4.3%)
T/H	2 (4.3%)	1 (2.1%)
R/H	1 (2.1%)	0
T/H/O	0	0
Missing	0	1 (2.1%)

[1] Workplace locations are the regular workplace (R), the telecommuting center (T), home (H), and other location (O).

The relative telecommuting frequency for various circumstances can also be compared between employees and supervisors (Table 3-30). The average manager and employee responses for telecommuting from a center are similar for all questions except the first. Managers said that the nature of the job would only allow working at the telecenter for 39% of the time on average, while employees felt that their jobs permitted center-based telecommuting for 43% of their time. A t-test of the means for telecommuting from a center shows that none of the differences in average frequency between employees and managers were statistically significant at the 0.05 level (see Table J-3, Appendix J).

For home-based telecommuting, however, the average frequencies of the supervisors were lower than those of the telecenter users for all categories. So, while it seems that these supervisors have embraced telecommuting from a center, they are still somewhat hesitant to approve telecommuting from home. A t-test of the means for home-based telecommuting shows that the means for the nature of the job and the supervisor/permit categories were significantly different at the 0.05 level between the employees and the managers (see Table J-3, Appendix J). It is plausible to find that employees consider the nature of their job to be less of a constraint than their managers do, and that employees think that their managers would allow them to telecommute from home more often than their managers actually would. Employees are likely to be more optimistic than their more conservative managers regarding the extent to which they could and should be allowed to telecommute. In some cases this is due to the employee having a greater motivation to telecommute than the manager has to allow them; in other cases it may be due to the employee's more accurate knowledge of the nature of his/her job.

Table 3-30: Comparison of Telecommuting Frequency Assessments (N = 47)

Question[1]	Percent of Work Week - Mean and Standard Deviation			
	Employees		Managers	
	From a Center	From Home	From a Center	From Home [5]
Job	43.1% (30.2)	29.0% (31.6)	38.7% (29.9)	**19.5% (26.7)[3]**
Supervisor/permit	42.7% (32.4)	26.0% (32.7)	44.3% (27.1)[3]	**16.8% (22.8)[2]**
Choice	33.7% (32.5)	11.0% (23.9)[2]	35.2% (29.3)[3]	7.8% (16.7)[4]
Prefer (emp. only)	48.4% (30.5)	23.1% (30.7)[3]	---	---
Expect	35.2% (30.3)	13.5% (28.1)[3]	37.3% (29.0)[3]	9.9% (16.8)[2]

[1] See Tables 3-12 and 3-24 for the text of the survey questions.
[2] N = 45 [3] N = 46 [4] N = 44
[5] Bolded manager means are significantly different from the corresponding employee means at $\alpha \leq 0.05$. See Table J-3, Appendix J for the test statistics.

3.4.4 Summary of Employee-Manager Comparison

This section summarizes the comparison of the responses from 47 center-based telecommuters and their managers. Not surprisingly, the preferred amount of telecommuting differs between

employees and managers. On average, employees would ideally work less of their time at the regular workplace (45.5%) and more at the telecommuting center (44.6%) than managers would prefer them to (58.5% and 31.4% at the regular workplace and telecenter, respectively). Working at the main office and the telecenter proved to be the most preferred combination of workplaces for both groups. On average, employees believed that their jobs permitted more frequent center-based telecommuting (43%) than their managers did (39%). Although some of the telecommuting frequency averages are similar for employees and managers, the managers select lower telecommuting amounts when there are substantial differences between the two.

Responses for similar job performance and satisfaction questions were mostly similar for both study groups. The three job satisfaction factors that had significant differences were supervisor-employee communication, resource availability, and supervisor appreciation. Employees were less satisfied on the first two job factors and more satisfied on the remaining factor than the managers were.

A two-way analysis of variance showed significant differences between employees and supervisors and across the three work locations for 15 work environment characteristics. The effect of the workplace location was significant for all of the statements except for supervisor comfortable and work judged by results. Similar to the results for employees only, the effect of the status factor showed that supervisors were more confident than employees regarding employee overeating and indulging and also rated their employees as having more independence at the regular workplace than their employees did. Moreover, scheduling flexibility factors such as working while sick or disabled and scheduling freedom tended to be rated more highly by the managers than by their employees. Finally, on average, employees were less inclined than their managers to believe that their work would be judged by its results.

T-tests showed that employees and managers did not differ significantly on the mean frequency of center-based telecommuting allowed by the job or by the manager, chosen by the employee, or expected six months later. However, for home-based telecommuting, employees believed their jobs and their managers to permit telecommuting more frequently than their managers actually did.

CHAPTER 4

TELECOMMUTING PATTERNS

4. TELECOMMUTING PATTERNS

4.1 Introduction

Though many studies have examined attitudes toward telecommuting (Mokhtarian, *et al.*, 1996), preference for telecommuting (Mokhtarian and Salomon, 1997; Stanek and Mokhtarian, 1997; Bagley and Mokhtarian, 1997), choice of telecommuting (Mokhtarian and Salomon, 1996; Bernardino, *et al.*, 1993; Mahmassani, *et al.*, 1993), and characteristics of telecommuters (Hartman, *et al.*, 1991; Yap and Tng, 1990), few studies to date have attempted to explore patterns of telecommuting behavior in detail. Questions of interest include how often individuals telecommute, the duration of their telecommuting participation, how much time they spend at the telecenter, how they distribute their telecommuting across days of the week, and how they distribute their time over various work locations on a given day.

It is useful to analyze these types of questions both at the disaggregate and aggregate levels. At the disaggregate level, analyzing telecommuting behavior provides further insight into individual choice patterns, and offers the potential for building models to explain and predict those choices. On the aggregate (site specific and all sites combined) level, such an analysis will support the evaluation of the centers' operational performance, the development of marketing strategies, and the recruitment of participants.

The following section discusses data collection and cleaning procedures. Section 4.3 presents the aggregate analysis of telecommuting patterns, including: utilization of the telecenter, distribution of telecenter occasions by day of the week, work time spent at the telecenter, workplace combinations on telecommuting days, and mode of travel to the telecenter. Section 4.4 offers a disaggregate analysis of telecommuting patterns, including telecommuting duration, telecommuting frequency, proportion of telecenter-only working days, individual work time spent at the telecenter, and mode choice to the telecenter. Section 4.5 summarizes the key findings of the chapter.

4.2 Data Collection and Cleaning

4.2.1 Data Collection

The information was collected at the telecenters participating in the project. Telecommuters were instructed to make an entry in the attendance log each day they used the telecenter. The entry included date, name, transportation mode used to get to the telecenter, and estimated work time to be spent at various workplaces, including telecenter, main office, home, and any other work location. An example attendance log sheet is found in Appendix D.

To the extent participants forgot or declined to sign in at each use, these data may somewhat undercount the usage of the telecenter by telecommuters. However, site administrators had an incentive to ensure the most accurate reporting possible, as occupancy levels were calculated based on the sign-in data and each site had a contractual obligation to meet certain occupancy levels. In addition, other uses of each telecenter occurred which were not captured by the attendance log (see Section 2.3).

For this report, sign-in data collected through June 30, 1996 from 15 telecenters (13 RABO sites and 2 non-RABO sites) were analyzed. However, the Vacaville - Ulatis, Modesto, and La Mesa sites were closed before this date, and for Davis and Anaheim, no data were available after January

and March 1995, respectively. Table 4-1 lists the availability of attendance log data at the RABO and non-RABO telecenters that provided attendance data. Fifty-four percent of the data came from the two non-RABO sites since they had been operating for a longer period. The data availability by site is shown in Table 4-2. The information from the non-RABO telecenter in Ontario dominates the overall data with 34.5% of all telecommuting occasions. Among the information gathered from the 13 RABO sites, more than one-third of the data come from the telecenters in Grass Valley and Chula Vista (on H St.). The amount of data produced by each site depends on (1) the operating length of the center, (2) the number of telecommuters, and (3) the frequency of use by each telecommuter. However, the telecommuting frequency of the users in some cases plays the dominant role among these three factors. Comparing the sites of Coronado and Grass Valley, for example, although Coronado was open longer and had more users, Grass Valley had almost twice as many telecommuting occasions. A similar observation can be made comparing the sites of Vacaville (Alamo) and Chula Vista (H St.).

Table 4-1: Data Availability

Group	Number of Occasions[1]	Number of Users	Number of Workstations
RABO sites	4,862 (46.0%)	153	104
Non-RABO sites	5,713 (54.0%)	213	30 (24[2])
Total	10,575 (100%)	367	134 (128[2])

[1] Denotes total number of person-day telecommuting occasions.
[2] At the Ontario center, the number of workstations decreased by six on March 1, 1994.

4.2.2 Data Cleaning

Each telecommuter was expected to sign in once for each telecommuting occasion. However, even after correcting data entry errors, double entries in the data set occurred due to the following reasons: (1) the telecommuter signed in twice on the same day (this may be the result of the telecommuter returning to the telecenter later in the day and forgetting that s/he had signed in already) or (2) the telecommuter attended two different telecenters on the same day.

Several rules were defined to process these unusual cases:

- If the two entries made on the same day by an individual were identical, one of them was eliminated. In the original data set, 47 cases (0.4% of RABO and non-RABO cases combined) fell into this category.
- If the two attendance log entries were for the same telecenter and different from each other, the one with the longer work time spent at the telecenter was preserved. It is assumed that the longer duration was the sum of work time for the two visits. Seven such cases were found in the original data set.
- For the occasions on which a telecommuter signed in at two different telecenters on the same day, both records were preserved for aggregate analyses of measures such as site occupancy rate. However, for the disaggregate analysis of indicators such as telecommuting frequency, the one with longer time spent at the telecenter was selected. Six of these cases were found.

Table 4-2: Data Availability by Site

Site	Start Date	End Date	Number of Weeks	Number of Occasions[1]	Number of Users	Number of Workstations
Coronado	11/01/93	06/30/96	138.9	452 (4.2%)	17	4
Grass Valley	02/08/94	06/30/96	124.7	819 (7.7%)	13	6
Anaheim	06/30/94	03/01/95	34.9	108 (1.0%)	10	15
Vacaville - Alamo	07/01/94	06/30/96	104.3	514 (4.8%)	29	8
Vacaville - Ulatis	08/01/94	06/30/95	47.6	229 (2.2%)	27	7
Davis	08/11/94	01/12/95	22.0	15 (0.1%)	4	10
Chula Vista - H St.	09/19/94	06/30/96	92.9	880 (8.3%)	19	10
Modesto	10/18/94	10/27/95	53.4	262 (2.5%)	10	10
Chula Vista - F St.	11/01/94	06/30/96	86.7	493 (4.7%)	12	8
Ventura Community College	02/01/95	06/30/96	73.6	481 (4.5%)	11	5
La Mesa	03/07/95	06/30/95	16.4	36 (0.3%)	5	6
Moorpark Community College	04/17/95	06/30/96	62.9	469 (4.4%)	6	5
San Juan Capistrano	02/18/96	06/30/96	20.5	104 (1.0%)	5	10
Ontario	11/27/91	06/26/96	237.0	3,644 (34.5%)	190	24 (18[2])
Highland	12/08/92	06/30/96	185.7	2,069 (19.6%)	23	6
Total			1,301.5	10,575 (100%)	367[3]	134 (128[2])

[1] Denotes total number of person-day telecommuting occasions.
[2] Eighteen workstations were available after March 1, 1994.
[3] Denotes total number of individuals: 13 telecommuters used both of the Vacaville telecenters and 1 telecommuter used both of the Chula Vista telecenters. They are counted under each site but not double-counted in the total.

Some entries in the data set were missing. The non-RABO sites of Highland and Ontario did not begin using the attendance logs designed by this project until February 1, 1994 and September 1, 1994, respectively. Prior to these dates, those sites obtained sign-in and sign-out times for each telecommuter but did not request information on transportation mode used to get to the telecenter nor on the distribution of work time at locations other than the telecenter. Thus, this information was not available for 2774 (48.6%) of the 5713 telecommuting occasions recorded in Table 4-1. Among these 5713 occasions, even the information on work time at the telecenter was missing for 1580 cases (27.7%).

Among the 4862 entries from RABO sites, the information associated with transportation mode and distribution of work time was missing for 191 (3.9%) and 26 (0.5%) of the cases, respectively. Among the 2939 entries from non-RABO sites using the attendance logs designed for this project, the information about transportation mode and distribution of work time was missing for 175 (6%) and 148 (5%) of the cases, respectively. The amount of missing data associated with the information for each site is shown in Table 4-3. Finally, attendance logs for some months are missing from some telecenters because the site administrators failed to provide the information: specifically August 1993 for Ontario; January 1994 and December 1995 for Highland; September and October 1994 for Davis; and August 1995 for Modesto. No attempt was made to estimate the number of telecommuting occasions or any other information for these months.

Table 4-3: Proportion of Missing Information for Each Site

Site	N[1]	Missing Work Time Data	Missing Travel Mode Data
Coronado	452	0.9%	1.8%
Grass Valley	819	0	2.0%
Anaheim	108	0	2.8%
Vacaville - Alamo	514	0.6%	4.5%
Vacaville - Ulatis	229	3.0%	1.7%
Davis	15	0	0
Chula Vista - H St.	880	0.6%	5.2%
Modesto	262	0.4%	3.1%
Chula Vista - F St.	493	0.2%	6.9%
Ventura Community College	481	1.0%	6.3%
La Mesa	36	0	0
Moorpark Community College	469	0	3.8%
San Juan Capistrano	104	0	1.0%
Ontario	1229	8.5%	6.7%
Highland	1710	2.5%	5.4%

[1] N is the total number of telecommuting occasions.

4.3 Aggregate Analysis

In this section, aggregate telecommuting patterns both across all sites combined and by each site separately are presented. The following five sections respectively discuss utilization of the telecenter, distribution of telecenter occasions by day of the week, work time spent at the telecenter, workplace combinations on telecommuting days, and means of travel to the telecenter.

4.3.1 Utilization of the Telecenter

To evaluate the operational performance of telecenters, one must develop a method to express how the facilities were utilized. The total number of telecommuting occasions is not an adequate measure because the telecenters are of different sizes. Thus, the largest number of occasions is likely to occur at the telecenters equipped with the most workstations. To control for differing sizes, two measures of telecenter utilization, the usage rate and the occupancy rate, were developed.

The monthly telecenter usage rate is the total number of occasions (person-days) on which the center was used for telecommuting, divided by the product of the number of workstations and the number of working days in the month:

$$\text{usage rate} = \frac{\text{number of telecommuting occasions}}{\text{number of workstations x number of work days}} . \qquad (4.1)$$

The monthly telecenter occupancy rate is calculated as the number of telecommuting occasions that are at least four hours long divided by the same denominator:

$$\text{occupancy rate} = \frac{\text{number of telecommuting occasions of at least 4 hours}}{\text{number of workstations x number of work days}} . \qquad (4.2)$$

That is, the usage rate is the proportion of "workspace-days" for which the center was used for any length of time (for telecommuting), and the occupancy rate is the proportion of workspace-days for which it was occupied at least four hours. These formulas draw on the concepts of exposure as used in accident studies. The denominator in equation 4.1 could be interpreted as the total number of possible opportunities for telecommuters to be exposed to the telecenter.

The total number of working days is adopted instead of the total number of days in the month because we are focusing on telecommuting as a substitution for commuting to the office on a normal working day. For the purposes of this analysis, "working days" excludes Saturdays, Sundays and eight federal holidays (New Year's Day, Martin Luther King Jr.'s Birthday, President's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas). For the aggregate analysis presented here in Section 4.3, if the initial observation for a *center* did not coincide with the first day of the month, only working days from the first telecommuting occasion onward were included in the usage and occupancy rates calculated for that first month of operation. For the disaggregate analysis presented in Section 4.4, if the initial observation for an *individual* did not coincide with the first day of the month, only working days from the first telecommuting occasion onward were included in the corresponding calculation for that individual.

Figure 4-1 shows the average usage and occupancy rates across all RABO sites, from the opening of the first site (Coronado) in November 1993 through June 1996. The trend varies considerably over time. Several reasons make it difficult to explain or predict the variation. First, the telecenters opened at different times. Since a center will typically open with relatively low usage and then build up over time, entry of a new site into the calculation tends to depress the average. (The bottom line on Figure 4-1 indicates how many sites were open each month, that is, the number of sites over which the average rates were calculated). Further, the size of each center also affects usage and occupancy rates. Fifty telecommuting occasions in a week would represent 100% usage for a 10-workstation site, but only 50% usage for a site with 20 workstations. Finally, the rates also change according to the number of telecommuters at the site in that month, as well as the number of their telecommuting occasions. Some telecommuters quit telecommuting, some newly joined, and some did not telecommute during certain months.

In spite of these factors, a couple of tentative observations may be made. First, the rates appear to have stabilized somewhat after Febuary 1995, although it should be noted that the eventual closure of some lightly-used centers contributed to keeping the average higher than it would have been if those centers had remained open. The average usage rates generally ranged between 15 and 25%. The occupancy rates were somewhat lower, ranging from 10 to 20%. Secondly, there does appear to be a seasonal effect, specifically a "summer slump". The dip in the summer of 1994 is partially confounded by the entry of four new sites, but the trend (based on only two sites) appears to have pre-dated those new openings. A dip also appears in the summer of 1995 based on 8-10 sites which had been operating for some time at that point. Therefore, the summer slump as a seasonal effect for telecenter usage may exist.

To control for the confounding factor of sites opening at different times, average usage and occupancy rates were then computed based on the number of months a site had been open. Note, however, that this introduces the confounding factor of seasonality. That is, the summer and winter holiday seasons will occur after a differing number of months of operation for each center, so it would not be easy to separate out those effects. The only way to control for both start-up and seasonal effects would be to extend the time period of observation well past the point at which start-up effects would be negligible for all sites and then look at the average rates on a calendar-month basis as in Figure 4-1. Unfortunately, most sites did not have sufficient data to permit such an analysis.

Figure 4-2 shows the average usage and occupancy rates for the first 18 months of operation across all RABO sites. The average usage rate begins at 8% in the first month of operation, rises to a high of 25% after 14 months, and then drops to 18%. The average occupancy rate shows a similar pattern, rising from 6 to 18% and then falling to 15% over the same period. The trends initially show slow but steady growth in the utilization of the telecenters, but the drop after 14 months of operation is troubling. It suggests that after an initial push to recruit participants, marketing efforts are not keeping pace with attrition. As shown in Figure 4-3, the individual usage rates demonstrate significant variation not only between sites but also at each site.

Figure 4-4 shows the individual usage rates at non-RABO sites. The center in Ontario maintained roughly steady usage rates between 10 to 20%. In contrast, Highland had a relatively high utilization, especially over the last few months of observation (from 40 to 70%). However, this relatively high usage was due to (1) the small number of workstations (six) compared to Ontario (24 or 18); and (2) the fact that several telecommuters, including a real estate agent, used the center

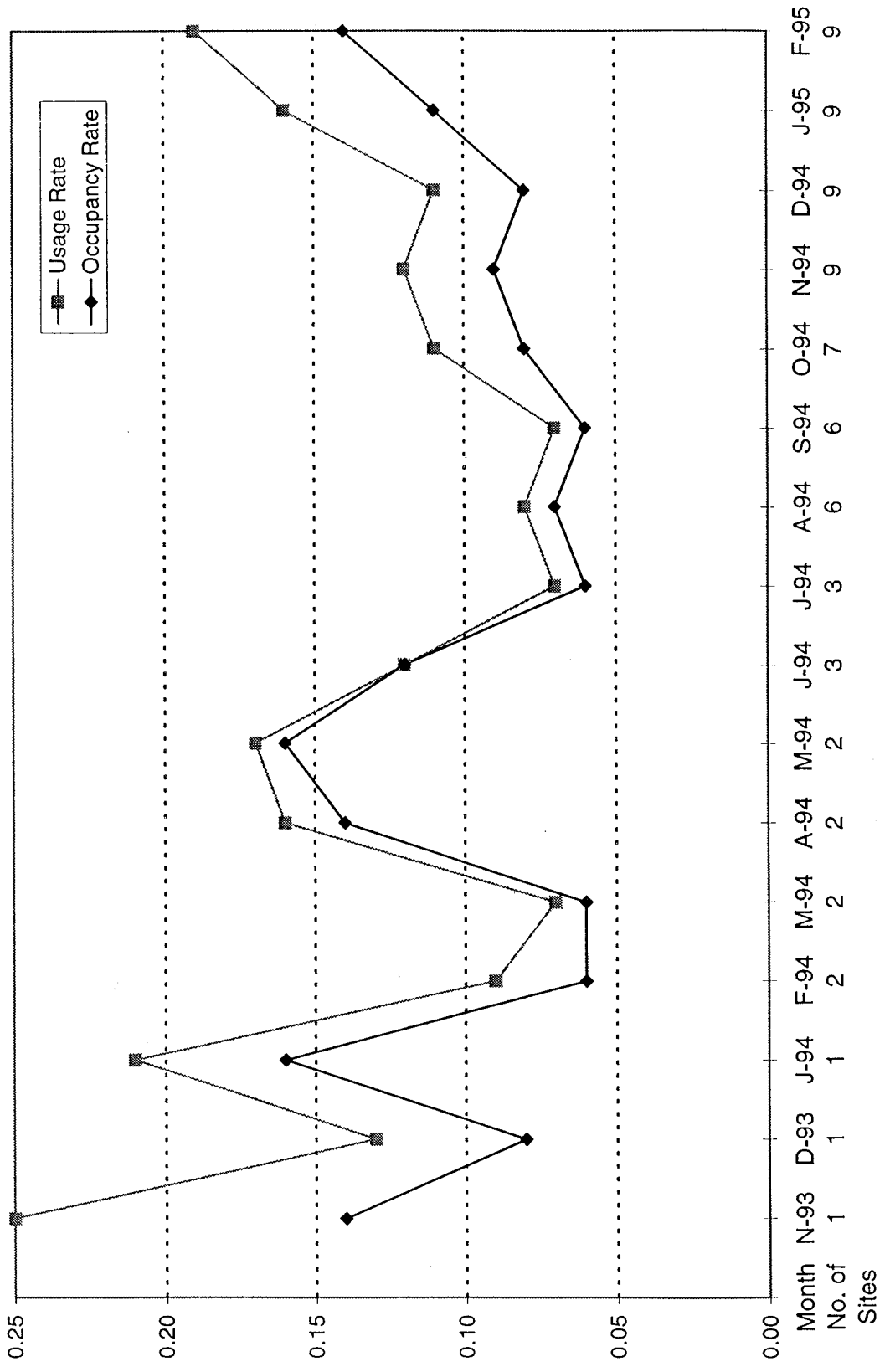
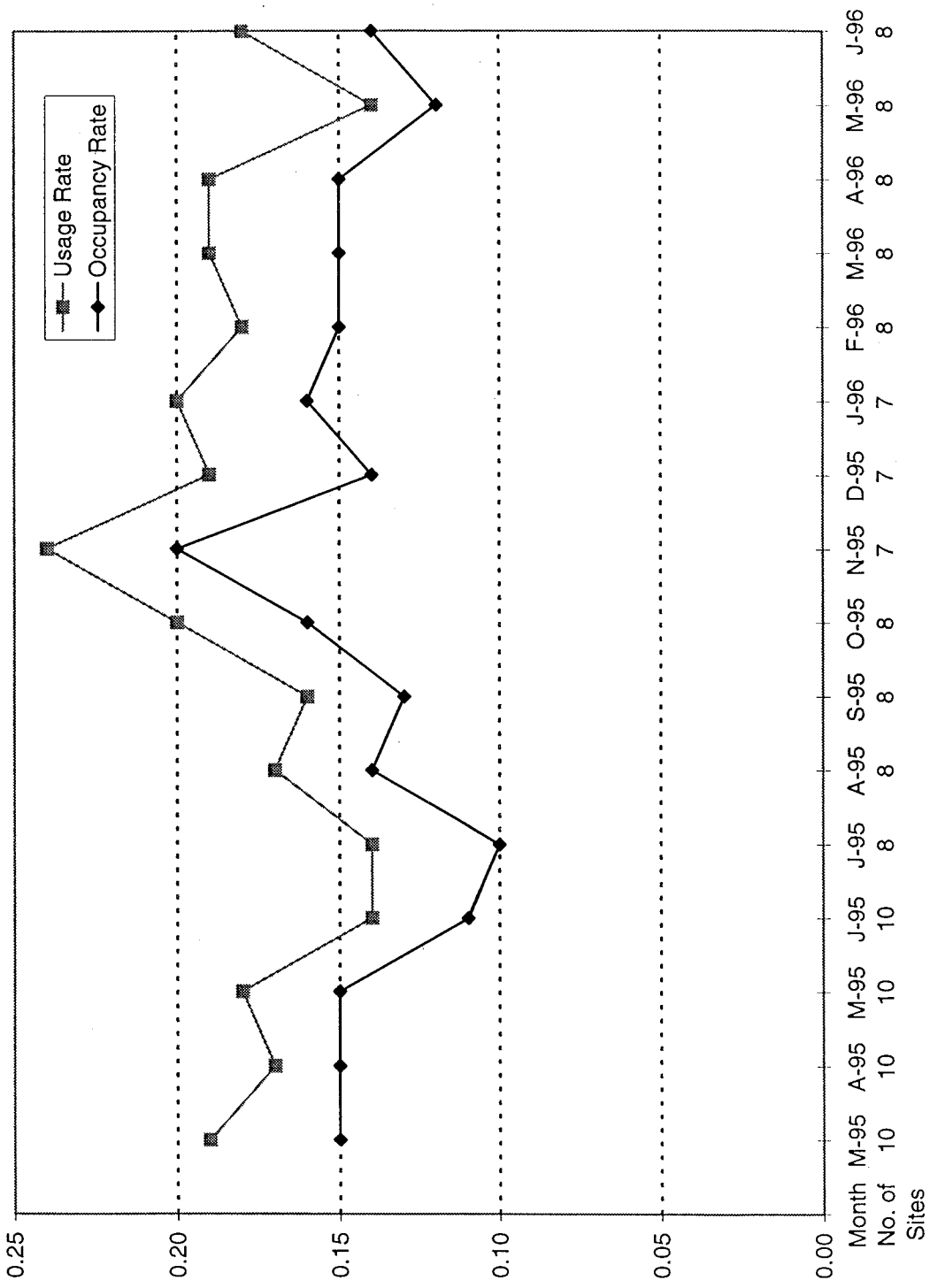


Figure 4-1: Average Occupancy and Usage Rates across RABO Sites

Figure 4-1: Average Occupancy and Usage Rates across RABO Sites (Continued)



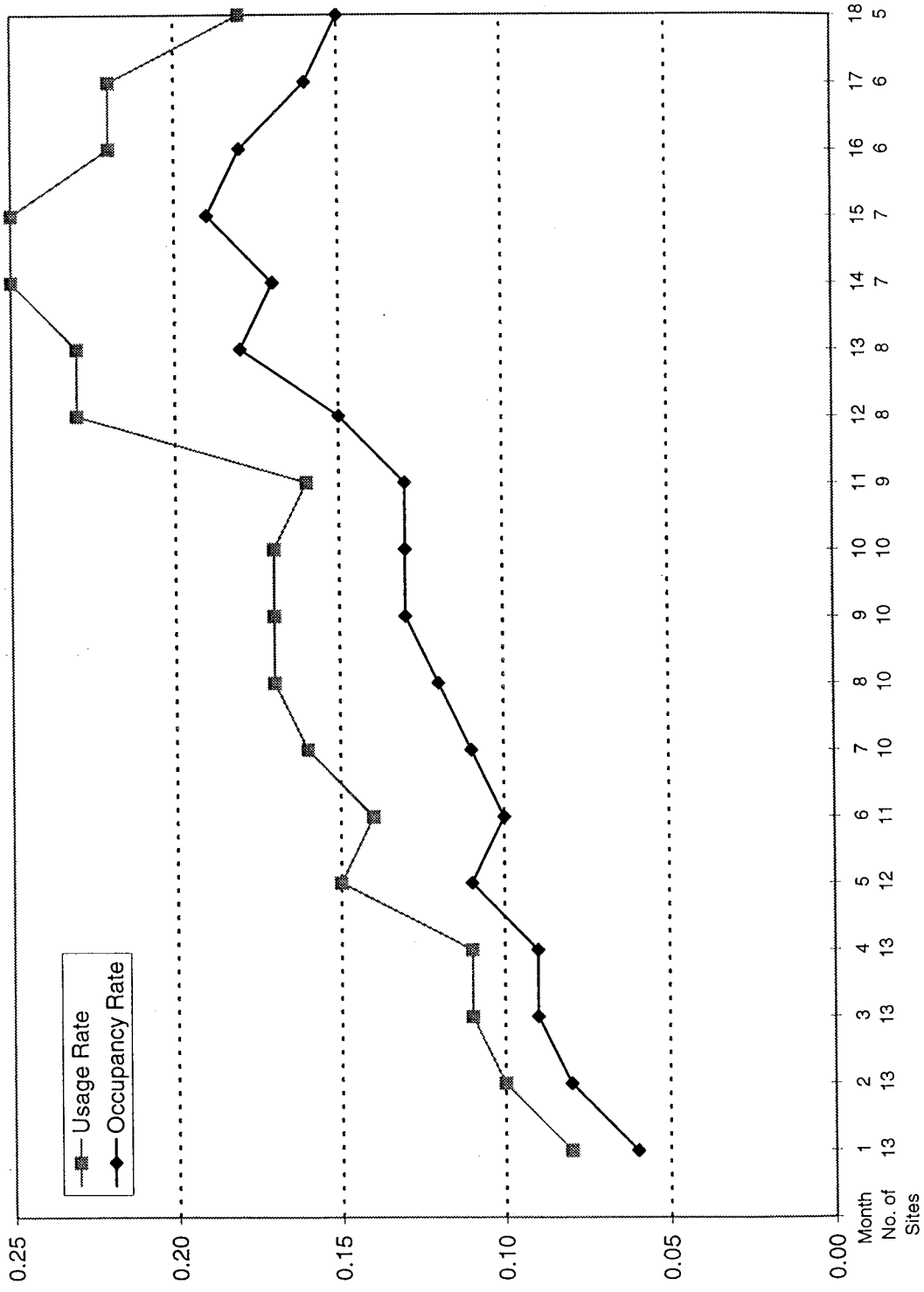


Figure 4-2: Occupancy and Usage Rates for the First 18 Months of Operation at RABO Sites

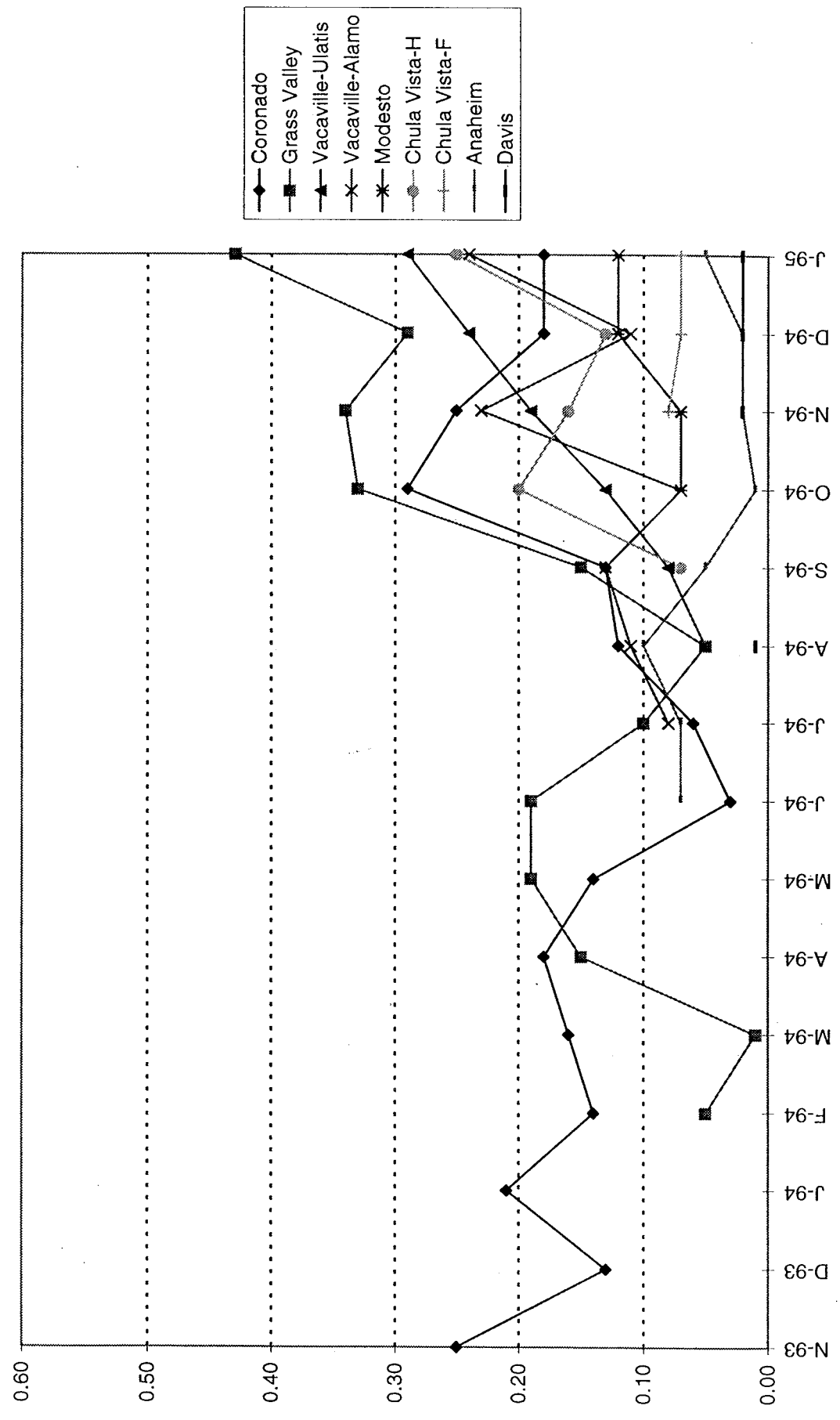


Figure 4-3: Usage Rates at Each RABO Site

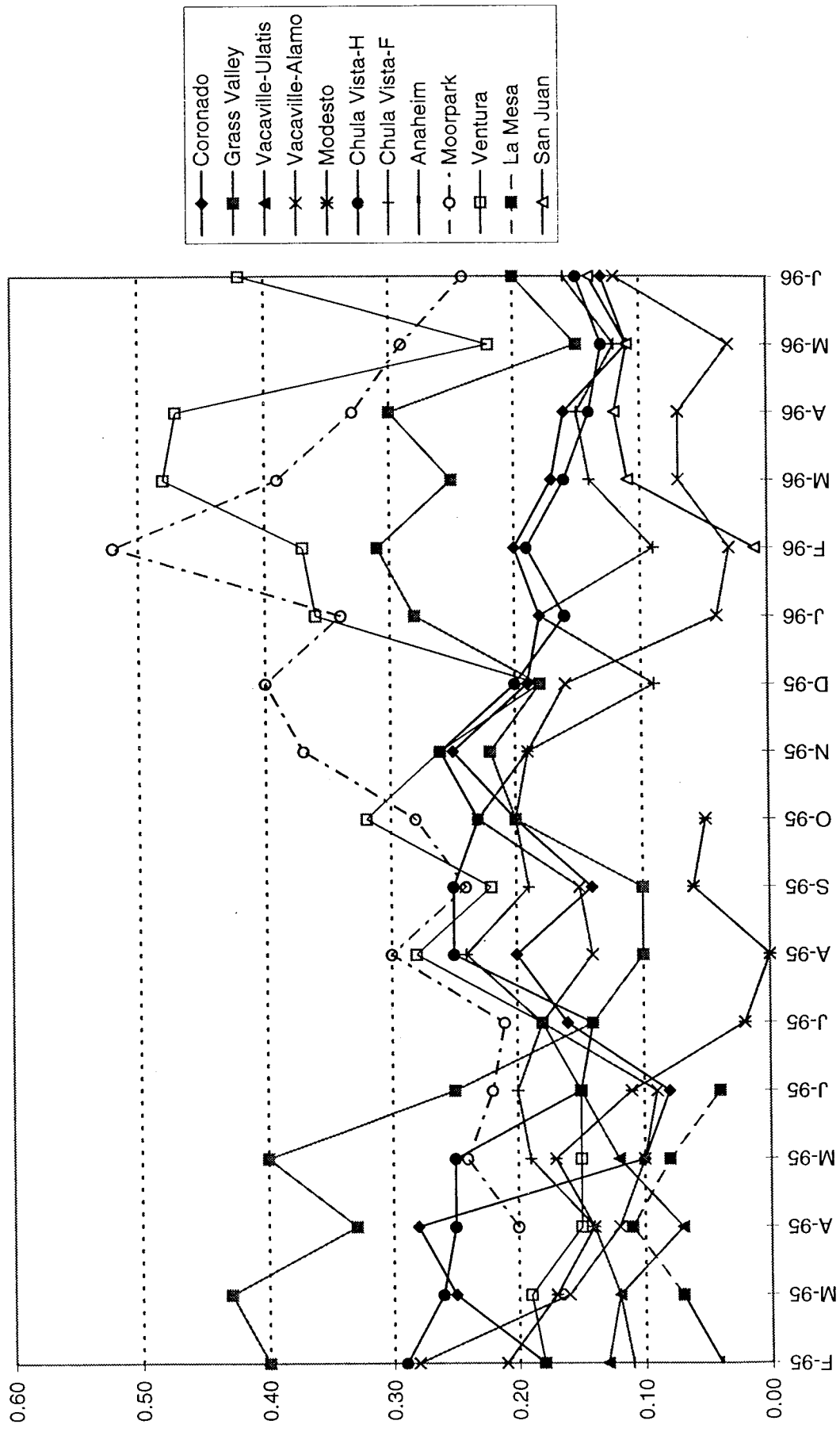


Figure 4-3: Usage Rates at Each RABO Site (Continued)

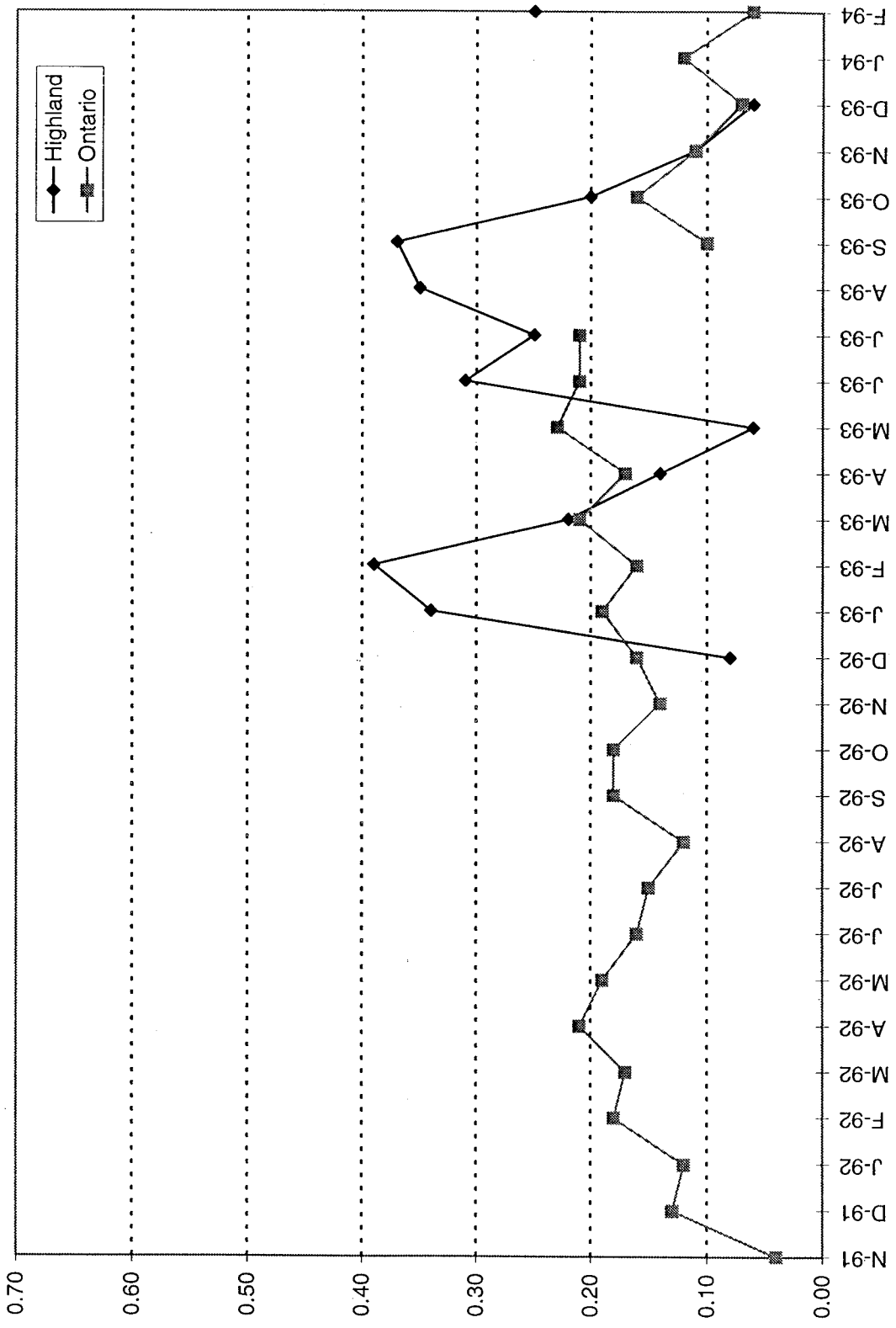


Figure 4-4: Usage Rates at Each Non-RABO Site

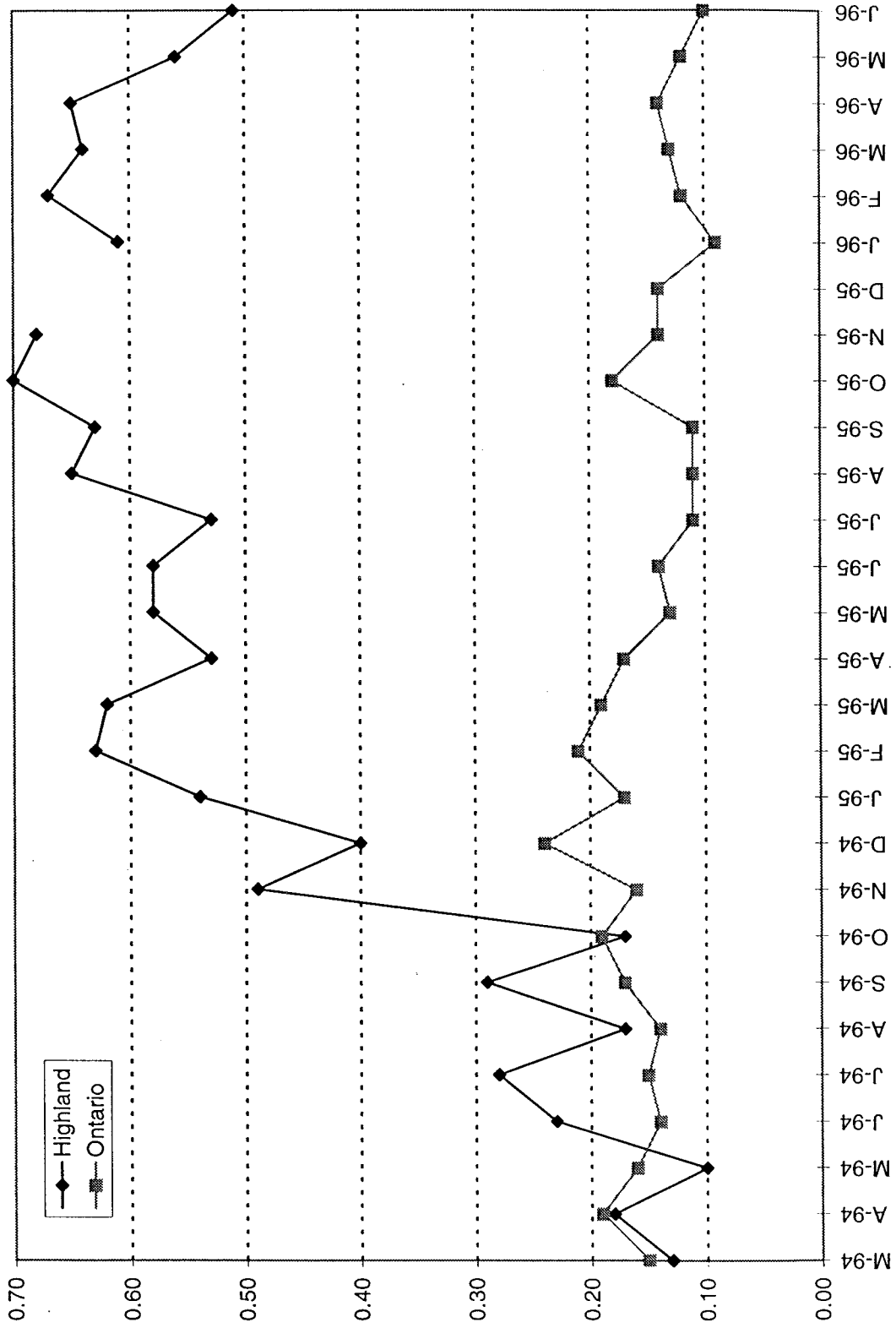


Figure 4-4: Usage Rates at Each Non-RABO Site (Continued)

nearly every day. Obviously, the usage rate is a function of the number of the workstations at the center and number of person-day telecommuting occasions. As a side note, the Ontario center closed in June 1996, after 3.5 years of operation (Buckinger *et al.*, 1997).

4.3.2 Distribution of Telecenter Occasions by Day of the Week

The distribution of telecommuting across days of the week has seldom been reported in previous studies. Yet knowledge of that distribution is important to assessing the impacts of telecommuting on transportation, as well as on other areas such as the demand for telecommunications services. If telecommuting does not occur homogeneously across the work week, for example, then transportation planners should be aware of the worst-case outcome, the day of the week on which the *least* telecommuting occurs.

The attendance log information collected in this study, comprising 10,575 observations spanning more than three years, offers a unique data set from which to address this question. Table 4-4 displays the distribution of these 10,575 telecenter occasions across day of the week and as can be seen the percent of telecommuting occasions remains relatively constant for weekdays. The slight decrease on Monday is not unexpected as managers might not want their employees to be tempted into extending their weekend break, but if that were the main cause of the results, we should see a corresponding decrease on Friday as well. Anecdotal information suggests that many workgroups hold regular meetings on Mondays, meetings for which the telecommuter would likely be expected to appear at the regular workplace.

Table 4-4: Distribution of Telecommuting Occasions by Day of the Week

Day of the Week	Number (Percent) of Telecommuting Occasions
Monday	1,815 (17.2)
Tuesday	2,141 (20.2)
Wednesday	2,166 (20.5)
Thursday	2,082 (19.7)
Friday	2,086 (19.7)
Saturday	187 (1.8)
Sunday	98 (0.9)

4.3.3 Work Time Spent at the Telecenter

On each telecommuting occasion, telecommuters reported how long they worked at the telecenter. The average work time for RABO telecenter users was 5.71 hours, with a standard deviation of 2.65 hours. Non-RABO telecenter users stayed at the telecenter for 6.67 hours on average, with a standard deviation of 2.70 hours. Under a test for equality of means, the two average work times were statistically different ($p \approx 0.000$).

Figure 4-5 illustrates the distribution of reported work time spent at the telecenter. For the RABO sites, peaks appear at 3-4 hours and 7-8 hours. These peaks reflect the tendency to spend either half a day or a full day at the telecenter. Nearly half of the occasions fell into these two categories. About 47% of the telecommuting occasions lasted 6 hours or longer. Although 27.7% of the information was missing for non-RABO sites, the available data show that the telecommuters were likely to work only at the telecenter on their telecommuting days. Figure 4-6 shows the cumulative distribution of the work time spent at the telecenter for both RABO and non-RABO sites based on the available data. A χ^2 test shows that the two work time distributions are significantly different ($p \approx 0.000$), with RABO sites showing a higher proportion of shorter telecommuting occasions.

4.3.4 Workplace Combinations on Telecommuting Days

On telecommuting days, it is possible that the telecommuters worked at more than one location, such as the regular workplace (R), home (H), and other locations (O) as well as the telecenter (T). To better understand how the telecenter is used, it is desirable to analyze the frequency of various workplace combinations. Eight combinations are possible: (1) T only, (2) T/R, (3) T/H, (4) T/O, (5) T/R/H, (6) T/R/O, (7) T/H/O, and (8) T/R/H/O.

Figure 4-7 shows the distribution of telecommuting occasions for each of the eight workplace combinations at RABO sites and non-RABO sites. At RABO sites, the most common patterns are (1) T only (59.5%), (2) T/O (18.3%), and (3) T/H (9.0%). Overall, 8.9% of all RABO telecommuting occasions involved working from the regular workplace, 14.8% involved working at home, and 25.5% involved working from another location. Only 8.1% of RABO occasions involved working at more than two locations. Working solely at the telecenter was by far the most frequent telecommuting pattern at non-RABO sites (88.7%). The second and third most common workplace combinations were T/O (6.7%) and T/R (3.2%), respectively.

Thus, contrary to expectation, telecommuting from a center is not often combined with home-based telecommuting in the same day – on only about 10% of the occasions in both RABO and non-RABO sites combined (see Table 4-7). Although many participants state they wish to engage in both home-based and center-based telecommuting to some degree (see Section 3.2.5), apparently any particular day is more likely to see one or the other forms of telecommuting exclusively.

The average work time distributed by workplace combination for RABO and non-RABO sites is presented in Tables 4-5 and 4-6, respectively. The findings for the most common combinations can be summarized as follows.

- On average, nearly 7 hours were spent at the center if the telecenter was the only work location used that day.
- If the telecommuters worked at the center and at an "other" location (T/O), the work time spent at the telecenter dropped to 4 hours or less on average. More work time was spent at the other workplace than at the telecenter. It is likely that the telecommuters' main task on that day was to work at the other location. They may have gone to the telecenter to prepare for or finish that main task.

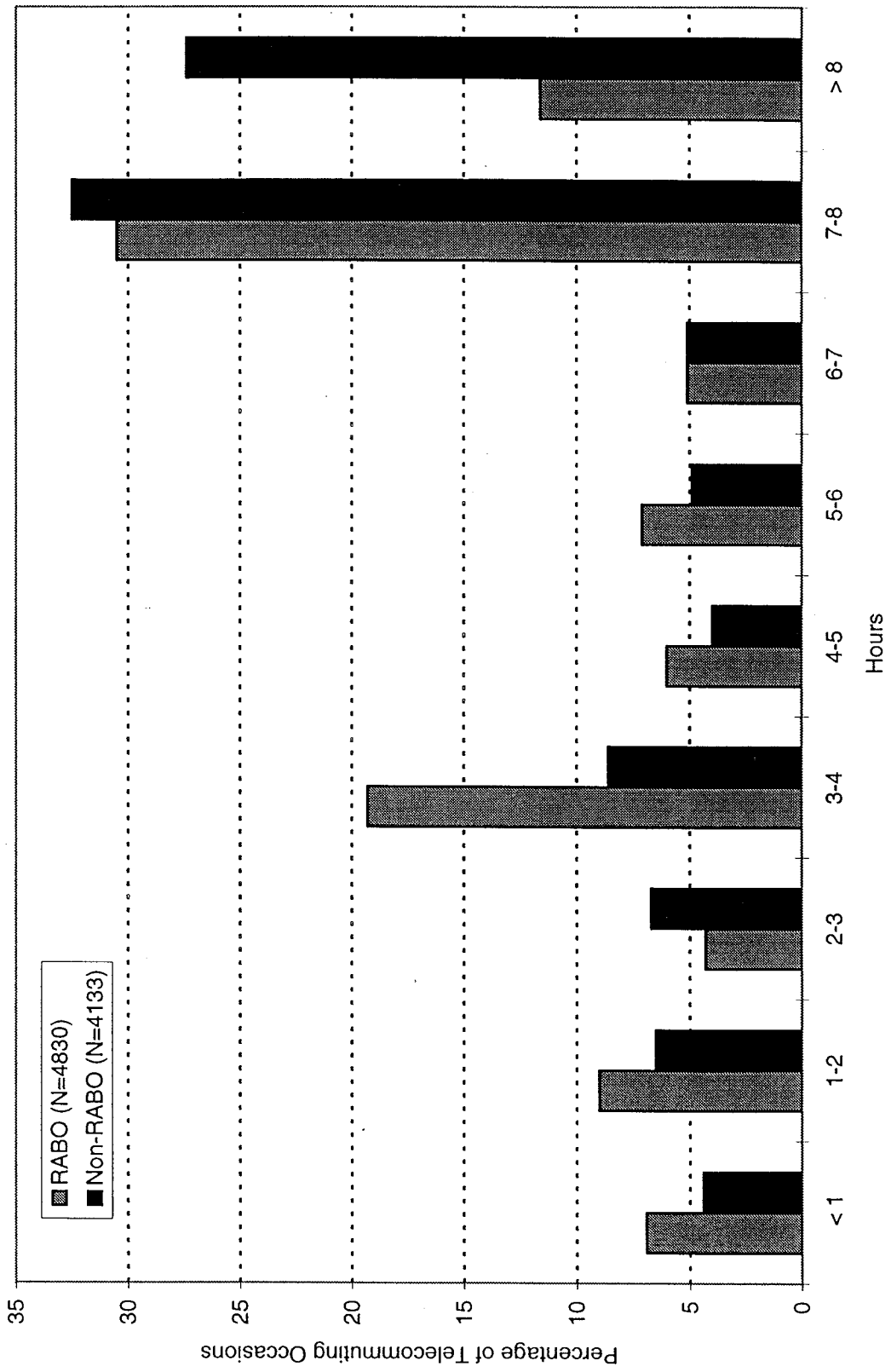


Figure 4-5: Distribution of Work Time Spent at the Telecenter

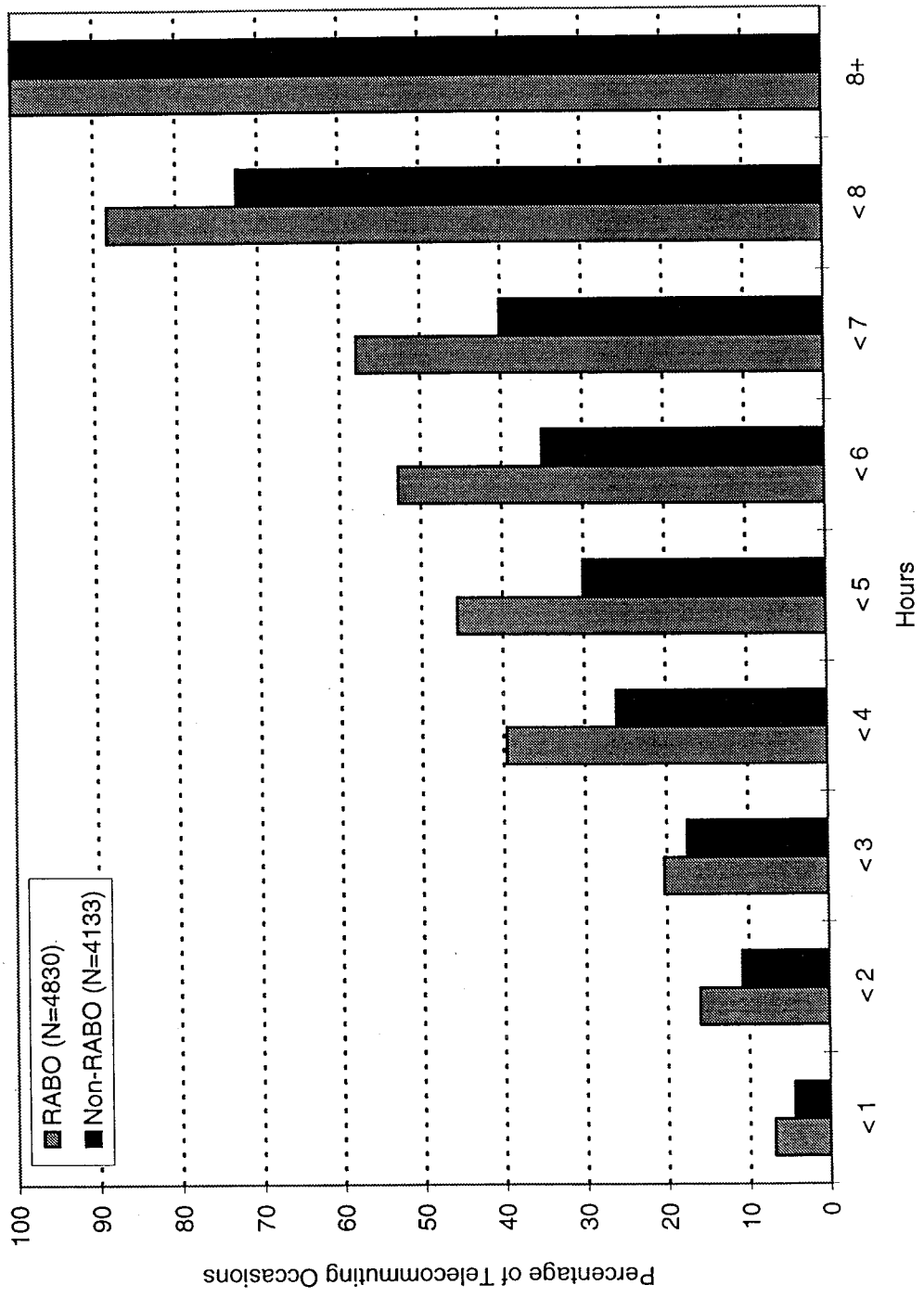


Figure 4-6: Cumulative Distribution of Work Time Spent at the Telecenter

Figure 4-7: Distribution of Workplace Combinations on Telecommuting Days
(T=telecenter, R=regular workplace, H=home, O=other location)

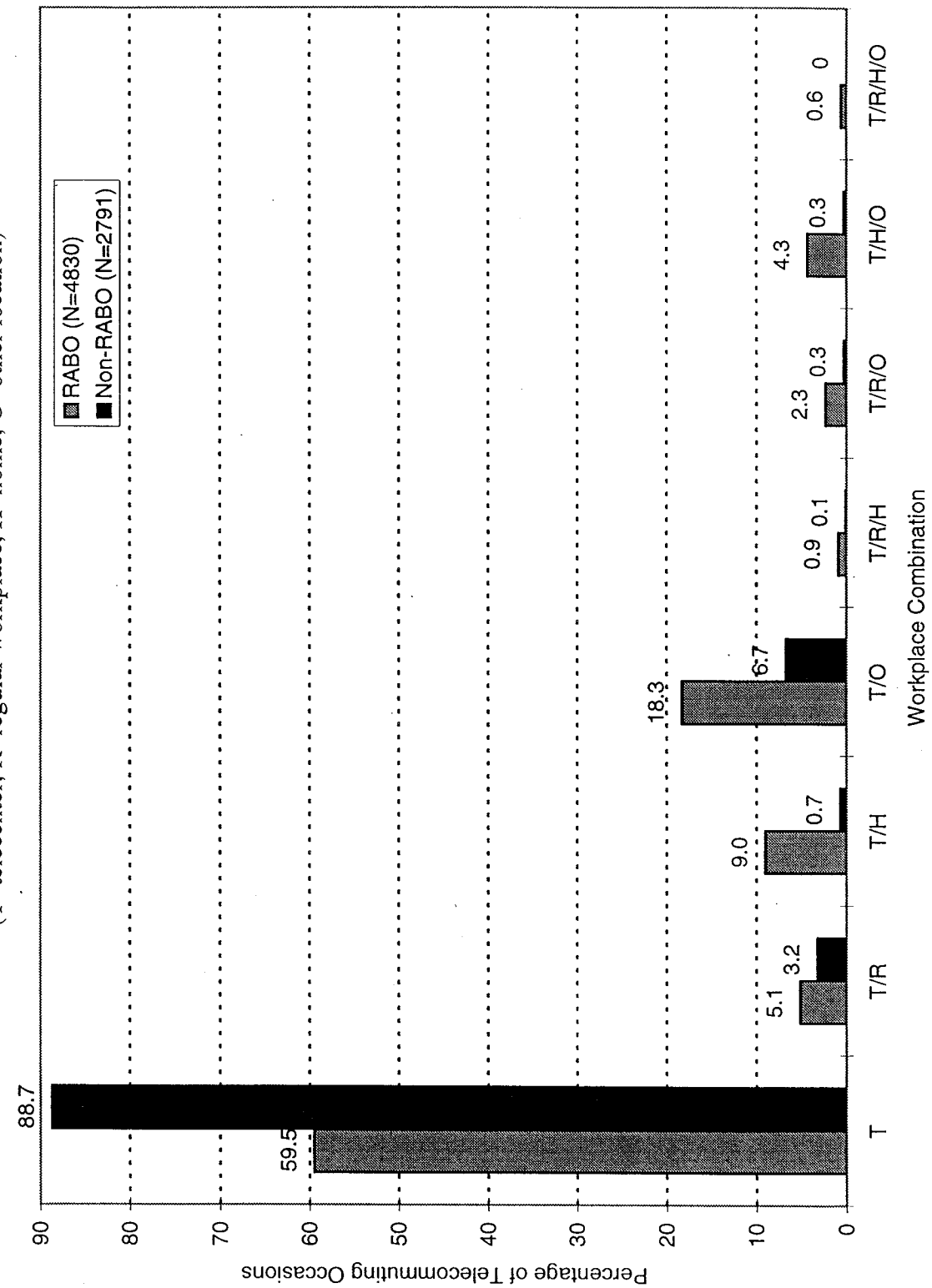


Table 4-5: Work Time Spent at Each Workplace for Various Combinations at RABO Sites

Workplace Combination	Number (Percent[1])	Hours (Mean and Standard Deviation)			
		Telecenter	Regular Workplace	Home	Other Location
T	2873 (59.5%)	6.84 (2.41)	---	---	---
T/R	246 (5.1%)	4.19 (1.79)	4.10 (1.81)	---	---
T/H	437 (9.0%)	5.43 (1.92)	---	2.80 (1.57)	---
T/O	884 (18.3%)	3.71 (2.02)	---	---	4.55 (1.95)
T/R/H	42 (0.9%)	3.23 (1.76)	3.42 (2.05)	2.06 (1.14)	---
T/R/O	111 (2.3%)	2.85 (1.66)	2.64 (1.61)	---	3.30 (2.04)
T/H/O	210 (4.3%)	3.47 (1.48)	---	1.62 (1.04)	3.06 (1.89)
T/R/H/O	27 (0.6%)	2.22 (1.56)	1.28 (0.51)	1.35 (0.69)	4.20 (2.10)
RABO	4830 (100%)	5.71 (2.65)	0.31 (1.14)	0.35 (1.02)	1.06 (2.09)
Non-RABO	2791	6.45 (2.51)	0.18 (1.01)	0.03 (0.38)	0.44 (1.32)
Total	7621	5.98 (2.63)	0.26 (1.09)	0.23 (0.84)	0.80 (1.88)

[1] The percentage is based on data from the RABO sites only. The averages for non-RABO sites and overall are presented for ease of comparison.

Table 4-6: Work Time Spent at Each Workplace for Various Combinations at Non-RABO Sites

Workplace Combination	Number (Percent[1])	Hours (Mean and Standard Deviation)			
		Telecenter	Regular Workplace	Home	Other Location
T	2476 (88.7%)	6.79 (2.37)	---	---	---
T/R	90 (3.2%)	3.13 (1.49)	5.39 (1.56)	---	---
T/H	20 (0.7%)	5.65 (1.90)	---	2.85 (1.23)	---
T/O	186 (6.7%)	3.88 (1.88)	---	---	4.82 (1.85)
T/R/H	2 (0.1%)	5.50 (0.71)	1.50 (0.71)	1.00 (0.00)	---
T/R/O	8 (0.3%)	2.75 (1.28)	3.38 (1.51)	---	3.25 (2.25)
T/H/O	9 (0.3%)	4.56 (2.07)	---	1.56 (1.01)	3.00 (1.00)
T/R/H/O	0 (0.0%)	---	---	---	---
Non-RABO	2791 (100%)	6.45 (2.51)	0.18 (1.01)	0.03 (0.28)	0.34 (1.32)
RABO	4830	5.71 (2.65)	0.31 (1.16)	0.35 (1.02)	1.06 (2.09)
Total	7621	5.98 (2.63)	0.26 (1.09)	0.23 (0.84)	0.80 (1.88)

[1] The percentage is based on data from the non-RABO sites only. The averages for RABO sites and overall are presented for ease of comparison.

Table 4-7 shows that the distribution of telecommuting occasions for the eight workplace combinations varies considerably across sites. Except for Ventura Community College, a plurality of the telecommuting occasions at each site was telecenter-only; this was the majority pattern at eleven of the fifteen sites. Working at the telecenter and an other location (T/O) was popular at Ulatis, Alamo, Chula Vista (H St.), La Mesa, and Ventura and Moorpark Community Colleges. This is in keeping with the use of the Ulatis and Alamo sites by several health care workers, who spent part of the day rendering services at patients' homes.

The T/H pattern was common at Coronado, Grass Valley and Ventura Community College. The T/R pattern was popular at Anaheim and at San Juan Capistrano. The T/H/O pattern occurred regularly at Alamo and Chula Vista (F St.). The variation in workplace combinations among sites is likely the result of the diverse job characteristics of telecommuters.

At the two non-RABO sites, the telecenter-only pattern dominates the sample, occurring on 88-89% of the occasions for both sites. The T/O combination is the second most common pattern for both sites.

4.3.5 Travel Modes for Accessing the Telecenter

Table 4-8 depicts the distribution of the primary transportation mode used to access RABO and non-RABO telecenters. For more than four-fifths of the telecommuting occasions (82.3%) at RABO sites, telecommuters drove alone to the telecenter. Other common travel modes were walking/biking (5.8%), being dropped off (5.7%), and carpooling (4.2%). On 1.5% of the occasions, an alternative-fuel vehicle was used (most of these trips were made to the Moorpark site). Clearly, driving alone was the primary means of commuting to RABO sites.

The utilization of transportation modes at non-RABO sites is similar to that at RABO sites. Driving alone was even more common for non-RABO sites (91.4%) than for RABO sites. Thus, the RABO project orientation of placing telecenters near residential areas may have had a marginal effect on lowering the share of drive-alone access trips. However, driving alone remained the dominant mode in both cases. For a more extensive discussion of mode choice and the transportation impacts of telecenters, see Chapter 6.

Although participants drove alone most of the time, the proportion of drive-alone occasions varied across sites from 49.3% to 95.9%, and each site had a somewhat different mode distribution. Other popular modes included walking/biking at Coronado (33.8%) and Davis (26.7%), carpooling at Alamo (29.9%) and Anaheim (14.1%), alternative-fuel vehicle (11.3%) at Moorpark Community College, and being dropped off at Grass Valley (16.2%) and Ventura Community College (22.0%).

However, it should be understood that the observed patterns are a function of the telecommuting frequency of individuals and the total number of individuals at each site. For example, four telecommuters were using the telecenter located at Moorpark Community College, and one of them commuted to the telecenter in an alternative-fuel vehicle. If this user were to telecommute more often, a higher share of this mode would result. This result does not imply that more people utilized that mode. Therefore, the mode distribution by sites only conveys information on what modes the telecommuters used and how many telecommuting occasions were made by that mode. The mode choice behavior of individual telecommuters is discussed in Section 4.4.6.

Table 4-7: Distribution of Workplace Usage by Each Site[1]

Site	N[2]	Workplace Combination[3]							
		T	T/R	T/H	T/O	T/R/H	T/R/O	T/H/O	T/R/H/O
Coronado	448	**74.1%**	2.9%	*13.2%*	4.5%	2.2%	2.5%	0.7%	0
Grass Valley	819	**74.6%**	5.1%	*13.6%*	4.9%	0.9%	0.6%	0.4%	0
Anaheim	108	**68.2%**	*22.4%*	0.9%	7.5%	0.9%	0	0	0
Vacaville - Alamo	511	**30.4%**	0.6%	10.4%	*29.8%*	1.2%	5.5%	19.6%	2.5%
Vacaville - Ulatis	222	**46.6%**	2.2%	3.6%	*37.2%*	0	4.0%	2.2%	4.0%
Davis	15	**86.7%**	*6.7%*	*6.7%*	0	0	0	0	0
Chula Vista - H St.	875	**44.3%**	9.4%	7.9%	*31.4%*	0.8%	3.1%	3.0%	0.1%
Modesto	261	**95.8%**	0.4%	*2.7%*	0.4%	0	0	0.8%	0
Chula Vista - F St.	492	**73.2%**	1.4%	7.7%	4.9%	0.4%	0.4%	*11.6%*	0.4%
Ventura	87	*30.3%*	10.3%	13.9%	**36.0%**	1.9%	4.2%	2.9%	0.4%
La Mesa	36	**82.9%**	2.9%	0	*14.3%*	0	0	0	0
Moorpark	469	**75.1%**	0	4.9%	*20.0%*	0	0	0	0
San Juan Capistrano	104	**62.5%**	*17.3%*	0	12.5%	0	7.7%	0	0
Ontario	1124	**88.4%**	4.5%	1.0%	*5.7%*	0.2%	0.2%	0	0
Highland	1667	**88.9%**	2.3%	0.5%	*7.3%*	0	0.4%	0.5%	0
All sites	7627	**70.2%**	4.4%	6.0%	*14.0%*	0.6%	1.5%	2.9%	0.4%

[1] The most frequent combination for each site is bolded, and the second most frequent is italicized and underlined.
[2] N is the number of telecommuting occasions.
[3] Workplace locations are the regular workplace (R), the telecommuting center (T), home (H), and other location (O).

Table 4-8: Distribution of Travel Modes for Accessing Each Telecenter[1]

Site	N	Walk/ Bike	Alt. Fuel Vehicle	Drive Alone	Carpool	Public Transit	Dropped Off	Other Mode
Coronado	444	*33.8%*	0.7%	**49.3%**	12.8%	0.2%	2.7%	0.5%
Grass Valley	803	7.5%	0	**74.7%**	0.4%	1.2%	*16.2%*	0
Anaheim	105	0	0	**77.1%**	*21.9%*	0	1.0%	0
Vacaville - Alamo	491	3.7%	0	**82.2%**	*14.1%*	0	0	0
Vacaville - Ulatis	225	0.9%	0	**95.6%**	*3.5%*	0	0	0
Davis	15	*26.7%*	0	**73.3%**	0	0	0	0
Chula Vista - H St.	834	0.7%	0.4%	**95.9%**	1.1%	*1.6%*	0.4%	0
Modesto	254	*10.6%*	0	**87.0%**	0.4%	0	2.0%	0
Chula Vista - F St.	460	0	0	**97.2%**	1.1%	0	*1.7%*	0
Ventura	450	0	2.9%	**72.2%**	2.7%	0	*22.0%*	0
La Mesa	36	8.3%	0	**72.2%**	8.3%	*11.1%*	0	0
Moorpark	451	0	*11.3%*	**88.7%**	0	0	0	0
San Juan Capistrano	103	0	0	**95.1%**	*4.9%*	0	0	0
RABO total	4671	*5.8%*	1.5%	**82.3%**	4.2%	0.3%	5.7%	0.1%
Ontario	1147	0.7%	0.1%	**86.3%**	*11.2%*	0.2%	1.2%	0.3%
Highland	1617	*3.3%*	0	**95.0%**	0.3%	0	1.3%	0
Non-RABO total	2764	2.2%	0	**91.4%**	*4.8%*	0.1%	1.3%	0.1%
Total	7435	*4.5%*	1.0%	**85.7%**	4.4%	0.2%	4.1%	0.1%

[1] The most frequent combination for each site is bolded, and the second most frequent is italicized and underlined.

4.4 Disaggregate Analysis

In the aggregate analysis, average telecommuting patterns for each center and across all telecenters were presented. The patterns are based on the pool of all telecommuting occasions considered together. Those who telecommute more often will have a disproportionate effect on the overall pattern, as their occasions appear more frequently in the pool. As a result, the aggregate patterns may not represent the behavior of an average telecommuter. To gain a better understanding of individual telecommuting behavior, the analysis reported in this section was performed on a person-by-person basis.

The study of telecommuting duration and frequency is fundamentally important to our understanding of the adoption of telecommuting and, hence, the impacts of telecommuting on travel and related issues. We may successfully predict that a certain number of individuals will telecommute. But if we falsely assume that they will telecommute in perpetuity (when in fact they, say, telecommute in a one-year-on, two-year-off cycle), and/or if we assume that they will telecommute (hypothetically) one day per week when the average is close to once every two weeks, we will greatly overestimate the number of people telecommuting on any given day and the associated travel-related impacts. The attendance log data collected for this study offers a unique opportunity to study these important questions, as well as other aspects of the telecommuting patterns of individuals.

The five disaggregate indicators analyzed here include individual telecommuting duration, telecommuting frequency, proportion of telecenter-only working days, work time spent at the telecenter, and proportion of drive-alone telecommuting days. However, not every individual in the data set was appropriate to include in the individual analyses. For 30 (19.6%) of the individuals at RABO sites and 62 (29.1%) at non-RABO sites, frequency and duration could not be meaningfully computed. These participants either telecommuted

- once only (13.7% at RABO sites; 25.4% at non-RABO sites),
- twice only, with less than two weeks between the two occasions (5.9% at RABO sites; 3.8% at non-RABO sites), or
- twice only, with more than a year between the two occasions (one user at a non-RABO site).

Among these 92 individuals, at least 20 people were registered program participants who dropped out after one or two telecommuting occasions (participants who quit the program are discussed further in Chapter 5). The rest were either non-RABO site participants who quit telecommuting before the site joined the evaluation program, or other users of the center who were not participating in the evaluation. These 92 one- and two-time telecommuters were excluded from all disaggregate analyses. (Other participants who only telecommuted twice were retained and will appear with relatively short duration and/or frequency in the subsequent sections). The remaining 123 telecommuters at RABO sites and 151 individuals at non-RABO sites comprise the primary sample for the disaggregate analysis of telecommuting duration and frequency.

For the analysis of the individual proportion of telecenter-only working days, proportion of drive-alone telecommuting days, and work time, the information is based on the 123 telecommuters from RABO sites only. Non-RABO telecommuters are excluded because information was unavailable for many cases. The information on travel mode and work time distribution at multiple locations was unavailable for 70 (46.4%) of the 151 non-RABO users because they stopped telecommuting prior to February 1, 1994 at Highland and September 1, 1994 at Ontario, the dates on which the attendance log designed by this project was introduced (see Appendix G). Only 46 (30.5%) non-

RABO telecommuters had provided complete information on the five indicators listed above, and the other 35 (23.1%) individuals had provided partial information.

4.4.1 Telecommuting Duration

This section analyzes the length of time over which individuals telecommute from a center, or their telecommuting duration. We assume that there is no missing attendance information, that is, that each telecommuter signed in properly on each telecommuting day. For RABO sites, administrators had a vested interest in ensuring completeness of the sign-in records, as they were contractually obligated to maintain certain occupancy targets. Thus, while there are doubtless some missing data, it is reasonable to believe that they constitute a relatively small proportion of the whole. For the purposes of calculating telecommuting duration, it is assumed that no left-censoring of the data occurs, that is, that the individual had not been telecommuting prior to the first recorded use of the center. In other words, it is assumed that the first use of the center coincides with the start of telecommuting.

There is a difficulty, however, in similarly assuming that the last attendance date is the day the individual quit telecommuting. If this were the case, all telecommuters would be considered to have quit using the telecenter on or before June 30, 1996. In reality, of course, some participants will have quit before June 30 and others will still have been using the center at that point. Since most of the participants did not telecommute every working day, or even with a constant frequency, it is difficult to determine whether a telecommuter had quit the program or was simply between uses of the telecenter.

Two decision rules were utilized to identify the status of the telecommuters as either quitters or stayers: one based on the existence of an exit interview and the other based on average length of time between telecommuting occasions. The telecommuters who were known to have stopped telecommuting were asked to participate in an exit interview as a part of this project. Those who completed an exit interview were easily identified as quitters (see Chapter 5). For the rest of the telecenter users, a rule was devised to define their telecommuting status. If the period of time from the last telecommuting date to the termination of data collection (June 30, 1996) was more than three times the average length of time between two successive telecommuting occasions for that person, the telecommuter was regarded as a quitter. Otherwise, s/he was a stayer, meaning that the actual exit time-point had not yet been observed for that individual. Thus, the telecommuting durations of stayers are right-censored.

Although arbitrary, using three times the average period between telecommuting occasions as the basis for a decision rule is based on the concern that the telecenter users may reduce their telecommuting frequency but still remain in the program. Nevertheless, applying this rule runs some risk of falsely classifying as stayers people who quit telecommuting shortly before June 30, as well as a risk of misclassification in the opposite direction. When this same rule was applied (with a cut-off date of June 30, 1995) for the interim data analysis, only four out of 146 individuals who were classified as quitters were found to telecommute after the termination date of data collection; and 10 out of 76 telecommuters who were classified as stayers never telecommuted after that date (most of their last telecommuting dates were close to the termination date of data collection). Therefore, this classification rule is quite reliable.

Therefore, the definition of telecommuting duration differs depending on whether the telecommuter is a quitter or stayer. For quitters, the last day of telecommuting is considered to be the date of their final attendance log entry. However, stayers are considered to be telecommuting up to June 30, 1996 instead of up to the last recorded day of telecommuting. For example, if a stayer's last recorded telecommuting occasion before the cutoff date was on June 21, 1996, the duration is counted from the first telecommuting date to June 30, 1996. In addition, the duration is rounded down to the nearest month. For example, if an individual telecommuted for 3.8 months, s/he is classified as a stayer for the first three months and as a quitter for the fourth month.

Telecommuting duration here is similar to the survival time of an individual in a conventional medical study: those who quit telecommuting are analogous to the patients who die and the stayers are analogous to those who are living at the end of the observation period. The data possess two features which correspond to the characteristics of survival data. First, telecommuting duration is not symmetrically distributed: some telecenter users quit within a very short time but some continue to telecommute for more than three years (at non-RABO sites). Second, as discussed above, the telecommuting duration is frequently right-censored.

The ratio between quitters and stayers is of importance to the analysis. If the right-censored observations (stayers) outnumber the uncensored ones (quitters), the statistical techniques associated with failure time data may not be appropriate for this study. Of the 274 individuals (123 at RABO sites and 151 at non-RABO sites) considered, 77 of the RABO telecenter users (62.9%) and 131 non-RABO users (86.8%) stopped telecommuting on or before June 30, 1996. This proportion of quitters is considered acceptable for the use of conventional failure time analysis techniques. The following is a summary of the model formulation drawn from Miller (1981), Cox and Oakes (1984), and Collett (1994).

A basic element in the analysis of telecommuting duration is the survival function. The survival function is defined as the proportion of telecenter users telecommuting beyond time t:

$$\hat{S}(t) = \frac{\text{number of telecenter users telecommuting longer than } t \text{ months}}{\text{total number of telecenter users}}. \tag{4.3}$$

Suppose that there are n telecommuters for whom telecommuting durations are observed. Some of these observations are right-censored, and there is also more than one telecommuter with the same observed exit time. Therefore, suppose there are r exit times among the individuals, where $r \le n$. Then these exit times are arranged in ascending order: $t_{(1)} < t_{(2)} < \ldots < t_{(r)}$. The probability of surviving at a specific time $t_{(j)}$ given that the individual has already survived past time $t_{(j-1)}$ could be estimated as

$$P(t_{(j)}) = \text{Prob}(T \ge t_{(j)} \mid T \ge t_{(j-1)}) = \frac{n_j - q_j}{n_j} \tag{4.4}$$

where T is the observed telecommuting duration, n_j is the number of individuals who were still telecommuting just before $t_{(j)}$ and q_j is the number of individuals who quit in the time interval $[t_{(j)}, t_{(j+1)})$.

The number of telecommuters n_j is governed by the equation

$$n_j = n_{j-1} - q_{j-1} - c_{j-1}, \tag{4.5}$$

where c_{j-1} is the number of censored observations in the time interval $[t_{(j-1)}, t_{(j)})$. The status of observations that are censored at time $t_{(j-1)}$ cannot be determined for later times, and hence these censored observations must be removed from the number of people n_j known to be telecommuting at times $t_{(j)}$ and later.

Suppose the exit times of telecommuters are assumed to occur independently. A series of time intervals can be constructed based on the observed exit times of the telecommuters. The cumulative probability of surviving beyond the kth exit time is the product of these k interval-specific survival probabilities:

$$\begin{aligned}
\hat{S}(t_{(k)}) &= \text{Prob}(T \geq t_{(k)}) \\
&= \text{Prob}(T \geq t_{(k-1)}, T \geq t_{(k)}) \\
&= \text{Prob}(T \geq t_{(k)} \mid T \geq t_{(k-1)}) \times \text{Prob}(T \geq t_{(k-1)}) \\
&= P(t_{(k)}) \times \hat{S}(t_{(k-1)}) \\
&= P(t_{(k)}) \times P(t_{(k-1)}) \times \ldots \times P(t_{(1)}) \\
&= \prod_{j=1}^{k} P(t_{(j)}) \\
&= \prod_{j=1}^{k} \frac{n_j - q_j}{n_j}.
\end{aligned} \tag{4.6}$$

Tables 4-9 and 4-10 illustrate the estimated survival functions for the telecommuters at RABO sites and non-RABO sites, respectively. These functions indicate the probabilities that an individual continues to telecommute after each time interval. From Table 4-9, for example, the probability of telecommuting beyond six months (through the six intervals) is

$$\begin{aligned}
\hat{S}(t_{(6)}) &= P(t_{(1)}) \times P(t_{(2)}) \times P(t_{(3)}) \times P(t_{(4)}) \times P(t_{(5)}) \times P(t_{(6)}) \\
&= (0.919)(0.881)(0.904)(0.878)(0.942)(0.938) \\
&= 0.567.
\end{aligned} \tag{4.7}$$

That is, there is a 56.7% chance that an individual at a RABO site will telecommute longer than six months. In a similar way, we can obtain a 33.9% chance of telecommuting more than 15 months. From the $P(t_{(j)})$ column of Table 4-9 it is seen, for example, that there is a 94.2% chance of continuing to telecommute past six months given that the individual has lasted five months. The graph of the estimated survival functions from BMDP software is shown in Figure 4-8. The estimated survival functions are constant between adjacent exit times and decrease at each exit time.

Table 4-9: Estimated Survival Function for RABO Telecommuters

Telecommuting Duration (Months) j	Initial Number n_j	Number of Quitters q_j	Number of Censored Observations c_j	Conditional Probability of Surviving Beyond $t_{(j)}$ $P(t_{(j)})$	Cumulative Probability of Surviving Beyond $t_{(j)}$ $\hat{S}(t_{(j)})$
0	123	0	0	1.000	1.000
1 - 2	123	10	4	0.919	0.919
2 - 3	109	13	2	0.881	0.809
3 - 4	94	9	3	0.904	0.732
4 - 5	82	10	3	0.878	0.642
5 - 6	69	4	1	0.942	0.605
6 - 7	64	4	1	0.938	0.567
7 - 8	59	4	1	0.932	0.529
8 - 9	54	2	3	0.963	0.509
9 - 10	49	3	4	0.939	0.478
10 - 11	42	4	2	0.905	0.433
11 - 12	36	2	2	0.944	0.409
12 - 14	32	2	3	0.938	0.383
14 - 15	27	2	2	0.926	0.355
15 - 16	23	1	1	0.957	0.339
16 - 17	21	2	3	0.905	0.307
17 - 19	16	2	3	0.875	0.269
19 - 20	11	1	1	0.909	0.244
20 - 27	9	1	6	0.889	0.217
27+	2	1	1	0.500	0.109

Table 4-10: Estimated Survival Function for Non-RABO Telecommuters

Telecommuting Duration (Months) j	Initial Number n_j	Number of Quitters q_j	Number of Censored Observations c_j	Conditional Probability of Surviving Beyond $t_{(j)}$ $P(t_{(j)})$	Cumulative Probability of Surviving Beyond $t_{(j)}$ $\hat{S}(t_{(j)})$
0 - 1	151	0	0	1.000	1.000
1 - 2	151	8	0	0.947	0.947
2 - 3	143	14	0	0.902	0.854
3 - 4	129	8	1	0.938	0.801
4 - 5	120	11	0	0.908	0.728
5 - 6	109	15	1	0.862	0.628
6 - 7	93	8	0	0.914	0.574
7 - 8	85	5	2	0.941	0.533
8 - 9	77	5	0	0.935	0.499
9 - 10	72	7	0	0.903	0.450
10 - 11	65	5	0	0.923	0.416
11 - 12	60	3	3	0.950	0.395
12 - 13	54	2	1	0.963	0.380
13 - 14	51	2	0	0.961	0.365
14 - 15	49	2	0	0.959	0.350
15 - 16	47	1	1	0.979	0.343
16 - 18	45	3	1	0.933	0.320
18 - 19	41	2	1	0.951	0.304
19 - 20	38	2	0	0.947	0.288
20 - 21	36	1	0	0.972	0.280
21 - 23	35	4	2	0.886	0.248
23 - 24	29	1	0	0.966	0.234

Table 4-10: Estimated Survival Function for Non-RABO Telecommuters (Continued)

Telecommuting Duration (Months) j	Initial Number n_j	Number of Quitters q_j	Number of Censored Observations c_j	Conditional Probability of Surviving Beyond $t_{(j)}$ $P(t_{(j)})$	Cumulative Probability of Surviving Beyond $t_{(j)}$ $\hat{S}(t_{(j)})$
24 - 25	28	3	0	0.893	0.214
25 - 26	25	1	1	0.960	0.206
26 - 28	23	3	0	0.870	0.179
28 - 30	20	1	0	0.950	0.170
30 - 31	19	1	0	0.947	0.161
31 - 32	18	1	0	0.944	0.152
32 - 35	17	1	0	0.941	0.143
35 - 37	16	2	0	0.875	0.125
37 - 41	14	1	2	0.929	0.116
41 - 43	11	2	2	0.818	0.095
43 - 48	7	1	2	0.857	0.082
48 - 49	4	1	0	0.750	0.061
49 - 53	3	1	0	0.667	0.041
53+	2	2	0	0.000	0.000

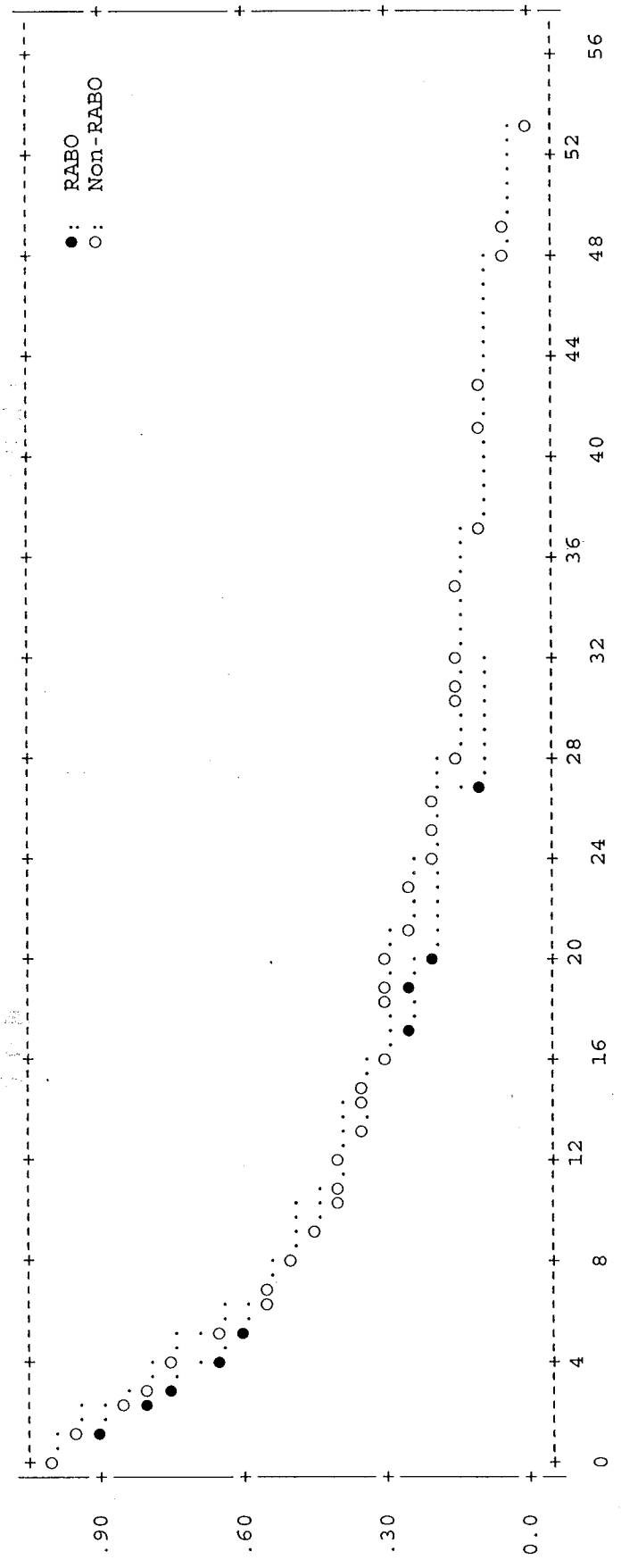


Figure 4-8: Telecommuting Survival Function

The median duration of telecommuting was 9 months at RABO sites and 8 months at non-RABO sites. This means that 50% of the participants telecommuted at least 9 and 8 months, respectively. Put negatively, it also means that half of the participants telecommuted at most 9 or 8 months. Among the RABO and non-RABO telecommuters, about 38% of them telecommuted for at least a year. Similarly, about 21% of both groups used the telecenter for at least two years. The two survival functions were not statistically different at a 0.10 level of significance. This means that at any time t, the estimated survival probability of telecommuting beyond t is statistically the same for telecommuters at both RABO and non-RABO sites. This result suggests that the operating length of the telecenter may not be an important factor in determining telecommuting duration. Rather, duration is probably a function of the characteristics of the individual telecommuter.

This relatively short median duration of telecommuting is an important finding. Few studies have collected data on attrition in telecommuting, so there is little to which to compare this figure. However, one study of home-based telecommuting reported an attrition rate of 33% within one year (Quaid and Lagerberg, 1992). Thus, these two studies suggest that attrition is higher for center-based telecommuting than for the home-based form, but further research is needed on this point.

Based on the analysis in this chapter, "once a telecommuter, always a telecommuter" is clearly not true. Reasons for quitting telecommuting are discussed in Chapter 5. In any case, later discussions of telecommuting frequency (Section 4.4.2) and of the travel impacts of telecommuting (Chapter 6) should be interpreted in the light of this information: that is, measured telecommuting frequencies and impacts may only be achieved for a relatively short period of time.

4.4.2 Telecommuting Frequency

To measure how often telecommuters used the telecenter, an individual's average telecommuting frequency is taken to be the ratio of the number of telecommuting days to the total number of working days during the duration of telecommuting. Again, this assumes no missing telecommuting occasions for each telecommuter. The number of working days includes the first and last telecenter visits but excludes Saturdays, Sundays, and eight federal holidays (see Section 4.3.1).

The frequency calculations were slightly modified to accommodate missing data. Data were missing for January 1994 and December 1995 at Highland, August 1993 at Ontario, and August 1995 at Modesto. The first and last telecommuting occasions could be used to judge whether the telecommuting duration included a missing month, but no information existed on specific telecommuting occasions. According to data from other months, 35 telecommuters may have telecommuted in those two months. For these cases, the number of working days in the missing month was subtracted from the total number of working days. Unless the telecommuting frequency for an individual was much higher or much lower than average during that month, the estimated frequency should be reliable.

Figure 4-9 shows the distribution of the average frequency of telecommuting for the 123 telecommuters at RABO sites and the 151 telecommuters at non-RABO sites. The cumulative distribution is shown in Figure 4-10. Since there are about 21 working days per month on average, a 5% telecommuting frequency is approximately equivalent to one telecommuting day per month. A 20% telecommuting frequency represents telecommuting once per week and 40% means twice per week. The weighted average frequency of telecommuting at RABO and non-RABO telecenters

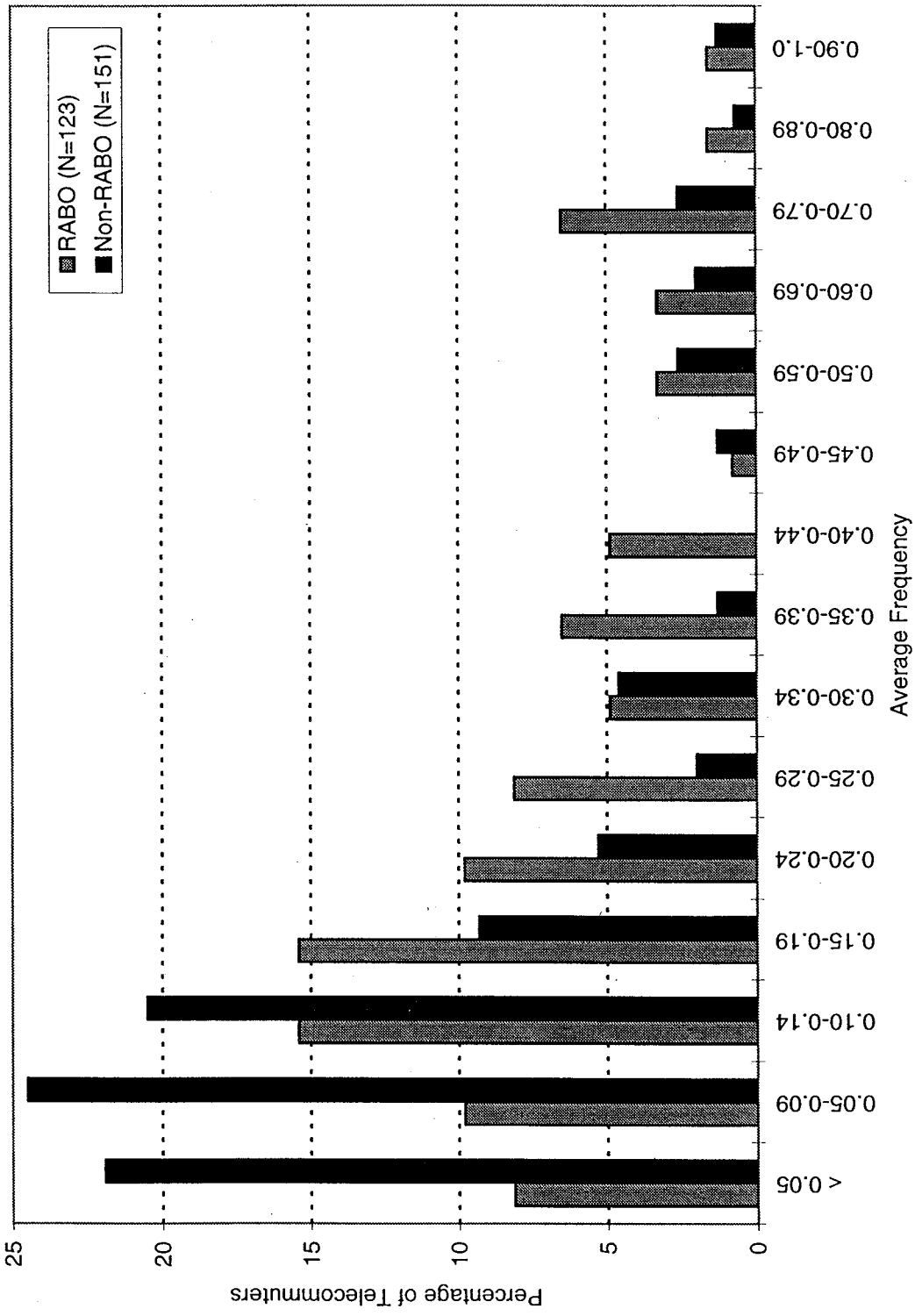


Figure 4-9: Distribution of Average Telecommuting Frequency

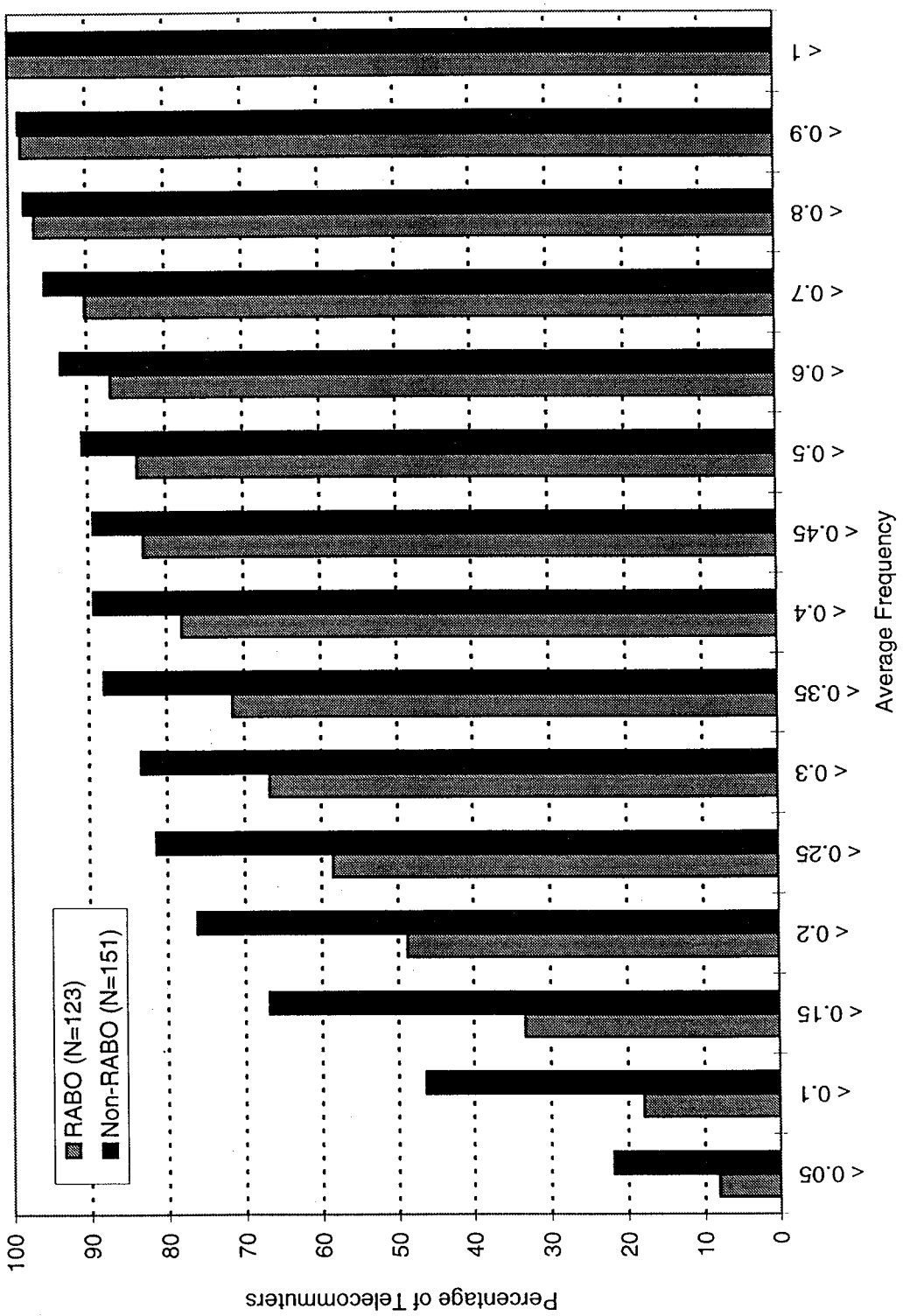


Figure 4-10: Cumulative Distribution of Average Telecommuting Frequency

combined was 22%, or about 1.1 days a week. However, nearly 64% of the combined sample telecommuted less than one day a week. At RABO sites, about 8% of the telecommuters telecommuted on fewer than 5% of their working days. This implies that, for them, the average length of time between two telecommuting occasions was more than a month. Nearly half of the RABO telecommuters telecommuted less than one day per week, and about 29% telecommuted one to two days per week, on average.

The average telecommuting frequency at non-RABO sites (17.3%) was lower than that at RABO sites (28.2%). Nearly 22% telecommuted less than once per month on average. About 76% telecommuted less than one day per week. The longer period of observation available for non-RABO sites may include a period of no telecommuting by the participants since some of the users were found to stop telecommuting for an extended period of time and then restart later on. Another possible explanation of the difference is that non-RABO site users may have been more likely not to sign in on occasions when they actually did use the center. Since non-RABO sites did not have the same contractual obligation to maintain target occupancy levels as the RABO sites did, they may not have rigorously enforced a policy of signing the attendance log on every occasion.

From the presentation of the average telecommuting frequency, it should not be inferred that telecommuters had a constant telecommuting frequency. The telecommuters are likely to have had several periods with different telecommuting frequencies during the entire duration of telecommuting. Therefore, the average frequency only reflects aggregate individual telecommuting behavior.

4.4.3 Comparison of Different Measures of Telecommuting Frequency

The center-based telecommuting frequency for project participants may be estimated from two sources, namely, the after attitudinal surveys and the sign-in logs. The preceding section discussed the distribution of telecommuting frequencies based on the complete available sign-in log data for 123 RABO and 151 non-RABO telecommuters. An average frequency of 22% was found, for telecommuting durations ranging from one to fifty-three months. However, from the attitudinal survey data for the 69 RABO and non-RABO respondents who completed after surveys (Table 3-12 in Section 3.2.5), a "current" average telecommuting frequency of 33% was computed. This difference between data sources may be due to differences in the sample (those who completed the after survey may have been higher-frequency telecommuters), changes in the frequency of telecommuting over time, and/or a survey response bias.

We chose to explore further the third possibility, that of a survey response bias. In particular, it is of interest to obtain some insight into how respondents interpreted the attitudinal survey question (D11a, see Appendix A), "How much do you currently telecommute from a telecommuting center?" Since no specific time frame was given in the question, several interpretations are plausible. Respondents may have tended to report their most recent frequency (say, over the last month), an average frequency since the start of telecommuting, or some perceived "typical" frequency which may or may not relate to either of the previous possibilities. It was hypothesized that responses to the attitudinal survey will tend to overstate the actual amount of telecommuting. There may be a number of reasons for this, including the tendency to telescope less frequent events into a shorter time frame than the actual, a desire to increase the apparent success of the program, and "wishful thinking" – that is, a tendency to confound the actual frequency of telecommuting with a desired, perhaps an explicitly-stated, target frequency. To examine this hypothesis, the sign-in log data for

the 69 attitudinal survey respondents was used to obtain the telecommuting frequency both during a one-month and a six-month window prior to the date on which the respondents filled out the after attitudinal surveys.

For the purposes of comparing these alternate measures of telecommuting frequency, a month was considered to have 22 working days. Holidays are disregarded, which means that the aggregate results discussed here slightly underestimate the frequency of telecommuting as a proportion of actual workdays. However, in reporting their telecommuting frequency as a general rate (for example, 1 to 2 days per week) in the attitudinal survey, it is unlikely that respondents precisely factored in the influence of holidays. In any case, the assumption is a convenient simplification, and as it is applied to all frequency measures equally, it should not affect the results of the comparison. Also, in calculating the average frequency from the attitudinal survey, the midpoint of the category checked was initially taken as the telecommuting frequency for that person (for example, the response category "about 1-3 days a month" was treated as a telecommuting frequency of 2/22, or 9.09%). The average frequencies obtained from the 69 attitudinal surveys and the corresponding sign-in log entries are shown in the first three rows of Table 4-11.

Table 4-11: Average Telecommuting Frequency

Source	Mean (S. D.)
Attitudinal survey (AS)	33.0% (30.5)
Six-month sign-in log (SIL6)	22.9% (21.8)
One-month sign-in log (SIL1)	23.3% (24.6)
Attitudinal survey (AS) [1]	26.8% (29.5)

[1] Using the lower bound rather than the midpoint of each category checked as the telecommuting frequency.

As hypothesized, the highest measure of telecommuting frequency was obtained from the attitudinal survey: 33%, or 1.65 days per week on average. The next highest measure was the one-month window from the sign-in log, showing an average 23.3% or 1.17 days per week frequency. The six-month sign-in log measure was 22.9%, or 1.15 days per week. The difference between the two sign-in log averages is not statistically significant ($t = 0.10$; p-value = 0.923). However, the differences between AS and SIL6 ($t = 2.23$; p-value = 0.027), and between AS and SIL1 ($t = 2.06$; p-value = 0.042) are statistically significant at a 0.05 level of confidence. Thus, initially the evidence seems to support the hypothesis that on the attitudinal survey, respondents overstated their actual telecommuting frequency as determined by the attendance log.

However, another potential cause for this result should be examined. It may be that the majority of the frequencies reported in the attitudinal survey actually fell in the lower half of the chosen categories. For example, in the "1-2 days a week" category, it is possible (even likely) that more respondents telecommuted one day per week than two days per week. If this were true, then taking the midpoint of the interval as the average frequency for each category artificially inflated the overall average.

To further examine this potential cause of the observed results, the lower bound rather than the center of the interval was taken as the representative value for each category in the attitudinal survey, and the telecommuting frequency average was re-calculated. Now, if the obtained average were still significantly different from the averages obtained from SIL1 and SIL6, then a reasonable conclusion would be that the respondents consistently over-reported their frequencies. However, if the obtained average were not significantly different, then either or both of the above two reasons could be valid. Note that using the lower bound as the representative value is a conservative test, as the true average for the category is almost certainly higher than the lower bound.

The average telecommuting frequency obtained from the attitudinal survey, using the lower bound rather than the midpoint of the interval as the frequency value for each category, is presented in the last row of Table 4-11. Using this approach, the average obtained from the attitudinal surveys is still greater than the averages obtained from the one-month and six-month sign-in log data. However, t-tests reveal that the differences between AS and SIL6 ($t = 0.89$; p-value = 0.376) and between AS and SIL1 ($t = 0.77$; p-value = 0.405) are not statistically significant. This implies that the higher average obtained from the attitudinal surveys could be the result of either an over-reporting bias on the part of the respondents in the attitudinal survey, or an artifact of the way point frequencies were estimated from the categorical (interval) responses.

This equivocal result calls for even deeper exploration. Since we have the sign-in log data representing actual telecommuting frequencies, we can reconstruct the true distribution of frequencies across the sample and compare that to the distribution based on the reported frequencies of the attitudinal survey. If the observed result is due to the fact that actual frequencies tend to fall in the lower half of the reported frequency category, the distributions from the two sources will match relatively closely at the category level. If, on the other hand, reported frequencies tend to overstate actual frequencies, then there will be a mismatch of the two distributions, with the reported frequency distribution disproportionately skewed toward higher frequency categories.

Figure 4-11 and Table 4-12 show the telecommuting frequency distribution from the attitudinal survey data, six-month sign-in log data, and the one-month sign-in log data. Visually, the figure indicates that although the AS distribution is relatively similar to the SIL1 distribution, it is skewed slightly upward. In particular, several more respondents reported an AS frequency of three or more days per week than actually telecommuted that often within the last month, which accounts for the higher average frequency obtained from the attitudinal survey. Nevertheless, a chi-squared test emphatically fails to reject the hypothesis that the two distributions are equivalent. Similar observations apply to the comparison between the AS and SIL6 distributions.

In Table 4-12, the two numbers in the parentheses depict the number of respondents whose frequencies fell into the lower half and the upper half of the category, respectively. From the figures in the parentheses, we see that for both SIL6 and for SIL1 the frequency values do predominantly lie in the lower half of the categories ([38 lower, 31 upper] and [44 lower, 25 upper], respectively).

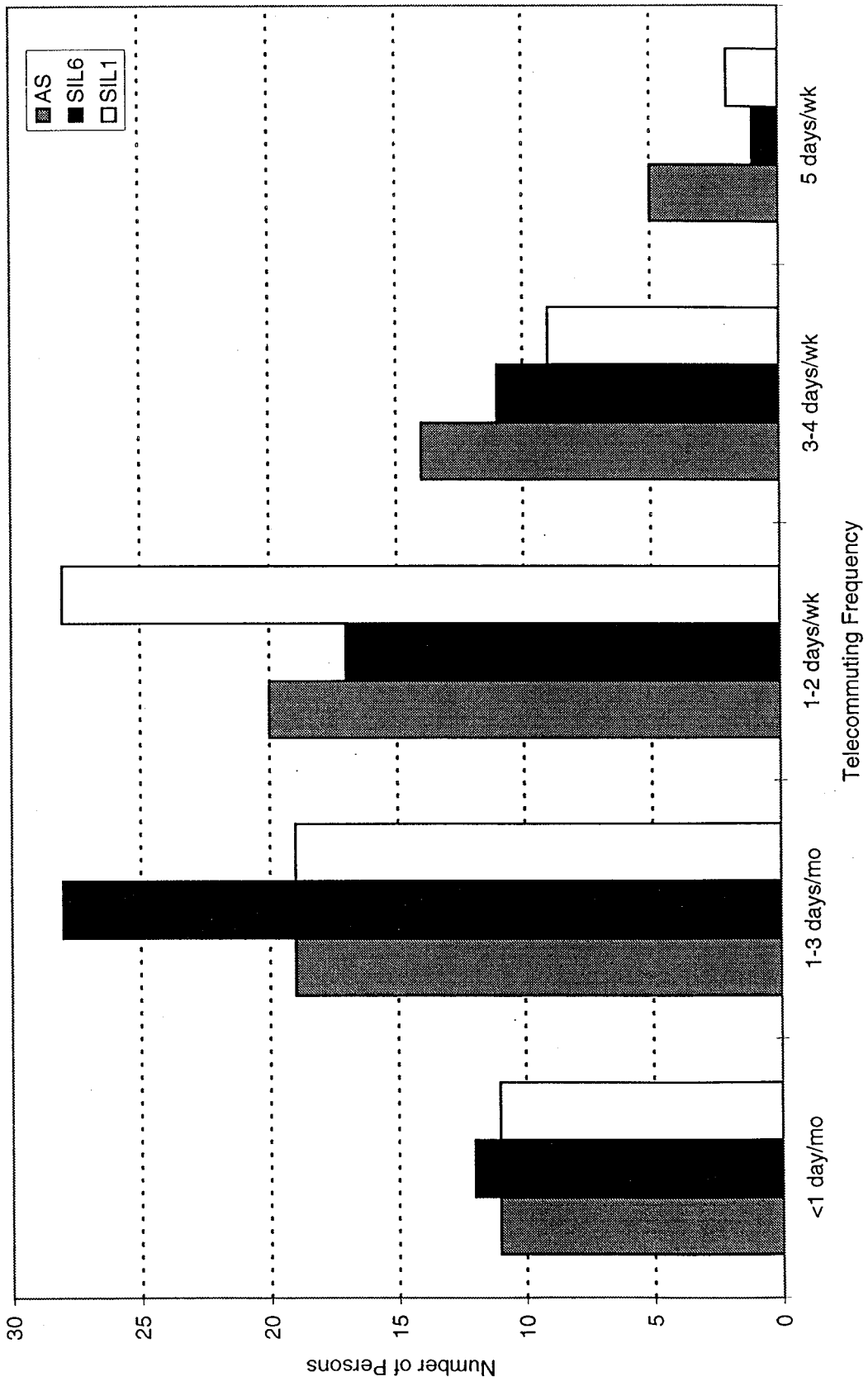


Figure 4-11: Telecommuting Frequency Distribution (N=69)

These results indicate that the telecommuting frequencies reported in the attitudinal survey do not differ significantly from the actual frequencies, within either the preceding month or the preceding six months. Thus, there is no strong evidence to support the hypothesized over-reporting bias. The results further suggest relative stability in telecommuting frequencies over a six-month period, at least in the aggregate. That is, on average, telecommuting frequencies neither increased nor declined over the six-month window analyzed. Individual telecommuting frequencies may still have fluctuated, however.

Table 4-12: Comparison of Three Measures of Telecommuting Frequency (N = 69)

Frequency	Attitudinal Survey (AS)	Six-month Sign-in Log (SIL6)	One-month Sign-in Log (SIL1)
< 1 day/month	11	12 (5, 7)	11 (11, 0)
1-3 days/month	19	28 (14, 14)	19 (10, 9)
1-2 days/week	20	17 (9, 8)	28 (18, 10)
3-4 days/week	14	11 (9, 2)	9 (5, 4)
5 days/week	5	1 (1, 0)	2 (0, 2)

SIL6-AS: $\chi^2 = \mathbf{3.58}$ (critical χ^2 (3, 0.05) = 7.81)
SIL1-AS: $\chi^2 = \mathbf{3.47}$ (critical χ^2 (3, 0.05) = 7.81)
SIL1-SIL6: $\chi^2 = \mathbf{4.50}$ (critical χ^2 (3, 0.05) = 7.81)
(The χ^2 values were calculated after combining 5 days/week cells with 3-4 days/week cells.)

4.4.4 Proportion of Telecenter-only Working Days

In the aggregate analysis, it was found that the RABO telecommuters worked entirely at the telecenter for nearly 60% of the days on which telecommuting occurred. Individual telecommuting behavior is further analyzed below.

Figure 4-12 illustrates the distribution of telecenter-only working days. The proportion is calculated by dividing the number of telecommuting-only days over the total number of telecommuting occasions for an individual. Among the 123 telecommuters at RABO sites, 18.7% worked entirely at the telecenter on all telecommuting days, and another 26.8% had a high proportion (80%-99%) of telecenter-only days. It was also found that seven telecommuters (4.1%) worked at additional workplaces on all telecommuting days. Approximately 30% of the RABO telecommuters worked at more than one location on telecommuting days at least 60% of the time.

The distribution according to each site shown in Table 4-13 has some consistency with the patterns found in the aggregate analysis (shown in Table 4-5). Modesto had the highest proportion of telecenter-only telecommuting occasions, with 60% of its telecommuters working only at the telecenter on their telecommuting days. By contrast, the two Vacaville sites had a relatively small proportion of telecenter-only occasions, with about 47% of their telecommuters having telecenter-only occasions 40% of the time or less. The implication is that these individuals frequently worked at two or more workplaces on telecommuting days.

Figure 4-12: Proportion of Telecenter-only Working Days by RABO Telecommuters (N=123)

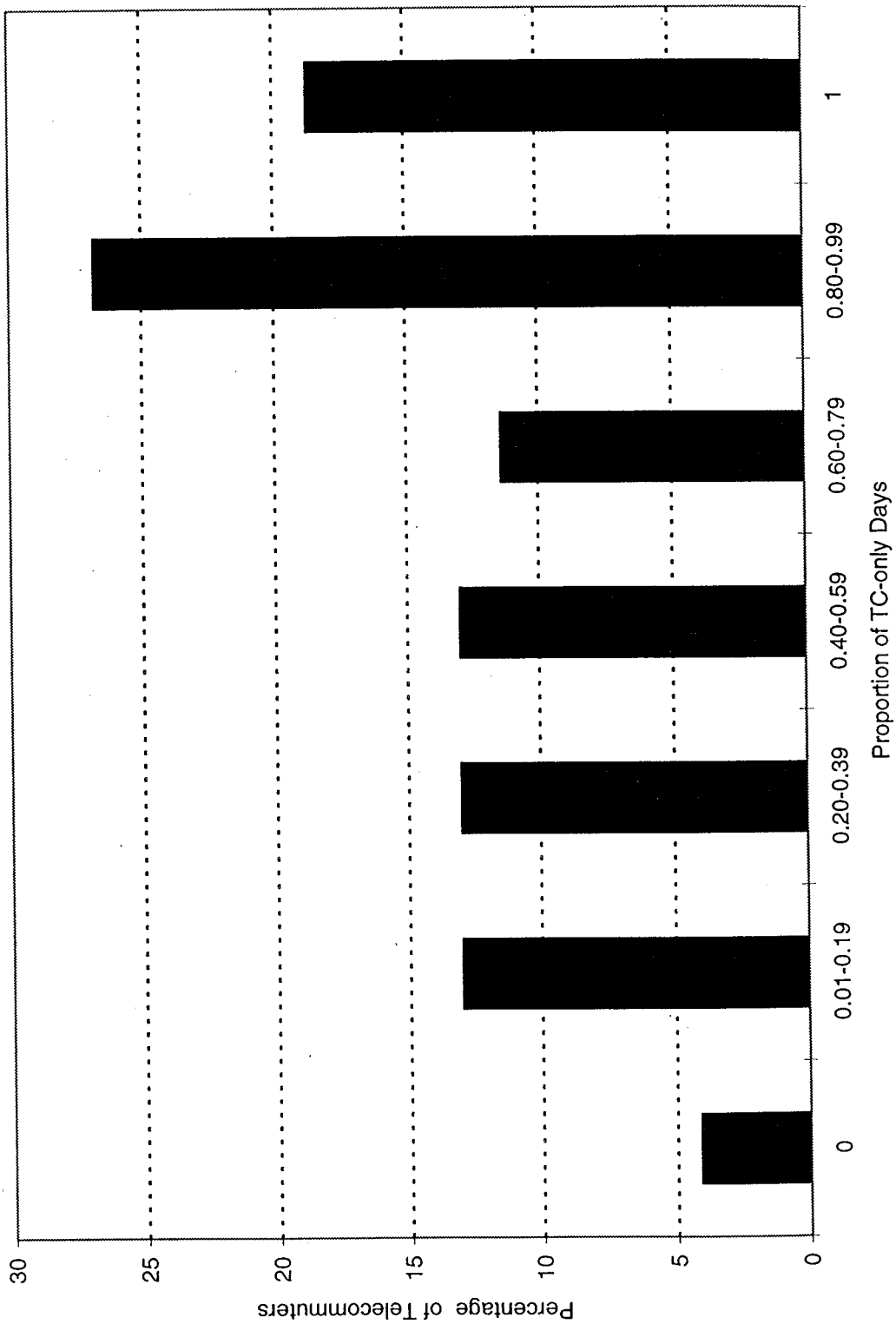


Table 4-13: Distribution of the Percentage of Telecenter-only Working Days by RABO Telecommuters

Site	N	0%	1-19%	20-39%	40-59%	60-79%	80-99%	100%
Coronado	11	18.2%	18.2%	---	9.1%	18.2%	36.4%	---
Grass Valley	11	---	9.1%	9.1%	9.1%%	9.1%	45.5%	18.2%
Anaheim	10	---	10.0%	10.0%	20.0%	---	50.0%	10.0%
Vacaville (2 Sites)	30	3.3%	20.0%	23.3%	16.7%	6.7%	6.7%	13.3%
Davis	3	---	---	---	33.3%	---	33.3%	33.3%
Chula Vista - H St.	16	---	12.5%	18.8%	25.0%	25.0%	18.8%	---
Modesto	10	10.0%	---	---	---	---	30.0%	60.0%
Chula Vista - F St.	9	---	---	11.1%	---	22.2%	33.3%	33.3%
Ventura	11	9.1%	36.4%	18.2%	---	9.1%	9.1%	18.2%
La Mesa	4	---	---	---	---	25.0%	50.0%	25.0%
Moorpark	4	---	---	25.0%	---	---	25.0%	50.0%
San Juan Capistrano	4	---	---	25.0%	50.0%	---	---	25.0%
Total	123	4.1%	13.0%	13.0%	13.0%	11.4%	26.8%	18.7%

4.4.5 Individual Work Time Spent at the Telecenter

From the aggregate analysis, it was found that work time spent at the telecenter on telecommuting occasions varied because telecommuters worked at a number of different locations in the same day. In this section, an attempt is made to establish the pattern of individuals. The behavior at a disaggregate level may differ from the average results of the site-level analysis.

The average work time spent at telecenters by an individual was calculated by dividing the sum of work time for all his/her telecommuting occasions by the total number of those occasions (missing data were excluded). The distribution of the resulting average work time is presented in Figure 4-13. About half of the telecommuters worked at the telecenters more than six hours per telecommuting occasion on average. More than three quarters (75.7%) stayed at the telecenters for more than four hours. This shows that the telecenter was the main workplace for most of the telecommuters on telecommuting days even though they might have more than one work location. A substantial minority (about a quarter of the sample), however, typically used the telecenter for half a day or less – either as a drop-in location between work-related meetings elsewhere or in conjunction with telecommuting from home or commuting to the conventional workplace.

Interestingly, a significant proportion of the RABO telecommuters (10.6%) were likely to work more than eight hours per day at the telecenter. On average, 39.1% worked at the telecenter for at least seven hours per telecommuting day. However, from the distribution shown in Figure 4-12, only 18.7% worked exclusively at the telecenter. Even if they all worked for at least seven hours, there still is a significant proportion of individuals (20.4%) who not only worked at the telecenter for at least seven hours on average but also spent some time at other workplaces.

4.4.6 Mode Choice to the Telecenter

The examination of the mode choice behavior of the telecommuters uses an approach similar to the previous analysis of individual patterns of workplace use. The frequency of driving alone on telecommuting days is calculated through dividing the number of telecommuting occasions on which a person drove alone by the total number of telecommuting occasions for that individual.

Figure 4-14 shows the corresponding distribution at RABO sites. About 46% of the telecommuters drove alone to the telecenter for all telecommuting occasions. Almost three-quarters (73.8%) drove alone frequently (more than 75% of their occasions). Only 1.6% of the telecommuters never drove alone to the center. The above findings confirm that driving alone was the prevailing transportation mode of choice despite the effort to locate the centers close enough to residential neighborhoods so that walking and biking would be attractive options.

4.5 Summary and Conclusions

This chapter describes a study of the telecommuting patterns of center-based telecommuters, based primarily on information compiled from the attendance logs at the telecenters. This analysis identifies patterns of telecommuting duration and frequency, and increases our understanding of telecommuter working behavior on telecommuting days. The study analyzes telecommuting patterns both at the aggregate (site) level and the disaggregate (individual) level. Both analyses are consistent with each other and complementary.

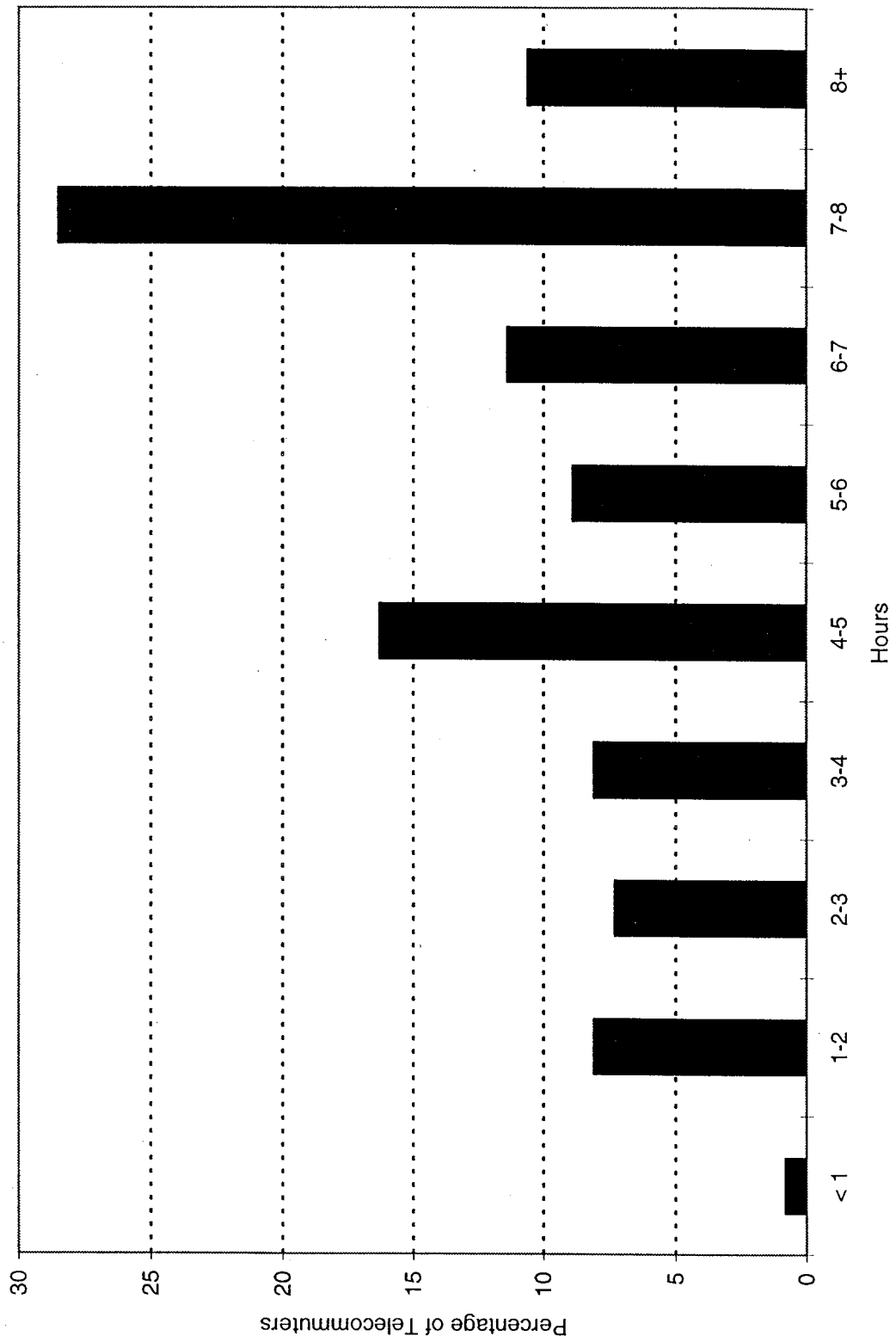


Figure 4-13: Distribution of Average Work Time at the Telecenter for RABO Telecommuters (N=123)

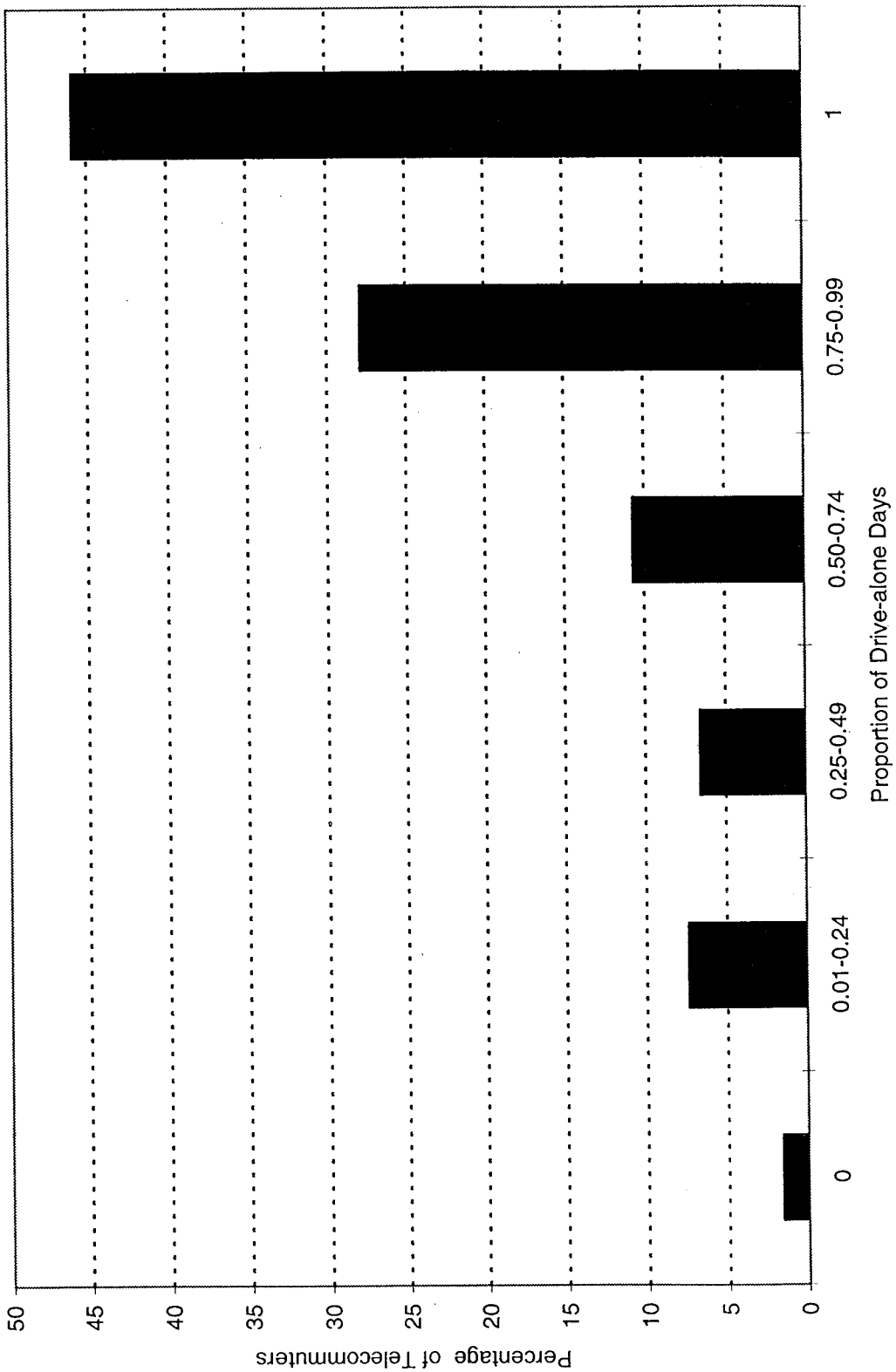


Figure 4-14: Proportion of Driving Alone to the Telecenter by RABO Telecommuters (N=123)

For most of the telecenters, a usage rate of between 15% and 25% was maintained, with a somewhat lower occupancy rate ranging from 10% to 20%. Though the usage rates fluctuated, with an apparent seasonal effect or slump in the summer, overall growth was apparent. However, a drop in average utilization after 14 months of operation may indicate that marketing efforts were not keeping pace with attrition. As of the June 30, 1996 cutoff date for this report, the RABO telecenters had been open an average of 1.3 years, with a minimum of 3.8 months and a maximum of a little more than 2.7 years. The two non-RABO telecenters have been operating for much longer, an average of 4.1 years.

The weighted average frequency of telecommuting at RABO and non-RABO telecenters combined was 22%, or about 1.1 days a week. Nearly 64% of the combined sample telecommuted less than one day a week. At RABO sites, the average telecommuting frequency was 28.2%, or 1.4 days per week. Nearly half of the telecommuters used the centers less than one day per week on average, and 29% telecommuted 1 to 2 days per week. The non-RABO telecommuters telecommuted less frequently than those who were at RABO sites; the average was 17.3%, with about 76% of non-RABO telecenter users telecommuting less than one day per week. A detailed comparison of these frequency results with those computed from the attitudinal survey, where respondents indicated how much they currently telecommuted from the center, showed no significant differences. The results suggest a relative stability in telecommuting over a six-month period, in the aggregate.

Attrition at the telecenters was relatively high, with 50% of all telecommuters quitting within the first nine months. Although little comparative data are available, this appears to be higher than for home-based programs. Reasons for quitting telecommuting are analyzed in Chapter 5. But in any case, the frequency and distribution of telecommuting are crucial factors to consider in any forecast of levels and impacts of telecommuting. Of the 123 RABO participants who telecommuted often enough to analyze, half telecommuted for at least 9 months, and more than 38% telecommuted for at least one year. At non-RABO sites, 50% of the 151 telecommuters analyzed telecommuted for at least 8 months, and 21% telecommuted for at least 2 years. There is no significant difference in the distributions of telecommuting durations between RABO and non-RABO sites, meaning that the operating length of the telecenter may not be an important factor in determining telecommuting duration.

Half of RABO telecommuters worked at the telecenters for at least 6 hours on average on their telecommuting days. The most common telecommuting pattern was to work entirely at the telecenter. Approximately 19% of the telecommuters at RABO sites telecommuted with this pattern on all of their telecommuting occasions, and an additional 24% did so at least 80% of the time. At least 31% usually worked at more than one work location, including 4% who always did. The second most common workplace combination was telecenter/other work location (i.e., other than home or the regular workplace). Contrary to expectation, center- and home-based telecommuting are not often combined on the same day; patterns involving these two locations occurred only 15% of the time at RABO sites and 1.1% of the time at non-RABO sites.

Driving alone was the dominant transportation mode used by the telecommuters in commuting to the center. About 46% of the RABO telecommuters drove alone to the center on all of their telecommuting occasions. Almost three-quarters drove alone to the center very frequently (more than 75% of their occasions).

CHAPTER 5

ANALYSIS OF TELECOMMUTING RETENTION

5. ANALYSIS OF TELECOMMUTING RETENTION

5.1 Analysis and Classification of Stayers and Quitters

Many evaluation reports on telecommuting programs make little or no reference to attrition among telecommuters. Very few actually study attrition seriously (Quaid and Lagerberg (1992) is one exception), yet the importance of this factor to estimating the adoption and impacts of telecommuting cannot be emphasized enough. Forecasts of the proportion of the workforce likely to become telecommuters (and derivative forecasts, such as impacts on transportation) implicitly assume "once a telecommuter, always a telecommuter". But if the typical participant only telecommutes six months before terminating the arrangement (or, viewed another way, if only two percent of those who will ever telecommute are doing so at any given time), then impact assessments based on the proportion of the workforce ever expected to telecommute will be wildly overstated. In this chapter, we examine the attrition of telecenter users and explore the reasons for that attrition.

Telecommuting retention is analyzed in the following three ways. In Section 5.2, the attitudes and characteristics of those participants who remain in the program (stayers) are compared with those who left it (quitters). The goal is to determine which work and household variables may affect the decision to stop telecommuting from a center. In this study, work and household data were collected using an attitudinal survey as described in Section 3.2. A subset of the before-wave data were used to compare the stayers and quitters according to selected factors that are hypothesized to influence the decision to quit.

The comparison of stayers and quitters in terms of the duration and frequency of telecenter use, presented in Section 5.3, is another way to analyze telecommuting retention. Individual telecommuting duration and frequency can be computed from the attendance log data as described in Section 4.4. A particular pattern of telecenter use may be characteristic of each group. These patterns may suggest a possible motivation for quitting or may be used as an indicator of the likelihood to quit. In addition, questions about the current and ideal distribution of work time were included in the exit interview. A difference between current and ideal work frequency can show whether a preference for telecommuting from a center still exists even though the respondent has ceased to telecommute from the center.

A third way to study attrition is to examine the motivations to quit, as presented in Section 5.4. Some possible reasons for dropping out of a telecommuting program include residential relocation, changes in job duties, technical problems, and discomfort with telecommuting. Particularly important to this project, those who quit using a telecommuting center may, in fact, prefer telecommuting from home. The motivation for leaving the telecenter program was the most important part of the exit interview, which was conducted, where possible, with each telecenter user who left the project. Reasons given for quitting by managers of telecommuters are discussed in Section 5.5.

Before the aforesaid analyses can be conducted, an appropriate study group must be chosen. The identification of the sample of stayers and quitters begins with the group of respondents to the before employee survey. The before-wave data are used here since not all participants in the RABO Project (especially those who quit) completed after surveys. The attitudinal data will allow the comparison of attitudes and characteristics between the two groups of interest (see Section 5.2). Of the 206 respondents in the before-wave data set, 56 were classified as either home-based or non-

telecommuters and were excluded from further consideration for the final analysis of telecommuting retention. The remaining 150 telecenter respondents were assigned stayer or quitter status according to information collected from the attendance logs through June 30, 1996 (see Section 4.4.1 for the classification procedure). According to this classification process, 44 of the respondents are stayers and 106 are quitters.

As mentioned, the analyses for each of the three sections (5.2 - 5.4) used different data sets: Section 5.2 involves the before employee attitudinal survey data, Section 5.3 the sign-in log data, and Section 5.4 the employee exit interview data. The basis for classifying individuals as stayers or quitters remained the same in each database except for a small group of respondents who quit telecommuting because their telecenter closed. For the analyses in Section 5.2 (as well as those in Section 4.4.1), these individuals were considered stayers because, even though they quit, it is assumed that they would have continued to telecommute if the center had stayed open. The focus of Section 5.4, however, was to study reasons for quitting (including the telecenter closing), so there, these individuals were classified as quitters. While the classification of stayers and quitters remains constant (with the above exception) the sample sizes of each data set will not be the same. The data set of Section 5.2 is a subset of the sign-in log data used in Section 5.3, with only those who completed a before attitudinal survey included. (This excludes individuals who began telecommuting before the start of the project and did not fill out a before survey). Additionally, some of the individuals who filled out the sign-in log and/or the before attitudinal survey may not be included in Section 5.4 because they did not participate in an exit interview. No demographic or attitudinal data were available for respondents who were only in the attendance log database.

5.2 Attitudes and Characteristics of Stayers and Quitters

Unlike the earlier description of telecommuter characteristics (see Section 3.2), the following comparison of the stayers and quitters only uses the data collected in the before surveys. Data from the early wave of surveys are used since the majority of the quitters ceased telecommuting prior to the administration of the later wave of surveys. Thus, information on attitudes and characteristics is only available from the before surveys. The comparison of the survey results for the 44 stayers and 106 quitters covers the sections of the survey in the following order: demographic and travel characteristics, work characteristics, amount of telecommuting experience, and preferences for time spent telecommuting.

The stayers and quitters are relatively similar according to demographic indicators. There are comparable distributions for gender, age, and educational background. Both groups are statistically similar in terms of household size and available vehicles (see Table 5-1). Stayers have longer commutes (one-way) to the regular workplace by 4.5 miles and shorter commutes to the telecenter (one-way) by 2.8 miles (which might suggest a stronger motivation to keep telecommuting), however these differences did not prove to be statistically significant.

Work characteristics also do not vary greatly between stayers and quitters. The distribution of manager, sales and professional positions is quite similar between the two groups. Stayers have worked for their supervisor about a year longer than quitters (suggesting manager trust/comfort might be an issue), but the difference is significant only at the 10% level of confidence. As might be expected, stayers spend slightly more time on average working independently or remotely (work ideally suited to telecommuting) and slightly less time working face-to-face or at a specific location than do quitters (see Table 5-2), but once again these differences are not statistically significant.

A similar proportion of each group (about 25%) had prior experience with telecommuting. Of those who had such experience, the quitters had telecommuted an average of one year longer than the stayers (3.2 and 1.9 years, respectively) but this difference did not prove to be statistically significant.

Table 5-1: Demographic and Travel Characteristics for Stayers and Quitters

Question	Mean		T-statistic	P-value
	Stayers (N = 44)	Quitters (N = 106)		
Household size	2.91	2.98	0.29	0.771
Full-time workers	1.48	1.39	-0.73	0.465
Part-time workers	0.27	0.32	0.46	0.645
Vehicles per household	2.20	2.01	-1.26	0.209
Miles to regular workplace (one-way)	41.63	37.14[1]	-1.03	0.302
Miles to telecenter (one-way)	6.43	9.19[2]	1.49	0.137

[1] N = 104 [2] N = 102

Table 5-2: Work Characteristics for Stayers and Quitters

Question	Mean		T-statistic	P-value
	Stayers (N = 42)	Quitters (N = 102)		
Years worked for supervisor	3.02[1]	2.22[2]	-1.64	0.103
Years worked for employer	6.55[3]	5.88[4]	-0.63	0.531
Years worked in occupation	8.71	8.95[2]	0.17	0.862
Independent or remote time	66.17%	60.78%	-1.32	0.190
Face-to-face and location-dependent time	24.48%	29.11%	1.52	0.132
Work-related travel time	9.12%	10.11%	0.45	0.652

[1] N = 38 [2] N = 100 [3] N = 40 [4] N = 98

The average ideal distributions of time between the regular work place and home are relatively similar (see Table 5-3); however, the stayers assign somewhat more time than the quitters to the telecenter ($p = 0.08$) and the quitters prefer somewhat more time telecommuting from home than the stayers ($p = 0.41$). Although these (especially the latter) did not prove to be significant differences in this data set, they may be indications of distinct preferences among some telecommuters for one form of telecommuting but not the other.

Quitters and stayers report statistically similar average center-based and home-based telecommuting frequencies as a function of job suitability, manager support, preferences, and expectations (see Table K-1, Appendix K). Interestingly, quitters report somewhat more support from their managers for home-based telecommuting and actually prefer home-based telecommuting somewhat more than stayers. Appropriately, quitters foresee themselves telecommuting from home slightly more than stayers. Stayers ideally would spend more of their work time at the telecenter (see Table 5-3) and expect to be telecommuting from centers more of the time in the future than do the quitters, on average (see Table K-1, Appendix K). Although none of these differences are statistically significant, they further suggest a preference in the quitters group for home-based telecommuting and not necessarily a functional problem with telecommuting that causes them to quit.

Table 5-3: Telecommuting Experience and Preference for Stayers and Quitters

Question	Mean		T-statistic	P-value
	Stayers (N = 44)	Quitters (N = 103)		
Years of telecommute experience	2.28[1]	3.22[2]	0.45	0.656
Ideal % of time at the regular workplace	46.07%	45.83%	-0.05	0.961
Ideal % of time at the telecenter	42.52%	34.79%	-1.77	0.079
Ideal % of time at home	9.82%	12.29%	0.83	0.406
Preferred frequency (% of days) from a center	51.14%	53.15%[3]	0.36	0.719
Preferred frequency (% of days) from home	20.90%[4]	27.96%[5]	1.26	0.211

[1] N = 14 [2] N = 23 [3] N = 102 [4] N = 43 [5] N = 100

Similarly, respondents' evaluations of their own performance on the job, their satisfaction with their current job and employer, and their evaluation of their supervisor's satisfaction with their work show no significant differences between stayers and quitters (see Table K-2, Appendix K).

There are few meaningful differences between stayers and quitters in attitudes and preferences concerning their work environment. In fact, only four of the ninety responses to work environment questions carry statistically significant differences (see Table K-3, Appendix K). Substantially more of the quitters responded that they would have enough space to work at home (which would facilitate an existing preference of quitters for home-based telecommuting, and conversely indicate a constraint on stayers' ability to work from home). While both stayers and quitters agreed that they work effectively from all three workplaces, stayers agreed more strongly than quitters that they work effectively at the regular workplace. Finally, stayers agreed that they could dress the way they like at the regular workplace and the telecenter significantly more than quitters. Ironically, the only value that proves significant in the work characteristic importance means (see Table K-4, Appendix K) is that stayers rate dressing the way they like as more important than quitters ($p = 0.021$). But the mean importance for both groups of this attribute is not as high as others (see Table 3-7), indicating that this attribute is not central to the telecommuting decision.

Although the results of the attitudinal survey serve to characterize the stayers and quitters, they do not offer much insight into why some participants chose to quit. There is some indication of a pre-disposition (or least a *post hoc* preference) for home-based telecommuting being associated with quitting, but the evidence is not statistically strong. Even the statistically significant results reported above do not provide compelling reasons for wanting to stop telecommuting. In fact, the quitters do not view the telecenter negatively for any characteristic which might be expected of those who want to quit (such as feeling motivated at work, distractions from others, having necessary equipment, etc.). However, these surveys were administered prior to the start of telecenter use, so attitudes about working from the telecommuting center may have changed over time. As a result, there is little basis for predicting who will quit telecommuting from the center using the data collected with the before wave of attitudinal surveys.

5.3 Telecommuting Frequency and Duration of Stayers and Quitters

The attendance logs are the primary data source for telecommuting duration and frequency (see Sections 4.4.1 and 4.4.2 for duration and frequency measures for the overall sample of project participants). Although both the attitudinal survey and the exit interview ask these questions about telecenter use, these responses are considered to be only rough estimates. While there are undoubtedly a few missing telecommuting occasions in the attendance logs (as discussed in Ch. 4), they likely provide the best measure of frequency. Importantly, some of the quitters had zero duration and frequency: those participants who did not use the center at all, or who used it only once.

Using the attendance log data, it is of interest to examine the relationship between telecommuting frequency and retention (stayer/quitter status). Table 5-4 shows that stayers telecommute more often than quitters, on average – about 1½ and 1 day(s) a week, respectively. Similarly, the medians and standard deviations of stayers' frequencies are also larger than those of quitters. Thus, stayers not only telecommute more often than quitters, but have more variability as a group in their telecommuting frequency than do quitters. The difference in mean frequencies is statistically significant; however, the distributions of telecommuting frequency for stayers and quitters, shown in Figure 5-1, are only marginally significantly different according to a chi-squared test (p-value = 0.069).

Table 5-4: Telecommuting Frequency of Stayers and Quitters

Group	Frequency			
	N	Mean	Median	Std. Deviation
Stayers	66	28.2%	17.5%	26.2%
Quitters	208	20.2%	13.1%	19.5%

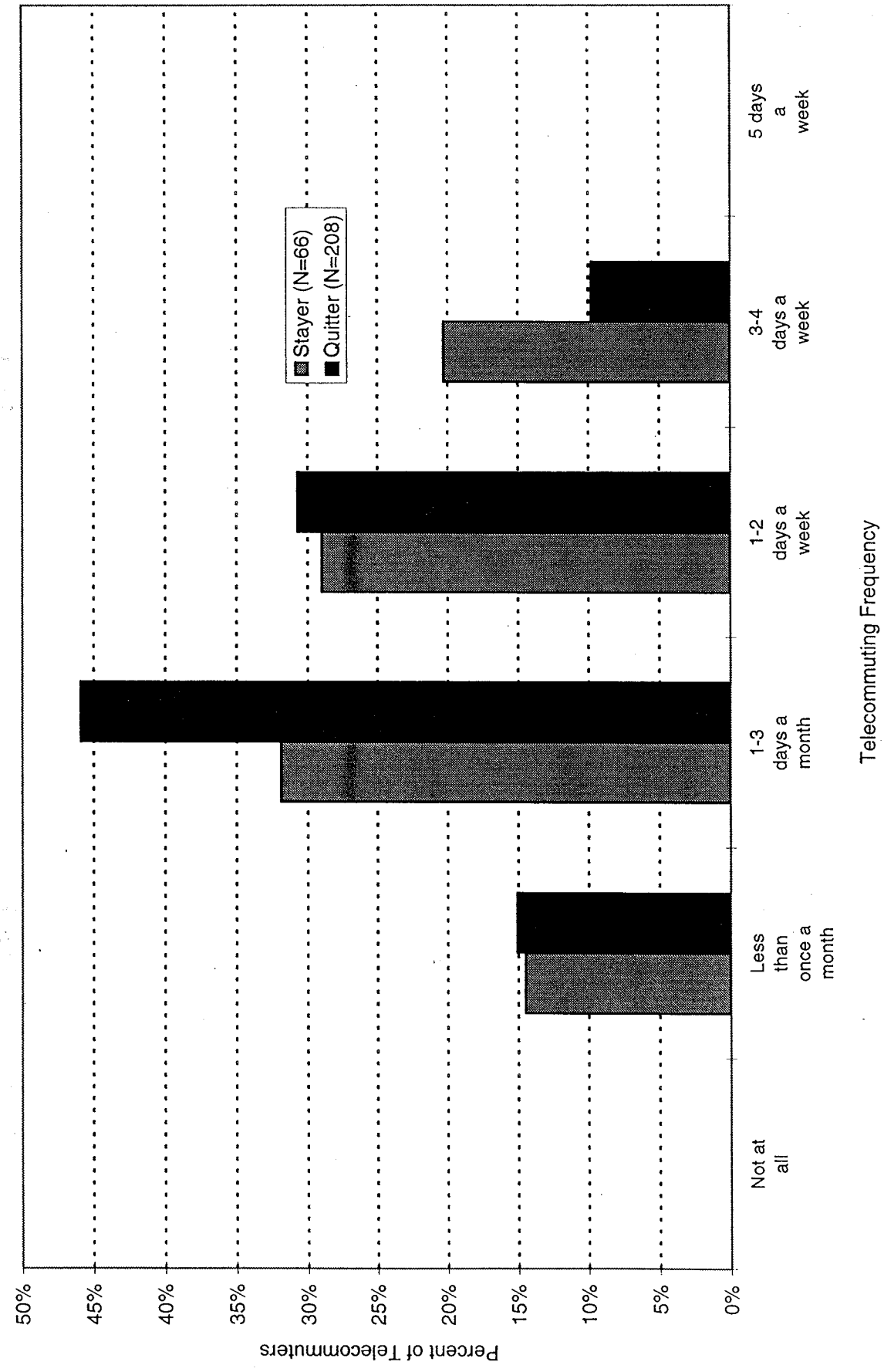


Figure 5-1: Frequency Distribution of Stayers and Quitters

As mentioned earlier, questions concerning telecommuting duration and frequency were included in the exit interview. The means for duration and frequency from the surveys conducted directly with the participant (first-hand information) are reported here. On average, the quitters reported using the telecenter for 12.1 months (standard deviation = 13.4, N = 71). The average telecommuting frequency given by this group was 4.6 days per month, or 21% (std. dev. = 4.4, N = 72). Although there are missing data from the exit interviews, the self-reported telecommuting duration is much higher than the average calculated according to the attendance log data, while the self-reported frequency is relatively close (but still higher). These differences are caused by misperception on the part of the participants, missing data (either missing entries in the attendance log, different samples between the attendance log and the exit interview, or both), and/or (for frequency) variation in the pattern of telecenter use.

The last section of the exit interview asked about the ideal distribution of work time. At the time of the interview, these quitters worked primarily at the regular workplace (for 76.6% of their time) or at another location (11.7%, on average). Additionally, the participants worked from home for 10.9% of the time, on average, and only one respondent was utilizing another telecenter. However, according to the respondents, the average ideal distribution of their work time at the regular work place, the telecommuting center, and home would be 53.4%, 20.1%, and 14.2%, respectively. So, many of the workers still preferred to use the telecenter but were not able to due to certain circumstances.

5.4 Reasons for Quitting

In this section, we examine the motivations to quit center-based telecommuting and the extent to which quitters remain interested in telecommuting. An attempt was made to conduct an exit interview with each participant who quit during the project, primarily in order to identify the reason for quitting. However, contacting and eliciting the information from all quitters proved to be difficult since they may no longer have perceived an obligation to participate in the evaluation or may have changed phone numbers. Despite this, at least some data (some of it second-hand) are available for 161 respondents.

Importantly, some participants quit the project without ever telecommuting from a center. Although this information was not specifically requested during the exit interview, most respondents discussed this factor if it applied to their experience. In order to verify this, the attendance log data were cross-checked. Five respondents who reported never using the center actually had signed the attendance log at least once. Accordingly, these five quitters were considered to have used the center. Conversely, six respondents did not have entries in the attendance log but did report using the center up to four times. In these cases, the exit surveys were considered to reflect their true behavior since respondents would be more likely to forget or not know to sign in rather than to fabricate telecommuting activity. After reclassification, there were thirty participants who quit the project without using the telecenter, and of these, the reason for quitting was unknown for 13 (43.3%) (see Table 5-5).

First-hand data were obtained from direct communication with the respondent in the form of an exit interview. When the employee could not be reached after several attempts, second-hand information on the reasons for quitting was obtained from site administrators, co-workers, or managers. Second-hand information is less reliable but is still considered useful and hence is included in this analysis. See Table 5-5 for the distribution of first- and second-hand information. Reasons for quitting are

known for 114 people or 71% of the sample. They will be the focus of this section and are shown in Table 5-6.

Table 5-5: Reporting Quality vs. Center Use and Knowledge of Reason for Quitting

		Reporting Quality		Total
		First-hand	Second-hand	
Center used	Yes	70 (53.4%)	61 (46.6%)	131 (81.4%)
	No	8 (26.7%)	22 (73.3%)	30 (18.6%)
Reason for quitting	Known	64 (56.1%)	50 (43.9%)	114 (70.8%)
	Unknown	14 (29.8%)	33 (70.2%)	47 (29.2%)
Total		78 (48.4%)	83 (51.6%)	161 (100.0%)

Because it was possible for a respondent to provide more than one reason for quitting, there are 117 responses given by 114 respondents in Table 5-6. The percentages listed in the table columns were calculated on a *respondent* basis (N = 64, N = 50, N = 114, respectively). The most frequently given reasons for quitting were job-related (37.7%). Sixteen respondents (14.0%) left the organization and another two (1.8%) were laid off. Sixteen others were forced to stop telecommuting from the center because they formally changed positions within the organization or switched to doing different, presumably less telecommutable, tasks. These effects were in many cases caused by restructuring that resulted in a reduction in staff and required the remaining employees to take over some tasks that formerly belonged to other positions. Thus, the participants needed to be at the main office more or in some other way could not complete their new tasks at the telecommuting center. Similarly, in a previous study of home-based telecommuting retention, office problems and job changes accounted for 29% of the reasons for dropping out of the program (Quaid and Lagerberg, 1992).

The second most frequent reasons for quitting were manager- or supervisor-related (14.9%). Fifteen respondents (13.2%) were either required or encouraged to quit telecommuting from the center and another three (2.6%) changed supervisors. Other reasons given for quitting were center-related (13.2%) or personal (9.6%), centering around the telecenter closing (12.3%) and the respondents moving their residence away from the telecenter (7.9%), respectively. Ten of the respondents (8.8%) quit telecommuting from the center in order to telecommute from home instead. Three individuals (2.6%) apparently dropped out because of an unwillingness to complete the evaluation requirements and 17 respondents (14.9%) gave other miscellaneous reasons for quitting. Importantly, no respondents indicated that the reason they quit was due to not liking center-based telecommuting or because they did not receive enough contact.

The exit interview also contained a pair of questions about the prospects for future telecommuting by the respondent. Of the quitters who completed this part of the interview (73 of the surveys with first-hand information), only six (8.2%) respondents categorically refused to consider telecommuting from a center again, while fifteen (20.5%) would not consider telecommuting from home. For this subgroup of quitters, their preference is to continue to use telecommuting centers. The preference for more telecenter use in the future, as well as the reasons given for quitting, suggest that the

continuation of telecommuting by individuals who start is more often limited by external constraints than by personal reasons.

Table 5-6: Reasons for Quitting

Reason	Number (Percent of respondents in column)		
	First-hand N = 64	Second-hand N = 50	Total N = 114
Job-related reasons[1]	**20 (31.3)**	**23 (46.0)**	**43 (37.7)**
Changed jobs within the organization	9 (14.1)	7 (14.0)	16 (14.0)
Left organization	2 (3.1)	14 (28.0)	16 (14.0)
Job is unsuitable	4 (6.3)	1 (2.0)	5 (4.4)
Too costly	3 (4.7)	0	3 (2.6)
Technological problems	1 (1.6)	0	1 (0.9)
Laid off	1 (1.6)	1 (2.0)	2 (1.8)
Supervisor-related reasons[1]	**12 (18.8)**	**5 (10.0)**	**17 (14.9)**
Employer/supervisor required the worker to quit	8 (12.5)	5 (10.0)	13 (11.4)
Changed supervisors	3 (4.7)	0	3 (2.6)
Employer/supervisor encouraged the worker to quit	2 (3.1)	0	2 (1.8)
Center-related reasons[1]	**13 (20.3)**	**2 (4.0)**	**15 (13.2)**
Center closed	13 (20.3)	1 (2.0)	14 (12.3)
Problems with others at the center	0	1 (2.0)	1 (0.9)
Personal reasons[1]	**3 (4.7)**	**8 (16.0)**	**11 (9.6)**
Moved	2 (3.1)	7 (14.0)	9 (7.9)
Situation at home changed	1 (1.6)	1 (2.0)	2 (1.8)
Switched to home-based telecommuting	**9 (14.1)**	**1 (2.0)**	**10 (8.8)**
Didn't like evaluation requirements	**0**	**3 (6.0)**	**3 (2.6)**
Didn't like center-based telecommuting	**0**	**0**	**0**
Not enough contact	**0**	**0**	**0**
Other	**7 (10.9)**	**10 (20.0)**	**17 (14.9)**

[1] No. (percent) of respondents giving any (one or more) of the reasons in this category.

5.5 Manager Exit Interview Analysis

The previous section analyzed employees' reasons for quitting center-based telecommuting. However, managers may have a different perspective. It is important to understand managers' views of the success of telecommuting for their employees, and whether having an employee who quit telecommuting indicates a generally negative perception by the manager or just specialized circumstances for the employee. Just as an attempt was made to conduct an exit interview with each participant who quit, so was an attempt made to contact each quitter's manager for a similar exit interview. The manager exit interviews encountered difficulties similar to those experienced with the employee interviews; however, data were gathered successfully from the managers of 90 participants.

The manager and employee exit interviews were similar enough in content to allow for comparison regarding the reasons for quitting. However, the manager exit interview included several questions not included on the employee exit interview, specifically regarding overall managerial and organizational satisfaction with telecommuting in general and with center-based telecommuting in particular. These questions are identical to some of those included in the manager after attitudinal survey (see Section 3.3.6). They were asked in the exit interview in recognition of the fact that managers of quitting employees may not be filling out an after survey (thereby potentially biasing those responses to be more positive toward telecommuting than is the case for managers as a whole), or may have changed their attitudes toward telecommuting since completing the after survey. Hence, the exit interview responses to these questions are important indicators of potential managerial and organizational concerns with telecommuting. However, there may still be a selection bias, in that managers who were willing to be interviewed may be more favorable toward telecommuting and the telecenters program. As a short phone interview was considered to be less onerous than completing and returning a lengthier written survey, though, it is believed that selection bias for the exit interviews is as small as could be expected.

It should be noted that some of the managers had more than one employee participating in the project who quit and that these managers were asked to complete an exit interview for each employee. In all, 64 managers supervised the 90 employees covered by manager interviews. One manager, an anomaly, had a total of 11 employees quit telecommuting. The most employees any other manager had quit was four, and most only had one. The manager with 11 employees in the project answered many of the interview questions similarly and (not surprisingly) appeared to be dissatisfied with the research requirements (paperwork) of the project, but was also generally very satisfied with telecommuting.

The reason(s) for leaving the telecenter, as given by the managers, are shown in Table 5-7 (the frequencies do not sum to 90 because respondents could give more than one reason). As with the employee interviews, the most frequent type of reason given for quitting was job-related (37.8%). The job being generally unsuitable to telecommuting was a reason given by 12 (13.3%) of the managers, while 10 (11.1%) had employees who left the company during the project. Seven (7.8%) employees changed jobs within the company, and 6 (6.7%) had technological problems with working from a telecenter.

Interestingly, while 13.2% of the employees interviewed said they had been required or encouraged to quit by their supervisor or employer (see Section 5.4), only 3.3% of the managers interviewed gave this response. This may be partially due to the fact that the exit interviews are not a matched

set (there is not a corresponding manager exit interview for every employee exit interview, and vice versa) and the set of managerial data is somewhat smaller than the employee data. It may well be that managers who required their employees to quit were more reluctant to be interviewed. But it may also be that employees were more likely to attribute a supervisorial request to quit as a whim of the manager, whereas managers were more likely (whether "rightly" or "wrongly", objectively speaking) to attribute it to another reason such as job unsuitability. This possibility is supported by the observation that only 4.4% of the employees gave job unsuitability as a reason for quitting, compared to 13.3% of the managers. The only other responses given by managers referring to supervisor-related problems were that upper management didn't like telecommuting and that management had to sign too many forms to get telecommuting approved. More concerns about managerial support arise later in the interview and will be discussed below. Managers agreed with employees, however, in that no one in either group responded that the employee quit because the employee did not like telecommuting.

Table 5-7: Managers' Reasons for the Employee Quitting

Reason	Number (Percent of 90 respondents)
Job-related reasons[1]	**34 (37.8)**
Job is unsuitable	12 (13.3)
Left organization	10 (11.1)
Changed jobs within the organization	7 (7.8)
Technological problems	6 (6.7)
Supervisor-related reasons[1]	**5 (5.6)**
Employer/supervisor required the worker to quit	3 (3.3)
Upper management did not like telecommuting	1 (1.1)
Manager had to sign too many forms to get telecommuting approved	1 (1.1)
Center closed	**26 (28.9)**
Moved	**5 (5.6)**
Switched to home-based telecommuting	**13 (14.4)**
Didn't like evaluation requirements	**10 (11.1)**
Employee didn't like center-based telecommuting	**0**
Other	**11 (12.2)**

[1] No. (percent) of respondents giving any (one or more) of the reasons in this category.

The single most frequently given reason for leaving the telecenter project was "center closed", offered in 26 (28.9%) cases. Of these 26, 21 (80.8%) listed this as the most important reason for

leaving (20 listed it as the only reason for leaving) and 5 (19.2%) listed it as the second most important reason for leaving. For those five, the most important reasons were: changing jobs within the company or leaving the company, the job being unsuitable, or wanting to switch to more home-based telecommuting. Further, 25 (96.2%) of these 26 respondents for whom the center closed rated their general attitude toward telecommuting as positive, and one (3.8%) didn't know. Only one (3.8%) rated his/her satisfaction with center-based telecommuting as very low, whereas 16 (61.5%) rated their satisfaction as high (the remaining 9 being split 4-5 between neutral and very high respectively). These responses are consistent with the responses from the managers of quitters for whom the center had not closed.

According to the managers' responses, 5 (5.6%) employees moved, and switching to home-based telecommuting took 13 (14.4%) participants out of the project. The other reasons for quitting fell into several broad categories: 5 (5.6%) reported that the company built or found a better/closer location; 2 (2.2%) managers reported that the employee never started using the center, and 1 (1.1%) manager noted that the employee went on disability. Three more managers marked the "other" selection but did not explain.

While the pair of questions concerning future telecommuting preferences showed a distinct preference of employees for more telecenter use in the future (see Section 5.4), the managers generally supported both telecenter and home-based telecommuting. All 90 of the manager interviews had responses to these questions. Only 5 (5.6%) of the managers said they would not consider letting an employee telecommute from a center in the future, and 7 (7.8%) said they would not consider it from home. Conversely, 71 (78.9%) said they would consider letting an employee telecommute from a center in the future and 65 (72.2%) said they would consider it from home. For both home-based and center-based telecommuting, 14 (15.6%) managers said that they may consider it depending on the employee in question, and given more potential to monitor their employees. The remaining respondents answered "don't know" to these questions.

The manager exit interview included an open-ended question that asked, "Under what circumstances could/would your employee use the telecenter again?" Seventy-eight (87%) of the managers answered this question and most of the responses fell into several broad categories. Twenty-six of the 78 (33.3%) responded that if a center were available and an employee wanted to telecommute she or he could do so as long as the job got done. Conversely, 9 (11.5%) managers responded that it was not possible at the time because of company policy or lack of upper management support. If the job permitted telecommuting, 13 (16.7%) managers claimed that it would be available to the employee. For 10 (12.8%) responses the research requirements would have to be lifted for the employee to use the center. A few of the managers indicated that they were concerned about the location of the centers, 8 (10.3%) stating that if the center were conveniently located or cut down on the commute time it would be allowed. Six (7.7%) managers referred to the need for adequate monitoring of the employee. Two managers each responded "if center reopened" and "if free".

Two questions attempted to elicit managers' general attitudes toward telecommuting and their level of satisfaction with center-based telecommuting in particular (see Table 5-8). Regarding the question, "What is your general attitude toward telecommuting?", 82 (91.1%) responded that their general attitude was positive, 5 (5.6%) responded that their attitude was neutral, and only 2 (2.2%) responded negatively. Regarding the question, "How would you rate your level of satisfaction with center-based telecommuting?", 59 (66.3%) responded that their satisfaction with center-based telecommuting was either high or very high. Twenty-seven (30.3%) gave a neutral rating and 3

(3.4%) rated it as low or very low. Hence, while very few managers were actively dissatisfied with telecommuting or telecenters, they were considerably more neutral about telecenters than about telecommuting in general. On the other hand, two-thirds of the sample were highly satisfied with telecenters.

Table 5-8: Managers' Satisfaction with Telecommuting Generally and Telecenters Specifically

Attitude	General Attitude toward Telecommuting (%) N = 90	Level of Satisfaction	Satisfaction with Telecenters (%) N = 90
Positive	82 (91.1)	Very high	13 (14.4)
		High	46 (51.1)
Neutral	5 (5.6)	Neutral	27 (30.0)
Negative	2 (2.2)	Low	1 (1.1)
		Very low	2 (2.2)
Didn't know	1 (1.1)	Missing	1 (1.1)

When asked how likely their organization is to offer center-based telecommuting in the future, the responses were more evenly distributed. All 90 of the respondents answered this question: 28 (31.6%) rated it as unlikely or very unlikely that their organization would offer center-based telecommuting as an option, 16 (17.8%) said they were not sure, and 46 (51.1%) rated it as likely or very likely that their company would offer center-based telecommuting. While it is encouraging that just over half of the managers thought it likely or very likely that their company would offer center-based telecommuting, this percentage is quite a bit lower than the general satisfaction ratings of the managers. This may indicate that the managerial constraints on telecommuting lie more with the upper management and with organizational policy than with the immediate supervisors of the participants in the project.

Finally, the managers were asked to explain what would need to change to make center-based telecommuting more attractive to their organization and to rate which one of those changes was most important. Table 5-9 lists the 132 responses to this question given by 90 managers. The most commonly-cited changes required were location of the center and manager acceptance, given in 23 (25.6%) and 18 (20.0%) cases, respectively. Location of the center was rated most important by 14 respondents; the biggest concern was that the center be convenient for the employees. Managerial acceptance was rated as most important by 15 of the managers, with most explanations relating to problems that upper management had with telecommuting. More or better equipment was needed in the view of 17 (18.9%) managers, but only 6 listed this as their primary concern. The cost would have to be low or free for 14 (15.6%) of the managers, 7 of whom rated this as most important. For 12 (13.3%) managers, the ability to better quantify the benefits of telecommuting to their organization was important, but only 4 rated this as most important. Center design and operation were issues in only a few cases, with some concern expressed about security, use of the center by competitors, the need for private offices, the need for clerical support, and support on the selection and training of telecommuters. Employee acceptance, the size and appearance of the center and the site administration were not perceived as needing change, indicating that these attributes were either satisfactory or unimportant. Eighteen (20%) respondents wrote in a response for "other" and these 18 also ranked those responses as the major concern, but they did not fit into any of the larger

categories. These "other" responses included lifting the survey requirements and the nature of work involved.

An equal number of respondents, 10 (11.1%), stated that either nothing more was needed (that it was already offered) or nothing could be done to make the organization accept telecommuting, and 8 each rated those respective responses as most important. These two responses represent opposite extremes of organizational acceptance.

Table 5-9: Changes to Make Center-based Telecommuting More Attractive to Organizations (N = 90)

Change Needed	No. of Responses (No. Ranking Change as Most Important)
Location of the center	23 (14)
Manager/organization acceptance	18 (15)
Equipment	17 (6)
The cost	14 (7)
The ability to quantify benefits to the organization	12 (4)
Security improved	5 (0)
Non-use of the center by competitors	2 (1)
Private offices provided at the center	1 (0)
Clerical support	1 (1)
Support on selection and training of telecommuters	1 (1)
Employee acceptance	0 (0)
Appearance of the center	0 (0)
Site administration	0 (0)
Size of the center	0 (0)
Other	18 (18)
Survey requirements lifted/nothing to sign/make process easier	12
Nature of work/work load heavy	3
Growth in number of employees	1
Organization too dependent on employee being physically present	1
Unsure	1
Nothing would make the organization likely to offer it	10 (8)
Nothing more is needed; we are already likely to offer it	10 (8)

5.6 Comparison of Exit Interview and Attitudinal Survey Results for Managers

The manager exit interview (discussed in Section 5.5) and manager attitudinal survey (discussed in Section 3.3) were intentionally constructed to allow for a comparison of responses on several similarly worded questions. As indicated in Section 5.5, there is some overlap between the two groups, and potential self-selection bias in both cases, but we would expect any negative attitudes toward telecommuting to be more prevalent among the managers of quitters (i.e. in the exit interview database). To control for different sample sizes, the following comparisons are made using the percentages of respondents to the exit interview (N = 90) and the attitudinal survey (N = 62).

The first similarly worded question asked managers to indicate what their attitude was toward telecommuting in general using a three-point scale (negative, neutral, and positive). Interestingly, the responses were very similar with the managers of quitters actually rating their attitude toward telecommuting as positive (91.1%) slightly more often than the after-survey managers (88.7%). When asked to rate their level of satisfaction with center-based telecommuting in particular using a five-point scale (very low, low, neutral, high, very high), it is not surprising to find that the after-survey managers more often ranked their satisfaction with telecenters as high (65.5%) than managers of quitters (51.1%). Conversely, the managers of quitters were more often neutral about telecenters (30.0%) than after-survey managers (21.0%). The negative responses to both of these questions were comparable between both sets of managers. Considering that managers of quitters ranked their general attitude towards telecommuting as somewhat higher than after-survey managers, but that the reverse was true for level of satisfaction with telecenters, it lends further support to the conclusion that some may prefer home-based telecommuting to center-based telecommuting, but that there is not an inherent problem with telecommuting altogether. Further, while the after-survey managers and managers of quitters assigned almost identical percentages of time (on the ideal distribution of time question) to the regular workplace (61.7% and 61.1%, respectively), after-survey managers assigned more time to the telecenter than to home (27.7% and 5.3%, respectively) whereas the opposite was true for the managers of quitters (11.6% to the home and 7.3% to the telecenter).

As shown in Table 5-10, managers of quitters reported that it was unlikely or very unlikely (23.8% and 7.8%, respectively) that their organization would offer telecommuting from a center in the future, and 17.8% were not sure. Conversely, a larger percentage of the after-survey managers reported that they were not sure if their organizations would offer telecommuting from a telecenter in the future (41.9%) and a smaller percent reported that it was unlikely or very unlikely (6.5% and 1.6%, respectively). Interestingly, while the percentages reporting future telecommuting from a center as likely or very likely were different between the two groups (46.8% and 1.6%, respectively for after-survey managers, and 27.8% and 23.3%, respectively for managers of quitters) the total percentage of managers who responded positively (that it was likely or very likely) was similar for both after-survey managers (48.4%) and managers of quitters (51.1%). Thus, managers of quitters tended, as a group, to have more crystallized opinions about the likelihood of center-based telecommuting being offered, whether that opinion was affirmative or negative. Perhaps the after survey data were collected before the organization had had a chance to evolve a clear position on the issue.

Finally, both surveys contain a question about what would need to change to make telecommuting from a center more appealing (see Table 5-11). Not surprisingly, managers of quitters were twice as likely to say that nothing could be done (11.1%, versus 6.5% for after-survey respondents)

whereas after-survey managers were three times as likely to say that nothing more needed to be done (33.9% compared to 11.1% for managers of quitters).

Table 5-10: Comparison of Likelihood of Offering Center-based Telecommuting

	Exit Interview Percent of Responses (N = 90)	Attitudinal Survey Percent of Responses (N = 62)
Very unlikely	7.8	1.6
Unlikely	23.8	6.5
Not sure	17.8	41.9
Likely	27.8	46.8
Very likely	23.3	1.6

Table 5-11: Comparison of Changes to Make Center-based Telecommuting More Attractive

Change Needed	Exit Interview Percent of Responses (N = 90)	Attitudinal Survey Percent of Responses (N = 62)
Location of the center	25.6	17.7
Manager/organization acceptance	20.0	30.6
Equipment	18.9	22.6
The cost	15.6	25.8
The ability to quantify benefits to the organization	13.3	25.8
Security improved	5.6	11.3
Non-use of the center by competitors	2.2	0
Private offices provided at the center	1.1	4.8
Clerical support	1.1	0
Support on selection and training of telecommuters	1.1	3.2
Employee acceptance	0	8.1
Appearance of the center	0	3.2
Site administration	0	1.6
Size of the center	0	0
Other	20.0	6.5
Nothing would make the organization likely to offer it	11.1	6.5
Nothing more is needed; we are already likely to offer it	11.1	33.9

5.7 *Summary of Retention Analysis*

This chapter studied the attrition of telecenter users and the reasons for that attrition by examining the responses to three different survey instruments: the attitudinal survey, the sign-in or attendance log, and the exit interview. The first analysis compared the attitudes and preferences of stayers (N = 44) and quitters (N = 106) using the before employee survey. It was found, using this data instrument, that there were few significant differences between the two groups in their demographics, travel and work characteristics, or attitudes and preferences toward work environment. Although the results of the attitudinal survey serve to characterize the stayers and quitters, they do not offer much insight into why some participants chose to quit. There is some indication of a predisposition or later-formed preference for home-based telecommuting being associated with quitting, but the evidence is not statistically strong. In fact, while some employees quit the center to take up home-based telecommuting, in general the quitters appeared still to like the center-based form at least as much (see below).

In the second analysis, the attendance or sign-in logs were used to compare the telecommuting frequency of stayers (N = 66) and quitters (N = 208). The average frequency of telecommuting for stayers (28.2%) was found to be somewhat higher and statistically different than that of quitters (20.2%), meaning that stayers telecommuted more often than quitters did. In this section, the exit interview was used to determine the ideal distribution of work time for quitters: 53.4% at the regular work place, 20.1% at the telecommuting center, and 14.2% from home. So, the quitters here still preferred to use the telecenter (over home-based telecommuting), but were not able to due to certain constraints.

In the third analysis, reasons for quitting were examined using employee (N = 144) and manager (N = 90) exit interviews. The most frequent type of reason given by employees for quitting was job-related (37.7%), followed by supervisor-related (14.9%). In the former case, employees quit telecommuting because they left the organization, changed positions or job duties within the company, or other related reasons. In the latter case, employees were required or encouraged to quit telecommuting by their manager or supervisor. Other major reasons for quitting were due to the telecenter closing (13.2%), employees switching to home-based telecommuting (8.8%), or individuals moving their residence (7.9%). In general, the results suggest that respondents did not quit center-based telecommuting because they did not like it (no one gave that as a reason), but rather that, in general, external constraints related to the job, manager, and telecenter prevented them from telecommuting. These results are substantiated by the response to a question about prospects for future telecommuting which showed that there is a preference for more telecenter use in the future.

The manager exit interview data seem to support the employee exit interview data in that most of the reasons managers gave for their employees quitting fell into the category of external constraints. Whether these external constraints included job or lifestyle changes, centers closing, or lack of support from upper management, they consistently outweighed problems at the telecenter, or with telecommuting in general from either employees or their managers.

Responses to questions about attitudes indicated that a majority of managers were satisfied with both telecommuting and telecenters, but that they were considerably more neutral about telecenters than about telecommuting in general. Specifically, though, two-thirds of the sample were highly satisfied with telecenters. When asked how likely their organization is to offer center-based telecommuting

in the future, however, just over half indicated that it was likely or very likely, which is quite a bit lower than the general satisfaction ratings of the managers with telecenters. Finally, the managers were asked to explain what would need to change to make center-based telecommuting more attractive to their organization and to identify which of these changes was most important. Managerial or organizational acceptance and location of the center were by far the most important changes indicated. Other important changes were equipment, cost, and the ability to quantify the benefits of center-based telecommuting to the organization. Eleven percent of the respondents indicated that no changes were needed (the organization already offered center-based telecommuting), and an equal percentage expressed the opposite extreme – that nothing would make the organization likely to offer it.

The responses to similarly-worded questions on the manager exit interview (N = 90) and manager after survey (N = 62) were compared. The data suggest, not surprisingly, that managers of quitters (based on the exit interview data) were more likely to favor home-based telecommuting and less likely to favor center-based telecommuting than after-survey manager respondents. Nevertheless, large majorities of both groups (89 - 91%) expressed positive views of telecommuting in general. Managers of quitters tended to be more certain about whether or not center-based telecommuting would be offered by the organization in the future, whether the answer was positive or negative. However, about half of both groups believed that the organization was likely or very likely to offer it (with the managers of quitters much more heavily concentrated in the "very likely" category than the after-survey managers).

CHAPTER 6

TRAVEL AND AIR QUALITY IMPACTS

6. TRAVEL AND AIR QUALITY IMPACTS

6.1 Motivation and Methodology

In recent years, telecommuting has generated considerable interest in the research and planning community for its potential as an effective transportation demand management strategy (Mokhtarian, 1991). As the adoption of telecommuting becomes widespread, opportunities arise to evaluate telecommuting for its ability to alleviate congestion (Hamer, *et al.*, 1991; Kitamura, *et al.*, 1991; Pendyala, *et al.*, 1991; Mokhtarian, *et al.*, 1995) and improve air quality (Sampath, *et al.*, 1991; Koenig, *et al.*, 1996; Henderson, *et al.*, 1996). The travel and emissions impacts of center-based telecommuting are of particular interest and have been little-studied to date (Henderson and Mokhtarian, 1996 being one exception).

Center-based and home-based telecommuting could potentially differ considerably in terms of the resulting transportation and air quality impacts. An obvious difference concerns the commute trip. While telecommuting from a center may reduce the length of the regular commute, home-based telecommuting may eliminate it altogether. However, there may be an increase in the number of discretionary trips made on home-based telecommuting days since there is more time for discretionary activities. Also, it is possible that a home-based telecommuter engages in several short "home-other-home" trips involving minimal trip chaining, and as we have seen in Chapter 3, telecenter users are more likely to make short trips home during the lunch hour on their telecommuting days. Thus, we are likely to see some interesting tradeoffs between distance, the number of trips, and the number of cold and hot starts, all of which are important factors in modeling travel and air quality impacts.

This chapter is divided into two parts. The first part examines the travel characteristics of the sample of telecenter users investigated in this report. In this section, seven fundamental travel indicators – number of person-trips, personal-vehicle trips, person-miles traveled (PMT), vehicle-miles traveled (VMT), cold starts, hot starts, and commute mode choice – are studied. These indicators offer an overview of key travel characteristics and lay the groundwork for conducting an emissions analysis on these data, which is described in part two of this chapter.

The data used in the following analyses come from three sources: the after travel diary, the after attitudinal survey, and the sign-in log (all of which are described in Section 1.2). The travel diary provided data for the analysis of the first six travel indicators (number of trips, personal-vehicle-trips, PMT, VMT, and cold and hot starts) and the subsequent emissions analysis. The calculation of the commute mode choice distributions, however, was relatively complex and involved input from multiple survey elements. The procedures involved will be discussed in detail in the appropriate sections.

The ideal analysis for this chapter would be a three-factor study involving *wave* (before and after), *group* (telecommuters and non-telecommuters) and *day* type (telecommuting (TC) and non-telecommuting (NTC)) as illustrated in Figure 6-1. Unfortunately, the restricted sample size precludes the possibility of such an analysis. A before-and-after study on the data set would have greatly reduced the sample size as only respondents common to both the before and after waves could be considered (43 telecenter users, 9 non-telecommuters and 8 home-based telecommuters had filled out diaries in both waves). Also, eleven of the telecenter users who had completed the after surveys would have to be removed since they had telecommuted in the before wave. This

would have further reduced the sample size of telecenter users to 32. Instead, the before and after diaries for each of the three groups were pooled together. Fifty-seven telecenter users and 4 home-based telecommuters who did not have at least one telecommuting day, in either the before or after wave, were removed from the data set. The main reason for doing so is that no data are available on their travel behavior as telecommuters, so they don't really belong in the center-based (or home-based) group – and yet they are not properly classified as non-telecommuters either.

So, the first six travel measures listed above were compared between *telecommuting* and *non-telecommuting days* using a combined *before and after* data set for *center- and home-based telecommuters* (TCers), with the non-telecommuters (Non-TCers) treated as a control group. The main advantage offered by this methodology is that of using a larger sample size. The disadvantage, however, is that observed differences between telecommuting and non-telecommuting may be confounded by spill-over effects from one group into another (for example, in the form of deferred trips). These interactive effects would be controlled for in a before-and-after study. The mode choice and emissions analyses were performed comparing just the telecenter users and non-telecommuters due to the small sample size of the home-based telecommuting group.

6.2 Travel Analysis

In this section, the methodology used to study the travel characteristics – number of person-trips, personal-vehicle trips (only drive-alone trips), PMT, VMT (here taken to be miles traveled by driving alone in a personal vehicle), cold starts (calculated only for drive-alone trips), hot starts (calculated only for drive-alone trips), and commute mode choice – is discussed, and the results of the analyses are presented. Analysis of variance (ANOVA) was conducted for each of the first six travel indicators. A one-way ANOVA was performed to compare the travel characteristics of non-telecommuters with those of center-based and home-based telecommuters on non-telecommuting days (Section 6.2.2). Also, a two-way ANOVA was performed to study the travel impacts of center-based and home-based telecommuting (Section 6.2.3). In addition, the impacts of center-based telecommuting on commute and non-commute travel, mode choice and commute mode choice were studied (Sections 6.2.4-6.2.6). The aggregate travel impacts for center-based telecommuters were estimated by factoring in the frequency of telecommuting (Section 6.2.7). Finally, a summary of the travel impacts of center-based telecommuting is presented (Section 6.2.8).

6.2.1 Description of Travel Diary Data

A travel diary (see Appendix H) was used to record the transportation activities of the three study groups during three consecutive days. The three groups were center-based telecommuters, home-based telecommuters and non-telecommuters. The home-based and non-telecommuter groups served both as controls for background effects and as comparisons to the travel activities of center-based telecommuters. Efforts were made to collect travel diary data from driving-age household members of these three groups as well, to permit an analysis of the extent to which telecommuting might affect their travel. However, these data are less complete than the data for the participating employees themselves. This report focuses on the analysis of the participating employees' data only, reserving household members' data for future extensions of this work.

Figure 6-1: Ideal Analysis Involving Three Dimensions

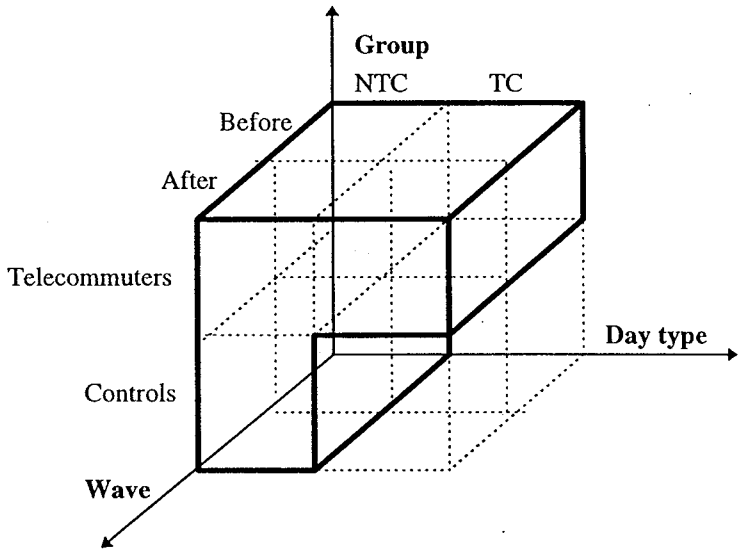
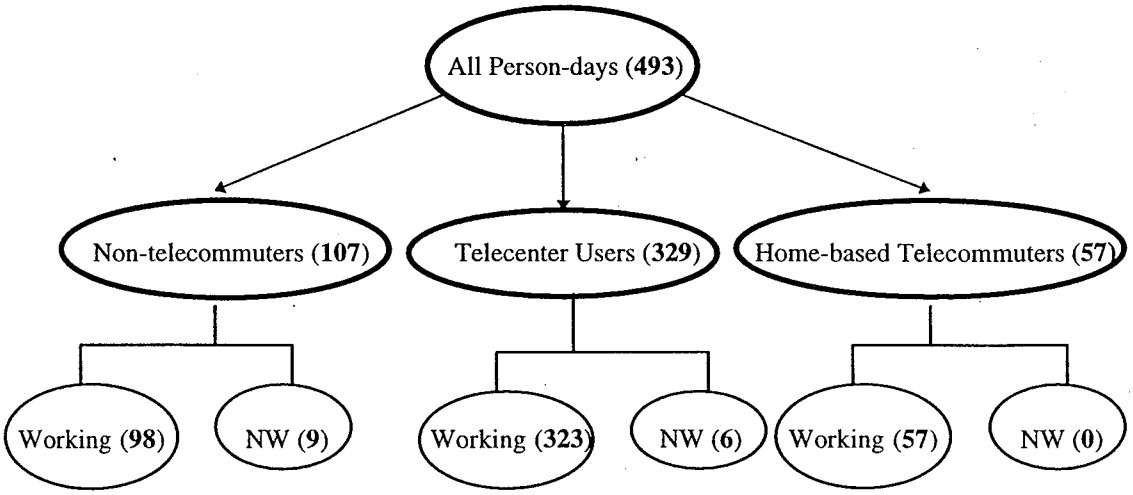


Figure 6-2: Number of Person-days Distributed by Group and Day Type



The travel diary was administered in two waves, before and approximately six months after telecenter use began. There were no day of the week restrictions for the control groups or for the prospective telecenter users in the before travel diary. However, on the after diary the center-based telecommuters were requested to include at least one telecenter use in their three-day period. Travel data on weekend days (which constituted less than 3% of the total person-days) were also included in the analysis.

Before the analysis was carried out, the data set was cleaned and missing values were imputed where possible. Specifically, two travel diaries had to be removed from the before data set because the respondents had completed them incorrectly. The proportion of missing data that could be corrected for the various questions ranged from less than 1% on the question regarding mode to nearly 18% on trip start times. Missing timing and distance information was imputed by cross-checking against other responses by the same respondent in the travel diary (for example, missing start times could be approximated from end times and an assumed average speed). Trip sequences were checked, and missing links were filled in to the extent possible. A total of 10 missing trips were inserted in the before travel diary data set and 13 in the after data set to complete trip records. The final cleaned data set had substantially less missing data, ranging from none for most questions to less than 3.5% for trip start times.

The combined before and after travel diary data consisted of *110 respondents* providing information for *493 person-days* and *2348 total trips* (includes trips made on not working days). Figure 6-2 presents a breakdown of person-days distributed by group and day type (working or not working).

The travel diary contained the following question for each day: "*Today I am working from (check all that apply): primary office, telecenter, home, other location, not working*" (see Appendix H). Based on the response to that question, each person-day was classified as one of four possible types as shown in Figure 6-3. A *telecenter day* (TC) was defined as a day on which a person *worked from a telecenter* irrespective of any other accompanying work location; this is illustrated in the figure by having any point in the dark gray circle classified as TC, even if the point also lies in the intersection with either of the other two circles. A day was classified as *home-based telecommuting* (HB) when the person worked *only from home;* thus in the figure, only points lying in the exclusive portion of the circle are classified as HB. A day was considered to be *non-telecommuting* (NTC) if a person worked from a regular work location or other location and did not use the telecenter, even if s/he worked from home as well. And finally, a day was classified as a *not working day* (NW) if on that day the person did not work at all.

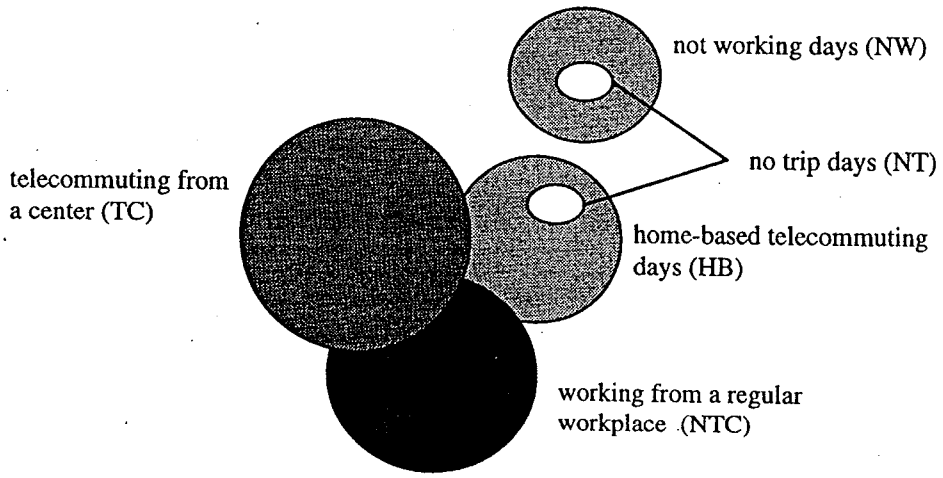
The elements of Figure 6-3 have been shaded to represent a hierarchy of expected direct travel benefits. Days on which no trips are made obviously represent the ideal travel reduction and are colored white. Next in order are NW and HB days. Both types of person-days are expected to provide similar travel improvements as the commute trip is eliminated. Between these two types, however, HB days are expected to result in greater travel reductions than NW days since presumably on an HB day a large proportion of the participant's waking hours are spent working. The next best person-day type would be the TC day, as the commute trip is considerably shortened. And finally, representing the highest-travel scenario is the regular NTC day, shaded black. It should be noted however, that the proposed hierarchy does not take into account

indirect travel effects, such as deferred trips or a compensating effect leading to an increase in discretionary trips, that may alter the hypothetical ordering.

Some features of this classification are worth noting: there are days when persons worked from more than one work location. Person-days classified as TC include not only days on which telecenter was the only work location but also days on which either home or the regular workplace was involved. This was done because in assessing the travel impacts of telecenters, it is important to take into account the extent to which telecenter use is accompanied by working from other locations. Classifying telecenter/work-at-home days as TC is reasonable because the person has to make a commute trip to the center irrespective of the amount of time spent there. Classifying telecenter/regular workplace days as TC results in a conservative estimate of the actual effect of telecommuting centers on travel, but thereby guards against the careless assumption that *any telecenter occasion will automatically replace the normal commute*. On the other hand, days on which both home and the regular workplace were work locations were classified as NTC days because a person makes a commute trip to the regular workplace irrespective of the amount of time spent there. Hence in comparing travel patterns on center-based TC and NTC days, it is reasonable to treat such days as NTC rather than TC. However, in previous studies focusing on the impacts of *home-based* telecommuting, such days have been classified as TC to highlight the fact that not every home-based telecommuting occasion replaces the normal commute.

One alternative to the scheme adopted would be to define separate categories for each combination of work locations: TC, TC-NTC, TC-HB, HB, HB-NTC, NTC. This would however, make the comparison process rather cumbersome and considerably reduce the number of cases available in each group.

Figure 6-3: Classification of Person-days by Expected Direct Travel Impacts



A cross-tabulation of the data set is presented in Tables 6-1 and 6-2. In the analyses, NW person-days were pooled with NTC person-days for consistency with previous studies. Combining the two groups provides more conservative estimates of the travel impacts of telecommuting. All the groups except the HB days of telecenter users are analyzed in the following chapters. The sample size of this group is too small (6 person-days) to permit a comparison between the travel characteristics of HB days of telecenter users and home-based telecommuters.

Table 6-1: Tabulation of Person-days According to Study Group, Survey Wave, and Day Type

Study Group (No. of Respondents)	Type of Person-day								Total
	NTC		NW		TC		HB		
	Before	After	Before	After	Before	After	Before	After	
Center-based (72)	120	81	2	4	38	78	3	3	329
Home-based (11)	20	14	0	0	0	0	13	10	57
Non-TCers (27)	67	31	7	2	0	0	0	0	107
Total (110)	333		15		116		29		493

Table 6-2: Tabulation of Person-trips According to Study Group, Survey Wave, and Day Type

Study Group (No. of Respondents)	Type of Person-day								Total
	NTC		NW		TC		HB		
	Before	After	Before	After	Before	After	Before	After	
Center-based (72)	539	343	10	12	224	314	12	8	1462
Home-based (11)	110	65	0	0	0	0	42	34	251
Non-TCers (27)	392	197	43	3	0	0	0	0	635
Total (110)	1646		68		538		96		2348

6.2.2 Control Group vs. Center- and Home-based Telecommuters

To better understand the impact of telecommuting (both center-based and home-based) on travel and emissions, it is important to eliminate or control for characteristics which are extraneous to the process of telecommuting but which may affect the final outcome. This can theoretically be achieved by comparing the travel characteristics of telecenter users and home-based telecommuters on NTC days with the control group of non-telecommuters. In the following discussion, all variables are in units of number of occurrences per person-day. Six travel-related indicators were analyzed: number of person-trips, number of personal-vehicle trips, PMT, VMT, cold starts, and hot starts.

Cold start and hot start calculations were performed on trips made by personal vehicles only. Cold start refers to the initial operation of a vehicle which has been turned off for at least one hour in the case of vehicles equipped with a catalytic converter, and at least four hours for vehicles not so equipped. All other initial operations of vehicles are considered to be hot starts. Since complete household data are not available to keep track of all the trips made by a vehicle on each of the travel diary days, an important assumption needs to be made to determine whether a trip involved a hot start or cold start. For this analysis, it is assumed that no other household

members were also driving the same vehicle(s). This is a conservative assumption since it could result in an over-estimation of the number of cold starts. However, it is probably not too inaccurate in view of the fact that on average in the sample, there was approximately one vehicle per licensed driver in the household and hence vehicles were likely to be "assigned" to specific drivers with little swapping.

Table 6-3 shows the mean values of the travel indicators for each group and also the F probabilities obtained from ANOVA. From the F probabilities it is clear that there are significant differences across the group means for all indicators except hot starts. The assumption of equal variances across groups (required for ANOVA to be legitimate) was violated for person-trips, cold starts, PMT and VMT. Pair-wise t-tests were performed to overcome this problem and also to further explore the significant differences between groups, for all indicators except hot starts.

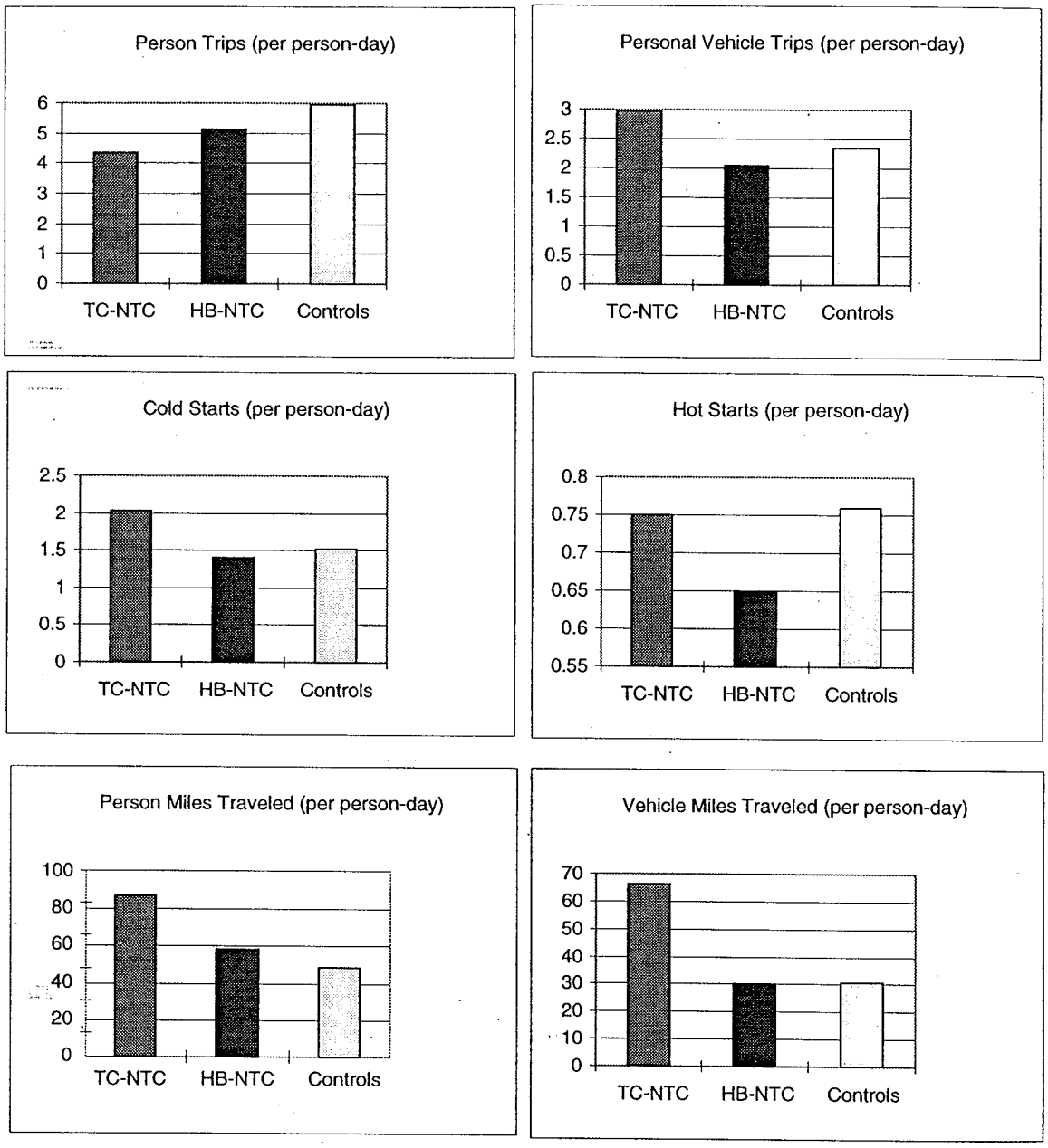
Table 6-3: One-way ANOVA Results

Variable	Group Means (Per Person-day)			F Probability
	TC-NTC (207 Person-days)	HB-NTC (34 Person-days)	Non-telecommuters (107 Person-days)	
Person-trips	4.36	5.15	5.93	.000
Personal-vehicle trips	2.98	2.06	2.35	.003
PMT	87.75	58.26	48.69	.000
VMT	66.39	30.08	30.99	.000
Cold starts[1]	2.03	1.41	1.53	.000
Hot starts[1]	0.75	0.65	0.76	.896

[1] The number of cold starts plus hot starts does not equal the number of personal-vehicle trips because of missing information in the travel diary data on start and end times for some trips.

The pair-wise t-tests (see Table 6-4) reveal that all travel indicator averages obtained for telecenter users were significantly different from each of the other two groups. Also, there are no significant differences between the non-telecommuter and HB-NTC groups. A number of interesting observations can be made by comparing the averages for the different groups (see Figure 6-4). Telecenter users made fewer person-trips but had significantly greater PMT and VMT than the other two groups. It is interesting to note that the relationships observed between the groups in this study (fewer trips but more miles traveled for telecenter users) mirror previous results reported by a study of data from the Puget Sound region (Henderson, *et al.*, 1996). That study hypothesized that the higher PMT (and VMT) for telecenter users is probably due to a longer average commute length, and the smaller number of trips is due to the longer commute trip taking up time that could otherwise be used for discretionary trips. Those hypotheses fit the current study as well. Also, though the average number of person-trips for telecenter users is lower than for home-based telecommuters and non-telecommuters, the average number of personal-vehicle trips and cold starts for telecenter users is greater than for the other two groups. It may be the case that the longer commutes undertaken by telecenter users are not very conducive to modes other than drive-alone (transit, rideshare, walk, etc.).

Figure 6-4: Group Means for all Travel Parameters



From the above analysis, we see that the baseline travel characteristics of non-telecommuters are quite different from those of telecenter users, although similar to those of home-based telecommuters. Hence, the travel analysis focuses primarily on two sets of comparisons: center-based versus home-based telecommuters (where even though the two groups start from a different NTC day base, the NTC-TC day differences between the groups still offer a legitimate basis for comparison) and center-based telecommuters on their NTC days versus on their TC days. These two sets of comparisons are presented in Sections 6.2.3 and 6.2.4-6.2.6, respectively.

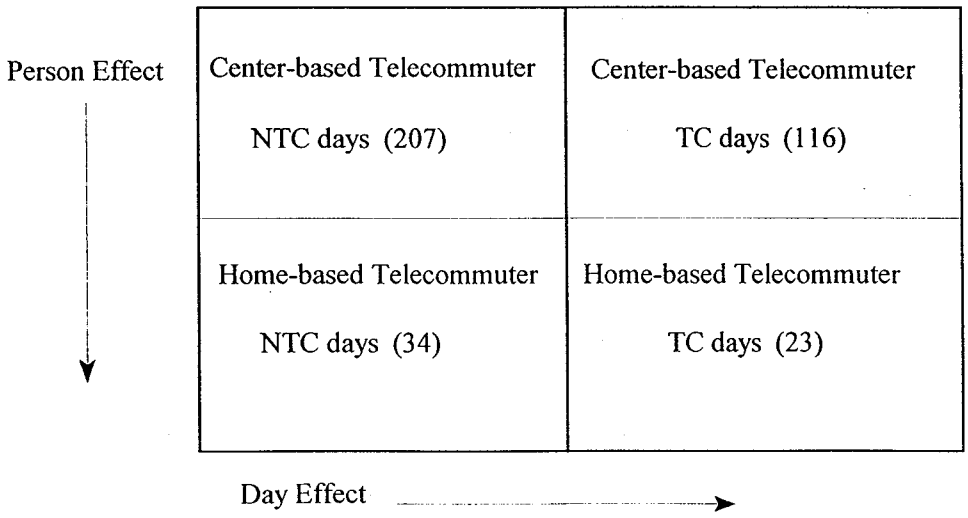
Table 6-4: Pair-wise T-test Results (P-values) for TC-NTC, Non-telecommuters, and HB-NTC Groups

Variable	TC-NTC vs. Non-telecommuter	TC-NTC vs. HB-NTC	Non-telecommuter vs. HB-NTC
Person-trips	.000	.068	.196
Personal-vehicle trips	.007	.009	.468
PMT	.000	.000	.127
VMT	.000	.000	.886
Cold starts	.001	.006	.620

6.2.3 TC vs. NTC Days for Center- and Home-based Telecommuters

A two-way ANOVA was performed to study the person and day main effects and interaction effects for each of the six travel indicators. The person effect compares the center-based telecommuters and home-based telecommuters to determine differences in the travel characteristics of these groups. The day effect characterizes the differences in the travel patterns between telecommuting and non-telecommuting days. The structure for the two-way ANOVA is shown in Figure 6-5 (the values in parentheses represent the number of travel diary person-days on which the analysis is based). In the following discussion, all variables are presented in terms of average number of occurrences per person-day.

Figure 6-5: Structure of Two-way ANOVA Comparison Groups



6.2.3.1 Person-trips

Table 6-5 shows the means and standard deviations of the number of person-trips for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is not violated. Table 6-6 shows the results from a two-way ANOVA for person-trips.

Table 6-5: Descriptive Statistics for Person-trips

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	4.36	2.28	4.64	2.60
Home-based telecommuters	5.15	2.79	3.30	2.01

From Table 6-6 we see that the day effect and interaction effects are significant whereas the person effect is not significant. These results can be interpreted by looking at Figure 6-6. The mean number of person-trips actually increases slightly (7%) on telecommuting days for center-based telecommuters whereas it decreases substantially (by 36%, or nearly two trips) for home-based telecommuters. The latter observation is to be expected because home-based telecommuting generally eliminates the two commute-related trips (home-to-work and work-to-home). Center-based telecommuters, on the other hand, not only do not eliminate any commute trips, but have the opportunity to make additional trips (e.g. trips from the telecenter to home for lunch) since their commute is shortened. This is further explored in Section 6.2.4. The significance of the interaction effect is due to telecommuting having opposite effects on the number of person-trips for center-based telecommuters and home-based telecommuters.

Table 6-6: Two-way ANOVA Results for Person-trips

Main Effects	F Probability
Day effect	.029
Person effect	.452
2-way Interaction	
Day effect – person effect	.003

6.2.3.2 Personal-vehicle Trips

Table 6-7 shows the means and standard deviations of the number of personal-vehicle trips (PV) for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is not violated. Table 6-8 shows the results from a two-way ANOVA for personal-vehicle trips.

Figure 6-6: Plot of Means for Person-trips

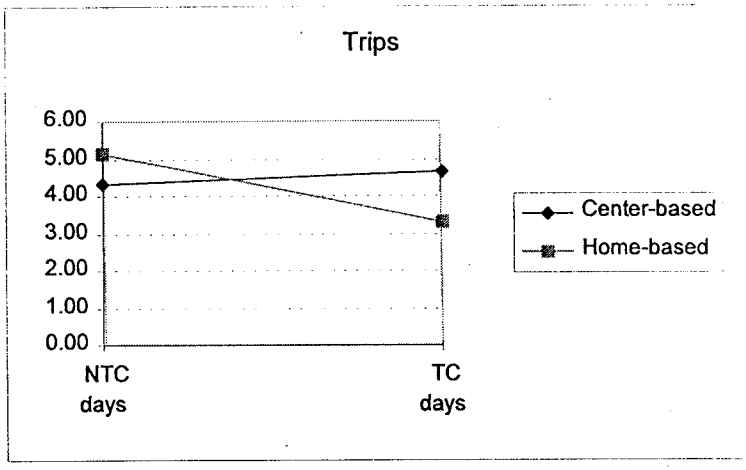


Table 6-7: Descriptive Statistics for Personal-vehicle Trips

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	2.98	1.88	3.29	1.96
Home-based telecommuters	2.06	1.81	1.83	1.61

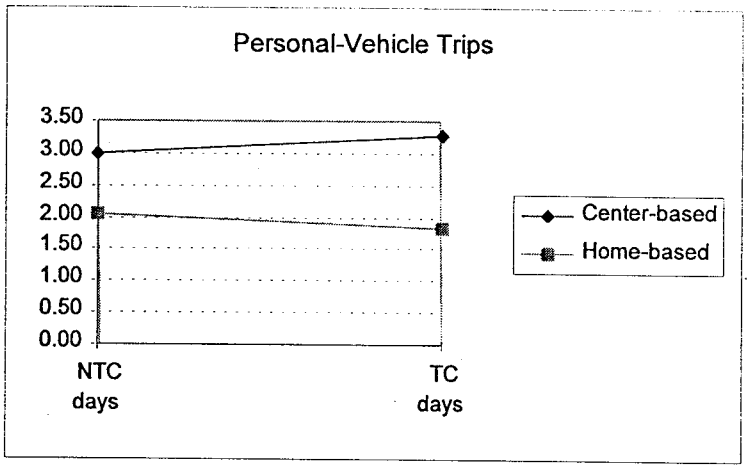
From Table 6-8 we see that the day effect and interaction effect are not significant whereas the person effect is significant. These results can be interpreted by looking at Figure 6-7. The significance of the person effect is due to the fact that the center-based telecommuters have more personal-vehicle trips than home-based telecommuters on both NTC and TC days. It is interesting to observe that though home-based telecommuters on average make more person-trips on NTC days than center-based telecommuters (Section 6.2.3.1), they make fewer personal-vehicle trips. Therefore, center-based telecommuters make fewer non-personal-vehicle (rideshare, transit, walk, etc.) trips than home-based telecommuters on both NTC and TC days.

Table 6-8: Two-way ANOVA Results for Personal-vehicle Trips

Main Effects	F Probability
Day effect	.879
Person effect	.000
2-way Interaction	
Day effect – person effect	.322

The insignificance of the day effect is not surprising for telecenter users, since as it was noted earlier, commute trips are not eliminated by telecommuting (and may even be created) for these respondents. The stability of the PV trip rate for home-based telecommuters, however, *is* surprising and is counter to the findings of other studies (e.g. Koenig, *et al.*, 1996; Henderson, *et al.*, 1996). Together with the fact that the total trip rate *does* decline on TC days for home-based telecommuters, the implication is that the trips that are eliminated on TC days tend to be non-PV trips such as transit and ridesharing. This is consistent with findings of Hamer, *et al.* (1992).

Figure 6-7: Plot of Means for Personal-vehicle Trips



6.2.3.3 Person-miles Traveled

Table 6-9 shows the means and standard deviations of PMT for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is violated (p-value = .000). However, the ANOVA was still carried out and the results were used only to aid in the interpretation of the plot of means (Figure 6-8). Table 6-10 shows the results from a two-way ANOVA for PMT.

From Figure 6-8 it is clear that, as hypothesized, PMT is drastically reduced on telecommuting days and also that the PMT average for center-based telecommuters is quite a lot higher than that for home-based telecommuters on both NTC and TC days. The higher PMT average for center-based telecommuters on NTC days compared to that for home-based telecommuters is probably due to center users' longer commute distances. Also, the lower PMT average for home-based telecommuters on TC days compared to that for center-based telecommuters is because of the elimination of commute trips. Interestingly, however, the average reduction in PMT on TC days is considerably greater for center-based (51 miles) than for home-based (34 miles) telecommuters. The implication is that the average distance from the telecenter to the regular workplace for center users (i.e. the distance typically eliminated on a telecommuting day) is longer than the average distance from home to the regular workplace for home-based telecommuters.

Table 6-9: Descriptive Statistics for PMT

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	87.75	61.01	36.94	42.48
Home-based telecommuters	58.26	27.62	23.86	29.89

Figure 6-8: Plot of Means for PMT

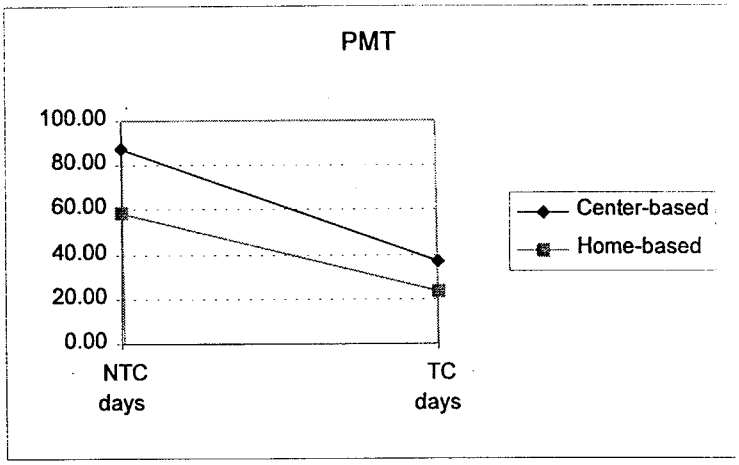


Table 6-10: Two-way ANOVA Results for PMT

Main Effects	F Probability
Day effect	.000
Person effect	.006
2-way Interaction	
Day effect – person effect	.284

6.2.3.4 Vehicle-miles Traveled

Table 6-11 shows the means and standard deviations of VMT for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is violated (p-value = .000). However, the ANOVA was still carried out and the results were used only to aid in the interpretation of the plot of means (Figure 6-9). Table 6-12 shows the results from a two-way ANOVA for VMT.

Again, Figure 6-9 shows that telecommuting drastically decreases the VMT for both center-based and home-based telecommuters. It is interesting to note that both PMT and VMT decrease even

more for telecenter users than for home-based telecommuters, despite the slight increases in trips and person-trips noted earlier. Also, the VMT values for center-based telecommuters are much higher than those for home-based telecommuters on both NTC and TC days. These results are not surprising because the reasons suggested in Section 6.2.3.3 for PMT apply to VMT also.

Table 6-11: Descriptive Statistics for VMT

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	66.39	61.01	31.16	41.55
Home-based telecommuters	30.08	30.95	15.53	19.67

Figure 6-9: Plot of Means for VMT

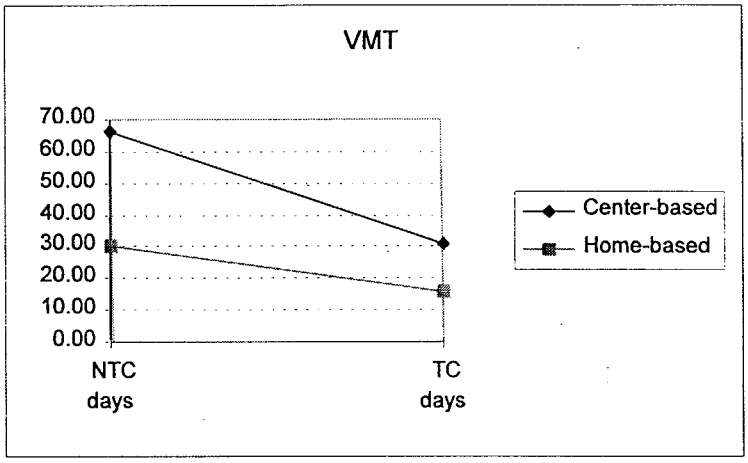


Table 6-12: Two-way ANOVA Results for VMT

Main Effects	F Probability
Day effect	.001
Person effect	.001
2-way Interaction	
Day effect – person effect	.175

6.2.3.5 *Cold Starts*

Table 6-13 shows the means and standard deviations of the number of cold starts for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is not violated. Table 6-14 shows the results from a two-way ANOVA for number of cold starts.

From Table 6-14 we see that the day effect and interaction effect are not significant (at the 0.05 level) whereas the person effect is significant. Figure 6-10 shows the plot of means for cold starts. These results are similar to the results obtained in Section 6.2.3.2 for personal-vehicle trips. This is not surprising because the number of cold starts is correlated to the number of personal-vehicle trips. However, the lack of a significant day effect is important. Taken together, these results mean that center-based telecommuting had little effect on the number of drive alone trips and cold starts, and hence that the portion of emissions most directly related to cold starts is likely to be little changed.

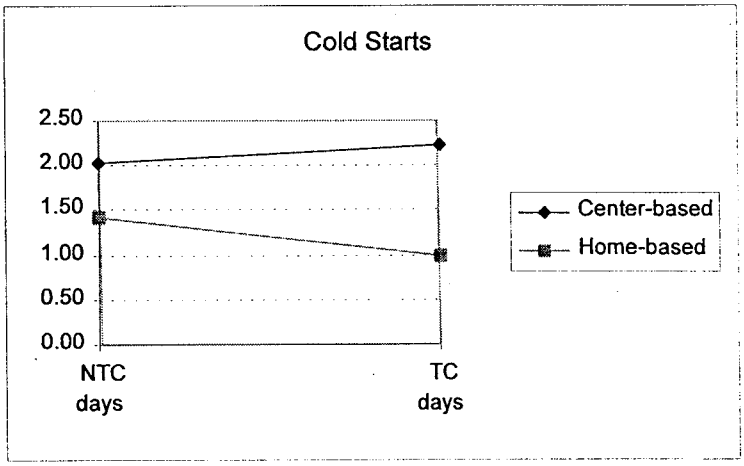
Table 6-13: Descriptive Statistics for Cold Starts

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	2.03	1.07	2.22	1.21
Home-based telecommuters	1.41	1.18	1.00	0.90

Table 6-14: Two-way ANOVA Results for Cold Starts

Main Effects	F Probability
Day effect	.484
Person effect	.000
2-way Interaction	
Day effect – person effect	.071

Figure 6-10: Plot of Means for Cold Starts



6.2.3.6 Hot Starts

Table 6-15 shows the means and standard deviations of number of hot starts for each of the four groups. A test for homogeneity of variance revealed that the assumption of equal variances required for ANOVA is violated (p-value = .022). However, the ANOVA was still carried out and the results were used only to aid in the interpretation of the plot of means (Figure 6-11). Table 6-16 shows the results from a two-way ANOVA for number of hot starts.

Table 6-15: Descriptive Statistics for Hot Starts

Variable	NTC Days		TC Days	
	Mean	Std. Dev.	Mean	Std. Dev.
Center-based telecommuters	0.74	1.25	1.01	1.45
Home-based telecommuters	0.65	1.07	0.83	0.94

Figure 6-11 shows that the average number of hot starts for both groups of telecommuters are very close on both NTC and TC days. This is further corroborated by the F-probability values shown in Table 6-16, none of which are significant. The figure also shows that TC days are associated with a marginal increase, though statistically not significant, in the number of hot starts. Also, the number of hot starts for center-based telecommuters is marginally greater than for home-based telecommuters on both NTC and TC days.

Figure 6-11: Plot of Means for Hot Starts

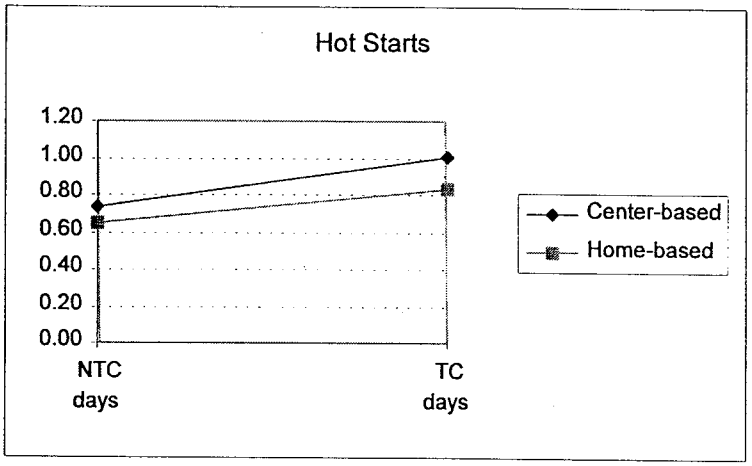


Table 6-16: Two-way ANOVA Results for Hot Starts

Main Effects	F Probability
Day effect	.240
Person effect	.459
2-way Interaction	
Day effect – person effect	.821

6.2.4 Comparison of Commute and Non-commute Travel for Telecenter Users

A detailed analysis of the after travel diary was performed to study the impact of center-based telecommuting on both commute and non-commute travel. Since there is a potential for an increase in non-commute travel due to telecommuting (Salomon, 1985), the primary motivation for the analysis was to determine how the reduction in distance traveled, and the marginal increase in trips (see Section 6.2.3), were distributed between commute and non-commute purposes.

A C program was developed to split PMT, VMT, person-trips, and personal-vehicle trips per person-day into commute and non-commute purposes. To calculate commute PMT, the travel diary data were first scanned to check for direct home-to-work trips. If a direct home-to-work (or home-to-telecenter on telecommuting days) trip entry was present on any of the days, the corresponding distance was taken as the commute distance for that person. Otherwise, the appropriate commute distance reported in the attitudinal survey was used, corresponding to whether it was a TC or NTC day. Calculating the commute VMT was more complicated since it could vary by day for the same person, so it had to be identified separately for each trip. For a home-to-work sequence in which not all links were drive alone, the commute VMT was taken to be the minimum of the length of drive alone link(s) and the direct home-to-work commute distance from the attitudinal survey or from other travel diary days. The following equations are used to make the remaining calculations (for a home-to-work-to-home chain, two commute trips are counted):

commute PMT/person-day = (# commute trips/person-day) x commute distance,
non-commute PMT/person-day = (total PMT/person-day) - (commute PMT/person-day),
commute VMT/person-day = (total commute VMT for an individual) / (total # of person-days for that individual),
non-commute VMT/person-day = (total VMT/person-day) - (commute VMT/person-day),
non-commute trips/person-day = (total trips/person-day) - (# commute trips/person-day),
non-commute PV trips/person-day = (total PV trips/person-day) - (# commute PV trips/person-day).

The above measures were calculated for non-telecommuting days and telecommuting days (see Table 6-17). There is a sizable reduction in the commute PMT and VMT on telecommuting days which is not surprising since the commute distance of telecenter users to the regular workplace is much greater than to the telecenter. More interestingly, the table shows that the non-commute PMT actually decreases by six miles on telecommuting days, though the difference is not statistically significant ($t = 1.05$; $p = 0.30$). This is a positive result from a transportation viewpoint, which counters the hypothesis that non-commute travel increases on telecommuting days. However, though the non-commute PMT decreases by six miles, non-commute VMT decreases by only 1.7 miles on telecommuting days. Again, the difference is not statistically significant ($t = 0.33$; $p = 0.74$).

Contrary to original expectations, the average numbers of person- and vehicle-trips actually increase on telecommuting days as seen in the previous section. However, the differences are not statistically significant ($t = 1.00$; $p = 0.32$ and $t = 1.49$; $p = 0.14$ respectively). These increases are mainly due to statistically significant increases of 0.6 commute person-trips ($t = 6.77$; $p = 0.00$) and 0.7 commute vehicle-trips ($t = 6.36$; $p = 0.00$) on telecommuting days.

The primary reason for this increase appears to be telecenter users going home for lunch more often on telecommuting days. There is a decrease of 0.4 non-commute person-trips on telecommuting days though the difference is not statistically significant ($t = 1.14$; $p = 0.25$). However, the decrease in non-commute vehicle-trips (0.4) on telecommuting days is statistically significant ($t = 2.12$; $p = .04$).

Table 6-17: The Impact of Center-based Telecommuting on Commute and Non-commute Person-trips, Vehicle-trips, PMT, and VMT[1]

Person-trips/Person-day	Non-telecommuting Days (N = 207)	Telecommuting Days (N = 116)
Total	4.4	4.6
Commute	**1.7**	**2.3**
Non-commute	2.7	2.3
PV trips/Person-day		
Total	3.0	3.3
Commute	**1.2**	**1.9**
Non-commute	**1.8**	**1.4**
PMT/Person-day		
Total	**87.8**	**36.9**
Commute	**62.6**	**17.7**
Non-commute	25.2	19.2
VMT/Person-day		
Total	**66.4**	**31.2**
Commute	**49.7**	**16.2**
Non-commute	16.7	15.0

[1] Bolded means are significantly different (at the 0.05 level) between telecommuting and non-telecommuting days.

6.2.5 Mode Choice for Telecenter Users

In this section the impact of telecommuting on the mode choice of telecenter users is analyzed by comparing mode choices on telecommuting and non-telecommuting days. Two types of impacts, especially on commute trips, may be hypothesized (Mokhtarian, 1991). First, on telecommuting days the proportion of transit and rideshare commute trips may be lower than on non-telecommuting days. This is because the commute trip to the telecenter is shorter and perhaps less well-served by the established transit systems and rideshare programs that focus on serving major employment centers. The second hypothesis is that commute trips to the telecenter (again because they are shorter) are more likely to involve environmentally-beneficial modes such

as walk and bike. To the extent that other trips are chained to the commute, these impacts on commute mode choice may affect non-commute trips in a similar way.

Mode splits were calculated in two ways: proportion of trips by each mode and proportion of distance traveled by each mode. The analysis presented here is based upon 902 non-telecommuting day trips and 538 telecommuting day trips.

Table 6-18 shows that there is an increase in the proportion of drive-alone trips and distances on telecommuting days (the distance-based split shows an increase of almost 9 percentage points in drive-alone travel). Also, as hypothesized, the distance-based mode split shows that there is a marginal decrease in the share of total distance that is traveled by rideshare/transit modes and a marginal increase in the share of total distance that is traveled by walk or bicycle on telecommuting days.

Table 6-18: Mode Split on Telecommuting and Non-telecommuting Days for Telecenter Users

Mode[1]	Trip-based Mode Split		Distance-based Mode Split	
	NTC Days (902 trips)	TC Days (538 trips)	NTC Days (miles)	TC Days (miles)
Drive alone[2]	616 (68.3%)	382 (71.0%)	13,742.3 (75.6%)	3615.1 (84.4%)
Carpool/vanpool[2]	195 (21.6%)	122 (22.7%)	3093.3 (17.0%)	643.0 (15.0%)
Bus	10 (1.1%)	0	210.0 (1.2%)	0
Light rail/trolley	5 (0.6%)	2 (0.4%)	166.0 (0.9%)	1.6 (0.0%)
BART/metro red line	1 (0.1%)	0	5.0 (0.0%)	0
Commuter train	11 (1.2%)	0	538.0 (3.0%)	0
Bicycle	2 (0.2%)	5 (0.9%)	4 (0.0%)	11 (0.3%)
Walk	53 (5.9%)	27 (5.0%)	29.4 (0.2%)	14.3 (0.3%)
Other	9 (1.0%)	0	376.3 (2.1%)	0

[1] "Drove/rode in electric vehicle" was one of the mode options given in the diary but never selected by the respondents.

[2] The mode category "drove conventional motor vehicle" was split into "drive alone" and "carpool/vanpool" based on the number of people in the vehicle. The mode was considered to be "carpool/vanpool" if the number of people in the vehicle was greater than one. Also, the mode category "rode in conventional motor vehicle" was merged with the "carpool/vanpool" category.

6.2.6 Commute Mode Choice for Telecenter Users

Since center-based telecommuting is expected to have the maximum effect on the commute trip, it is of interest to analyze the commute mode choices in isolation. This section analyzes the impact of telecommuting on the commute mode choice of telecenter users by comparing

telecommuting and non-telecommuting days. Again, the hypotheses discussed in the previous section are valid here.

A commute trip could consist of multiple trip segments and could involve more than one mode. Two methods were used to calculate the mode splits: the primary-mode method and the distance-based method. In the first method, the mode used for the longest portion of the commute trip is identified as the primary mode, and the percent of trips for which a given mode is primary is calculated. In the second method, a weighted average of all modes used in any commute trip is calculated, where the weights are the distances for which a given mode is used. Also, the mode split analysis for both methods focuses only on the home-to-work trip since the trip to work is less likely to be contaminated with side trips than the trip home.

As in the previous analyses, a total of 110 travel diaries were used in this analysis. The total number of person-days was 323, out of which 207 were classified as non-telecommuting and 116 were telecenter-based (see Section 6.2.1 for the definition of each day type). However, not all non-telecommuting person-days involved a home-based commute trip. On 33 person-days, respondents did not make a commute trip. Thus, the non-telecommuting day results presented below are based on the 174 person-days involving a regular commute trip. These 174 days actually comprise 177 commute trips, as individuals could go home and return to work sometime later in the day. Similarly, the 116 telecommuting person-days involved 133 commute trips.

A trip sequence was classified as a commute sequence if it originated at home and ended at either the regular workplace or the telecenter on the same person-day. Identifying the commute sequence was a non-trivial exercise since the number of segments in a commute sequence varies. A computer program was developed using the C language to identify the commute trips and evaluate the commute mode splits for telecenter users on telecommuting and non-telecommuting days.

Table 6-19 shows that on telecommuting days there is a substantial increase in the proportion of drive-alone commute trips. Also, as hypothesized, on telecommuting days the proportions of transit and rideshare commute trips decline, and the proportions of bicycle and walk commute trips increase marginally. From the data, we can also determine that the number of segments per commute trip on telecommuting days (1.17) is lower than on non-telecommuting days (1.41). This is not surprising since the commute distance to the telecenter is significantly shorter than the commute distance to the regular workplace so there are fewer opportunities for trip-chaining. Another interesting observation, adding specificity to a previously-noted result, is that on each of 17 (15%) telecommuting person-days, two commute trips were made, either to the telecenter alone or to the telecenter and the regular workplace. These additional trips home and back to work during the day are probably the result of a shorter commute distance to the telecenter on telecommuting days.

Table 6-19: Commute Mode Split on Telecommuting and Non-telecommuting Days for Telecenter Users

Mode[1]	Primary Mode Split		Distance-based Mode Split	
	NTC Days (177 trips)	TC Days (133 trips)	NTC Days (miles)	TC Days (miles)
Drive alone[2]	141 (79.7%)	116 (87.2%)	5255.4 (75.2%)	1104.5 (88.7%)
Carpool/vanpool[2]	25 (14.1%)	13 (9.7%)	1073.5 (15.4%)	138.3 (11.1%)
Bus	2 (1.1%)	0	105.0 (1.5%)	0
Light rail/trolley	2 (1.1%)	0	80.0 (1.1%)	0
BART/metro red line	0	0	5.0 (0.1%)	0
Commuter train	4 (2.3%)	0	304.0 (4.3%)	0
Bicycle	0	1 (0.8%)	0	1 (0.1%)
Walk	0	3 (2.3%)	2.4 (0.0%)	1.6 (0.1%)
Other	3 (1.7%)	0	167.4 (2.4%)	0

[1] "Drove/rode in electric vehicle" was one of the mode options given in the diary but never selected by the respondents.

[2] The mode category "drove conventional motor vehicle" was split into "drive alone" and "carpool/vanpool" based on the number of people in the vehicle. The mode was considered to be "carpool/vanpool" if the number of people in the vehicle was greater than one. Also, the mode category "rode in conventional motor vehicle" was merged with the "carpool/vanpool" category.

6.2.7 Aggregate Analysis

In the previous sections, TC and NTC days were analyzed separately. In this section the various results are combined to obtain an estimate of the overall work week travel impacts of telecommuting for telecenter users. Telecommuting as a work option is not likely to replace conventional work schedules completely but will only occur for a certain percentage of days in a work week. To account for this, the weighted average of travel indicators on TC and NTC days, where the weights are the relative frequencies of each day type, was computed based on the following formulas:

$$G_{AGG} = \Sigma_i G^i / N , \quad (6.1)$$

$$G^i = G^i_{TC} f^i_{TC} + G^i_{NTC} f^i_{NTC} + G^i_{HB} f^i_{HB} , \quad (6.2)$$

$$G^i_{XX} = \Sigma_j g^{ij}_{XX} / N^i_{XX} , \quad (6.3)$$

$$f^i_{XX} = N^i_{XX} / (N^i_{TC} + N^i_{NTC} + N^i_{HB}) , \quad (6.4)$$

$$f^i_{TC} + f^i_{NTC} + f^i_{HB} = 1, \quad (6.5)$$

where

G_{AGG} is the aggregate value of a generic travel indicator (number of trips, PMT, etc.),
G^i is the weighted average of the generic travel indicator for individual i,
N is the total number of respondents,
G^i_{XX} is the simple average of the travel indicator for the day type XX (TC, NTC, or HB) for respondent i,
g^{ij}_{XX} is the value of the travel indicator for the ith respondent on the respondent's jth day of type XX,
N^i_{XX} is the number of days of type XX for respondent i, and
f^i_{XX} is the frequency of occurrence of day type XX for respondent i.

The value of G_{AGG} obtained from equation (6.1) above would not be the same as the value obtained by simply replacing each element of equation (6.2) with its sample average because, by averaging first at the individual level, non-linear interactions between the frequencies and the values of the travel indicators are accounted for. For the following analysis, the last term corresponding to telecommuting from home will be neglected as it constitutes a relatively insignificant portion (6 out of 329) of the telecenter users' person-days. Using equation (6.1), the aggregate values of the number of trips, personal-vehicle trips, PMT, and VMT for telecenter users and non-telecommuters are calculated (see Table 6-20). For non-telecommuters, $f_{TC} = f_{HB} = 0$, and $G^i = G^i_{NTC}$. The G_{AGG} values obtained for non-telecommuters here are slightly different from the averages shown in Table 6-3 because here, the average travel indicators for each person are first calculated and then these averages are averaged over the entire group. This needed to be done to make the comparison equivalent among the three groups in Table 6-20. For telecenter users, $f_{HB} = 0$ and $f_{NTC} = 1 - f_{TC}$. The values of the individual telecommuting frequencies used in these calculations have been obtained from a six-month average of the sign-in log data for each person. In most cases, the window chosen was the period prior to the first TC day reported in the travel diary. However, a few respondents had filled out TC day travel diaries only in the "before" wave and for these people the six-month window was chosen from the first TC day onwards. Out of the 72 telecenter users whose travel diaries were analyzed in the earlier sections, three had diary entries for TC days only, even though their frequency of telecommuting was less than 100%. These people should not be included in the analysis since no information is available on their NTC day travel characteristics. Two telecommuters used the telecenter less than three times, and since it was not possible to reliably calculate their frequencies, they were not included in the analysis. Therefore, the results presented in Table 6-20 are based on the frequencies and travel characteristics of 67 telecenter users and 27 non-telecommuters.

Table 6-20: Comparison of the Aggregate Number of Trips, Personal-vehicle Trips, PMT, and VMT for Non-telecommuters and Telecenter Users

Study Group	Person-trips per Person-day	PV Trips per Person-day	PMT per Person-day	VMT per Person-day
Non-TCers	5.89	2.52	48.75	30.85
TCers (current)	4.37	2.95	79.16	57.94
TCers (if no telecommuting)	4.33	2.77	89.83	65.46

The values shown in the table above indicate that at current telecommuting frequencies the aggregate (over a work week) average PMT and VMT are still significantly higher for center-based than for non-telecommuters. This is because (1) the average non-telecommuting day PMT (and VMT) for telecenter users is considerably higher than for non-telecommuters (see Table 6-3), (2) the telecommuting frequency, f_{TC}, is not high enough to counter this difference in PMT (and VMT), and (3) neglecting home-based telecommuting inflates (albeit marginally) the proportion of non-telecommuting days.

The figures in the first two rows of Table 6-20 may be misleading in the sense that they seem to suggest that, in the aggregate, there are no positive travel impacts of telecommuting. However, in comparing the aggregate impacts for telecenter users to their own non-telecommuting baseline, the benefits of telecommuting for this group of long-distance commuters becomes clear. These results are shown in the final row of Table 6-20 for the no-telecommuting scenario. With the current levels of telecommuting (the average telecommuting frequency for the 67 telecenter users was 24.8%), there is a reduction of more than **11.9%** in average work-week PMT and **11.5%** in average work-week VMT when compared to the no-telecommuting alternative. Also, person and PV trips increase but only marginally (1% and 6%, respectively) over a work week, compared to the no-telecommuting alternative. This is to be expected based on the results obtained in Section 6.2.3, where we see an increase in person-trips and PV trips on TC days compared to NTC days.

6.2.8 Travel Summary

From the analysis presented in this chapter it is clear that center-based telecommuting has significant transportation impacts.

- Total person-trips increased by 0.2 trips (4.5%) on TC days, from 4.4 to 4.6 trips. However, the difference is not statistically significant at the 0.05 level (NSD).
- Commute person-trips increased by 0.6 trips (35.3%) on TC days, from 1.7 to 2.3 trips. The difference is statistically significant at the 0.05 level (SD).
- Non-commute person-trips decreased by 0.4 trips (14.8%) on TC days, from 2.7 to 2.3 trips (NSD).
- Total PV trips increased by 0.3 trips (10.0%) on TC days, from 3.0 to 3.3 trips (NSD).
- Commute PV trips increased by 0.7 trips (58.3%) on TC days, from 1.2 to 1.9 trips (SD).
- Non-commute PV trips decreased by 0.4 trips (22.2%) on TC days, from 1.8 to 1.4 trips (SD).

The increases in total and commute trips are contrary to original expectations. The primary reason for the increases appears to be telecenter users going home for lunch more often on telecommuting days, which, after all, is a desirable outcome suggesting an increased connection of the telecommuter to the family and/or neighborhood during the day.

- Total PMT decreased by 50.9 miles (58.0%) on TC days, from 87.8 to 36.9 miles (SD).
- Commute PMT decreased by 44.9 miles (71.7%) on TC days, from 62.6 to 17.7 miles (SD).
- Non-commute PMT decreased by 6.0 miles (23.8%) on TC days, from 25.2 to 19.2 miles (NSD).
- Total VMT decreased by 35.2 miles (53.0%) on TC days, from 66.4 to 31.2 miles (SD).
- Commute VMT decreased by 33.5 miles (67.4%) on TC days, from 49.7 to 16.2 miles (SD).

- Non-commute VMT decreased by 1.7 miles (10.2%) on TC days, from 16.7 to 15.0 miles (NSD).

As hypothesized, there is a sizable reduction in the commute PMT and VMT on telecommuting days. This reduction is mainly because the commute distance of telecenter users to the regular workplace is much greater than to the telecenter. There are non-significant decreases in non-commute PMT and VMT as well, contrary to the hypotheses of some researchers that telecommuting would generate non-work travel.

- With the current average telecommuting frequency of 24.8%, there is a reduction of more than 11.9% in average work-week PMT compared to the no-telecommuting alternative.
- Also, with the current frequency of telecommuting, there is a reduction of 11.5% in average work-week VMT compared to the no-telecommuting alternative.
- There is only a marginal increase in person- (1.0%) and PV trips (6.0%) over a work week with the current frequencies of telecommuting, compared to the no-telecommuting alternative.
- The mode choice analysis revealed that there is a substantial increase in the share of drive-alone commute trips on telecommuting days and a corresponding decrease in the share of transit and rideshare trips.

It is beyond the scope of the current study to analyze the total systemwide impacts of center-based telecommuting. As a fraction of total VMT from all sources (telecommuters, non-telecommuters, all days, for all purposes), current VMT reductions due to center-based telecommuting are negligible due to the low levels of this form of telecommuting. Other studies (Mokhtarian, 1998) suggest that even if telecommuting (in either form) increases to well beyond today's levels, the aggregate impacts on travel are likely to be modest. Nevertheless, the overall impacts are likely to be beneficial, and of an order of magnitude similar to those of other transportation demand management strategies. Hence, it appears to be appropriate to support both forms of telecommuting as such a strategy.

6.3 Emission Analysis

6.3.1 Introduction

To evaluate center-based telecommuting as a potential Transportation Demand Management strategy, it is important to study not only its travel impacts but also its air quality impacts. A number of earlier studies have examined the air quality impacts of home-based telecommuting (Sampath, *et al.*, 1991; Koenig, *et al.*, 1996; Henderson, *et al.*, 1996), but only one has studied the air quality impacts of center-based telecommuting (Henderson and Mokhtarian, 1996). The earlier studies have shown that home-based telecommuting has beneficial air quality impacts. These benefits include significant reductions in all pollutants generated (TOG, CO, NOx, and PM). However, it is not very clear if center-based telecommuting will have similar benefits, especially since center-based telecommuting does not entirely eliminate the commute trip. The earlier study on air quality impacts of center-based telecommuting (Henderson and Mokhtarian, 1996) showed that TOG and CO emissions were essentially unaffected, and NOx and PM emissions were significantly reduced, comparing telecommuting days to non-telecommuting days. However, the results were based on only 8 center-based telecommuters. So the present research offers a larger sample from which to draw conclusions.

The travel analysis conducted on the telecenter users (Section 6.2) revealed that center-based telecommuting in fact resulted in a marginal increase of 0.3 (10%) vehicle-trips/person-day, although VMT decreased by almost 53%. The significant reduction in VMT will have a positive impact on vehicle emissions. However, the marginal increase in the number of vehicle-trips (and a comparable 10% increase in the number of cold starts) may have a negative impact on vehicle emissions.

Using VMT and trips alone to gauge the probable emissions impacts has its limitations. These measures only partially explain vehicle emissions. The vehicle emission process is complex and involves an interaction of numerous other factors including: the vehicle types and pollution control technologies in the fleet; how the vehicles are operated (speeds, acceleration/deceleration, etc.); environmental conditions (including season and ambient temperature) and other travel-related indicators (number of cold and hot engine starts, etc.). An accurate assessment of emissions impacts involves using vehicle emissions models that take all of these factors into consideration.

This section compares the emission characteristics of center-based telecommuters, both on NTC days and TC days, and non-telecommuters.

6.3.2 Modeling Vehicular Emissions

The vehicular emissions are modeled in two steps (CARB, 1993). First, emission factors (e.g. grams/cold start, grams/mile of emissions) are developed for each emissions-producing vehicle activity (e.g. cold engine starts, VMT). Second, the total emissions for an activity are calculated by multiplying the emission factors by the appropriate vehicle activity. To model the vehicular emissions, the main data requirements include the following (Guensler, *et al.*, 1994): 1) quantifying the emissions-producing vehicle activity (e.g. number of trips, VMT, cold vehicle starts, hot vehicle starts); 2) determining the key characteristics of the vehicle fleet (e.g. vehicle classes, pollution control technologies, vehicle model years, operating characteristics); 3) obtaining data on environmental factors (e.g. season, ambient temperature); and 4) collecting emissions factor data for each emissions-producing process (engine starts, running exhaust processes, and evaporative processes). These data are then used in computer emissions models to calculate a total emissions inventory by weighting each emission-producing activity by its appropriate emissions factor and summing the totals for all activity in the sample.

6.3.3 Overview of the Models

The EMFAC7F and BURDEN7F models are designed to calculate aggregate emissions inventories (in tons per day) generated from vehicle activity for air basins in California (CARB, 1993). The user specifies the inventory year and the season (either summer or winter) in which vehicle activity takes place. The data for this project were collected over a period of four years (1993 - 1996). The inventory year was specified to be 1996 because this would enable the inclusion into the fleet mix data file of activities by vehicles of all model years found in the sample, whereas specifying an earlier inventory year would not allow activities by vehicles of later model years to be included. That fleet mix data file, as customized for our sample, contained the percentage of total activity within each class/technology group (e.g., the percent of all vehicle-miles traveled by catalyst-equipped light duty autos) that were accomplished by vehicles of each model year (regardless of the year in which the activity actually occurred). The

temperature distribution and fleet mix vary by calendar year, and the emission factors vary by season and calendar year. As a simplification the analysis uses the 1996 temperature distribution, regardless of the year in which the activity actually occurred. Summer and winter are the two seasons for which vehicle activity patterns and atmospheric conditions combine to produce the worst air quality. The different characteristics of the seasons are associated with violations of air quality standards for different pollutants. In summer, ozone precursors (TOG and NOx) are of greatest concern, whereas in the winter, CO levels are most important to monitor. For this study, an emissions inventory was run only for the summer season.

The travel data for this study were collected from different air basins throughout the state of California. Incorporating all these air basins into the models would make the analysis cumbersome. Therefore the single air basin where the most trips took place was chosen for the emissions inventory. The results presented below are for the San Diego air basin, since 40% of all the trips in the data collected took place in San Diego County. Assuming that all trips took place in one air basin would not greatly affect the relative comparison of emission levels among groups.

Seven *pollutant types* are modeled by EMFAC7F and BURDEN7F: total organic gases (TOG), reactive organic gases (ROG), carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), and lead. The SOx and lead outputs are not reported here because the vehicle activity in this small sample did not generate measurable amounts of these pollutants. The input for BURDEN7F required that personal vehicles be classified into *class/technology groups*. Three categories of vehicles were present in this sample: catalyst-equipped and non-catalyst-equipped light duty automobiles, and catalyst-equipped light duty trucks. Vehicles manufactured from 1975 onwards belong to the catalyst-equipped technology group (by law) and the earlier vehicles are assumed to belong to the non-catalyst-equipped technology group (only a small proportion of pre-1975 vehicles would have had a catalytic converter). Vehicles are modeled as having seven different emission-producing processes: running exhaust, cold start exhaust, hot start exhaust, hot soak emissions, evaporative running losses, diurnal emissions, and evaporative resting losses. To assess the impacts of changing ambient temperatures on vehicle emissions, BURDEN7F models vehicle activity for six different time periods throughout the day. These time periods are: 12 midnight to 6 a.m., 6 a.m. to 9 a.m., 9 a.m. to 12 noon, 12 noon to 3 p.m., 3 p.m. to 6 p.m., and 6 p.m. to 12 midnight.

For a particular calendar year, EMFAC7F calculates an array of emissions factors for each combination of vehicle class/technology group, emissions process, and pollutant type. BURDEN7F references these emissions factors, and compiles the emissions inventory for a specific set of vehicle activity data for each of the six time periods of the day. The emissions inventory is produced by weighting each measure of vehicle activity (VMT, number of cold starts, etc.) with the appropriate emissions factors and adding these emissions figures for each time period of the day. A detailed discussion of the models is found in CARB (1993).

6.3.4 Modifications to the Models

All the major input files to the models were changed using the travel diary data. A number of computer programs were written to tabulate the travel diary data and provide the necessary input for BURDEN7F's three main data files: 1) the cold start fraction of trips made by vehicles with and without catalytic converters for each of the six time periods of the day; 2) the vehicle

population, number of trips made and VMT by each vehicle class for each of the six time periods of the day; 3) VMT percentages by average speed for each of the six time periods.

EMFAC7F and BURDEN7F were developed to model aggregate emissions for each air basin in California, and therefore use an average California vehicle fleet. However, individual-level analyses require sample-specific data, rather than aggregate data, to provide meaningful comparisons across groups within the sample. Therefore, the average California vehicle fleet data in EMFAC7F was replaced with the actual vehicle representation for each group from the travel diary data. To allow the generation of accurate weighting functions, modified versions of the models were used in which the fleet mix file subroutine was deactivated. The output from the subroutine was generated manually to include vehicles, VMT, and trip information from the travel diary data.

6.3.5 Factors Affecting the Emissions Impacts of Telecommuting

To completely assess the air quality impacts of telecommuting, three types of impacts should be studied (Henderson, *et al.*, 1996). The first type of impacts are the *direct transportation* impacts which can be directly obtained from the travel diary data. The second type of air quality impacts are the *indirect transportation* impacts. These are due to indirect changes in household travel, weekend travel, and long-term residential location resulting from the adoption of telecommuting. The third type of impacts are the *indirect non-transportation impacts*. These are mostly related to changes in energy consumption due to telecommuting (e.g. lighting or heating that wouldn't be used otherwise). In this study however, the available data permit the analysis of only the direct transportation impacts of telecommuting.

A number of factors affecting the direct air quality impacts can be influenced by telecommuting and these changes will affect vehicle emission levels. These factors include: trip length (VMT), number of trips, cold starts, trip speeds, ambient temperature for the trip, and the season in which the vehicle activity takes place.

The running exhaust and running evaporative emissions are directly affected by the *vehicle-miles traveled (VMT)*. Running emissions constitute a significant portion (50%) of the total emissions for NOx and PM. Running emissions also contribute significantly to TOG and CO emissions. Since VMT decreases on telecommuting days (Section 6.2), this will contribute to lower vehicle emissions for all pollutants, especially NOx and PM.

Engine start-up emissions (cold and hot start) and engine shut-down emissions (hot soak) are directly related to the *number of trips*. Since center-based telecommuting actually increases the number of trips (Section 6.2), though only marginally, this could lead to an increase in emissions resulting from vehicle start-ups and shut-downs.

Emissions due to *cold starts* are significantly higher than hot start emissions. (An engine's start is considered "cold" if it has been turned off for more than one hour for vehicles with a catalytic converter, and four hours for vehicles without a catalytic converter). Cold starts are the primary source of TOG and CO emissions for short-to-moderate length trips. Since the number of cold starts on telecommuting days is slightly higher than that on non-telecommuting days (Section 6.2), there may not be significant reductions in TOG and CO; in fact there may be increases.

A number of other factors such as acceleration rates, deceleration rates, and average speeds, influence vehicle emission rates. Generally, there is a U-shaped relationship between speed and running emissions (CARB, 1990). Emission rates decrease as speeds increase up to approximately 50-60 mph, beyond which the emission rates increase with increasing speeds. The impact of telecommuting on travel speeds is uncertain (Sampath, *et al.*, 1991). If telecommuting tends to shift trips to off-peak periods of the day, this could lead to higher travel speeds. However, telecommuting could shift trips from freeways to the surface streets where vehicle travel is usually slower. Also, trips with more accelerations and decelerations result in higher emissions than those with constant speed. In this study, however, accelerations and decelerations could not be determined from the data and only an average speed could be calculated based on distance and time.

6.3.6 Uncertainties in Modeling Emissions

The specific modeling results obtained have a high degree of uncertainty because the emission models were only designed to roughly estimate a "bulk" emissions inventory for an entire air basin, and were never designed to evaluate policy issues (Guensler, *et al.*, 1994). Uncertainty is pervasive in all three emission modeling components: vehicle activity, activity-specific emission rates, and emission rate correction factors.

The emission rate model (EMFAC7F) employs an average speed modeling regime to calculate running exhaust emission rates. The average speed algorithms exhibit a large range of uncertainty and the relationship between average speed and emissions is not very clear. The emissions values calculated by these models for low speed vehicular activity are not very accurate. The speed correction factors used in these empirical models do not account for impacts of vehicle operating modes (such as acceleration and deceleration effects and increased engine loads) which adds further to the uncertainty in calculating emissions. Improving the models and developing entirely new ones is the subject of considerable research at the present, but in the meantime these models represent the current best practice. Though the numerical values for emissions presented in the following section may not be very accurate, the shortcomings of the models should apply approximately equally to both TC days and NTC days. Hence the relative comparison of emissions between the two day types is expected to be meaningful.

6.3.7 Emission Findings

The emissions analysis presented here is based on the travel diaries of telecenter users and non-telecommuters. Home-based telecommuters were not included in this analysis, mainly because the small sample size of home-based telecommuters may not provide an accurate measure of the impact of home-based telecommuting on vehicular emissions. Also, only drive-alone trips made by personal vehicles were included in the analysis. To calculate the emissions impacts of telecommuting the total emissions output from each group was converted to grams per person-day to control for the different size groups. The denominator of the grams per person-day calculation includes days on which participants did not make personal-vehicle trips. These days are included to represent emissions across the population as a whole, not just the population of those who drive alone. Further, one of the key impacts that is being measured is the reduction in personal-vehicle travel due to center-based telecommuting.

Table 6-21 summarizes the emission findings for center-based telecommuters, on both TC and NTC days, and the non-telecommuter group. The TC group consisted of 116 person-days out of which personal-vehicle trips were made on 103 (89%) person-days. The NTC group consisted of 207 person-days out of which personal-vehicle trips were made on 190 (92%) person-days. The non-telecommuter group consisted of 107 person-days out of which personal-vehicle trips were made on 75 (70%) person-days.

Table 6-21: Emissions Impacts of Telecommuting (Average per Person-day)

	Telecommuters		Non-telecommuters (N = 107)
	NTC Days (N = 207)	TC Days (N = 116)	
VMT	66.39	31.16	30.99
PV trips	2.98	3.29	2.35
Cold starts[1]	2.18	2.26	1.57
Hot starts[1]	0.80	1.03	0.78
Average mph (weighted by VMT)	46.49	46.38	44.59
TOG (gm)	19.13	16.27	15.73
CO (gm)	105.64	82.94	62.15
NOx (gm)	24.41	15.88	11.15
PM (gm)	13.37	6.49	6.36

[1] These numbers differ slightly from those in the previous section because, for the emissions analysis, trips with missing timing information were proportionately distributed between hot and cold starts.

Comparing the grams/day emissions of telecommuters on TC days and NTC days shows that vehicle emissions are greatly reduced as a result of telecommuting. (Statistical tests of the differences between day types cannot be performed since the model produces only aggregate rather than disaggregate emissions estimates, and hence, standard deviations are unknown). There is a 15% reduction for total organic gas emissions, 21% for carbon monoxide, 35% for oxides of nitrogen, and 51% for particulate matter. Another interesting observation is that the average speeds (weighted by VMT) on TC and NTC days are almost identical. This is not necessarily surprising since, as indicated in Section 6.3.5, effects in either direction are plausible.

The 53% reduction in VMT on TC days is the primary reason for the decrease in the emissions of all pollutants. VMT has been shown to be the primary contributor to PM and NOx and therefore we see the largest reductions for these emissions. The decrease in PM emissions is almost exactly proportional to the reduction in VMT.

The reductions in TOG (15%) and CO (21%) emissions (which are less directly related to VMT) have taken place in spite of marginal increases in the number of trips, cold starts and hot starts. Further analysis was done to find out the causes for the reductions. Table 6-22 and Figures 6-12, 6-13, 6-14, and 6-15 show the disaggregation of TOG, CO, NOx and PM emissions into the different emission-producing processes. From the table it is clear that most of the reductions

observed in the TOG emissions are due to reductions, on telecommuting days, in running exhaust and running losses which are dependent mainly on VMT. Also, there seems to be a slight decrease in cold start exhaust in spite of the marginal increase in cold starts on telecommuting days. Since cold start emissions depend not only on number of cold starts but also on the ambient temperatures, the observed reduction could be the result of more cold starts taking place during the middle of the day, when the temperatures are higher, on telecommuting days. Higher temperatures result in lower cold start emissions. The distribution of cold starts by time of day is further explored below. The reductions in the CO emissions on telecommuting days is mainly due to the reduction in running exhaust. Again, there is a marginal decrease in cold start exhaust. From Table 6-22 it is clear that the substantial reductions in NOx and PM emissions are due to the substantial decrease in VMT on telecommuting days.

Table 6-22: Comparison of Emissions on TC and NTC Days

	NTC Days (N = 207)	TC Days (N = 116)
TOG (gm)		
Total	19.13	16.27
Running exhaust	4.14	2.70
Cold start exhaust	6.42	6.14
Hot start exhaust	0.31	0.39
Diurnal evaporation	0.22	0.35
Hot soak evaporation	1.21	1.64
Running losses	6.64	4.69
Resting losses	0.20	0.35
CO (gm)		
Total	105.64	82.94
Running exhaust	31.38	12.55
Cold Start exhaust	69.55	64.25
Hot start exhaust	4.71	6.14
NOx (gm)		
Total	24.41	15.88
Running exhaust	20.09	11.30
Cold start exhaust	3.79	3.87
Hot start exhaust	0.53	0.70
PM (gm)		
Total	13.37	6.49
Exhaust	0.64	0.31
Tire-wear	12.73	6.18

Figure 6-12: Total Organic Gases

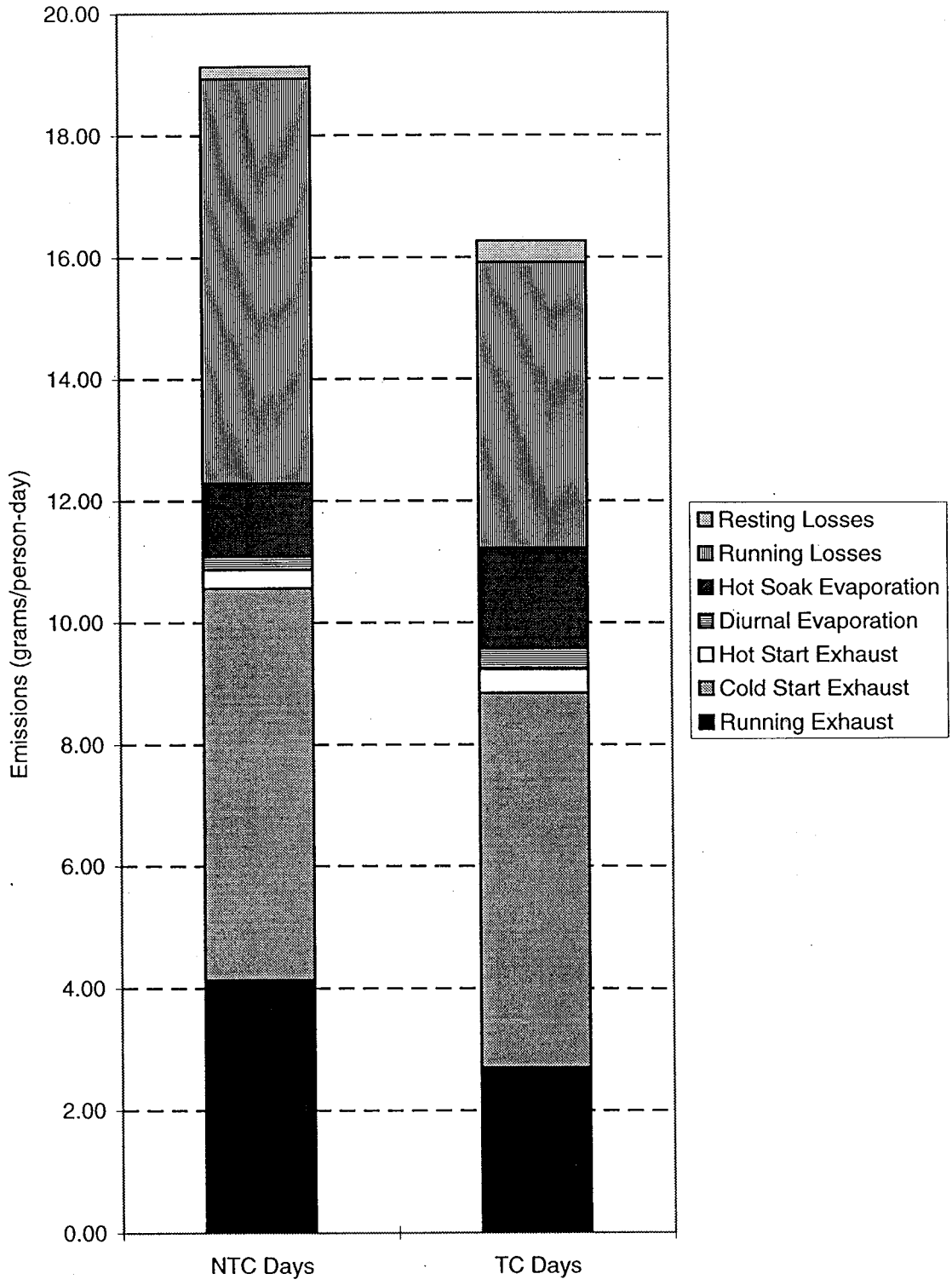


Figure 6-13: Carbon Monoxide

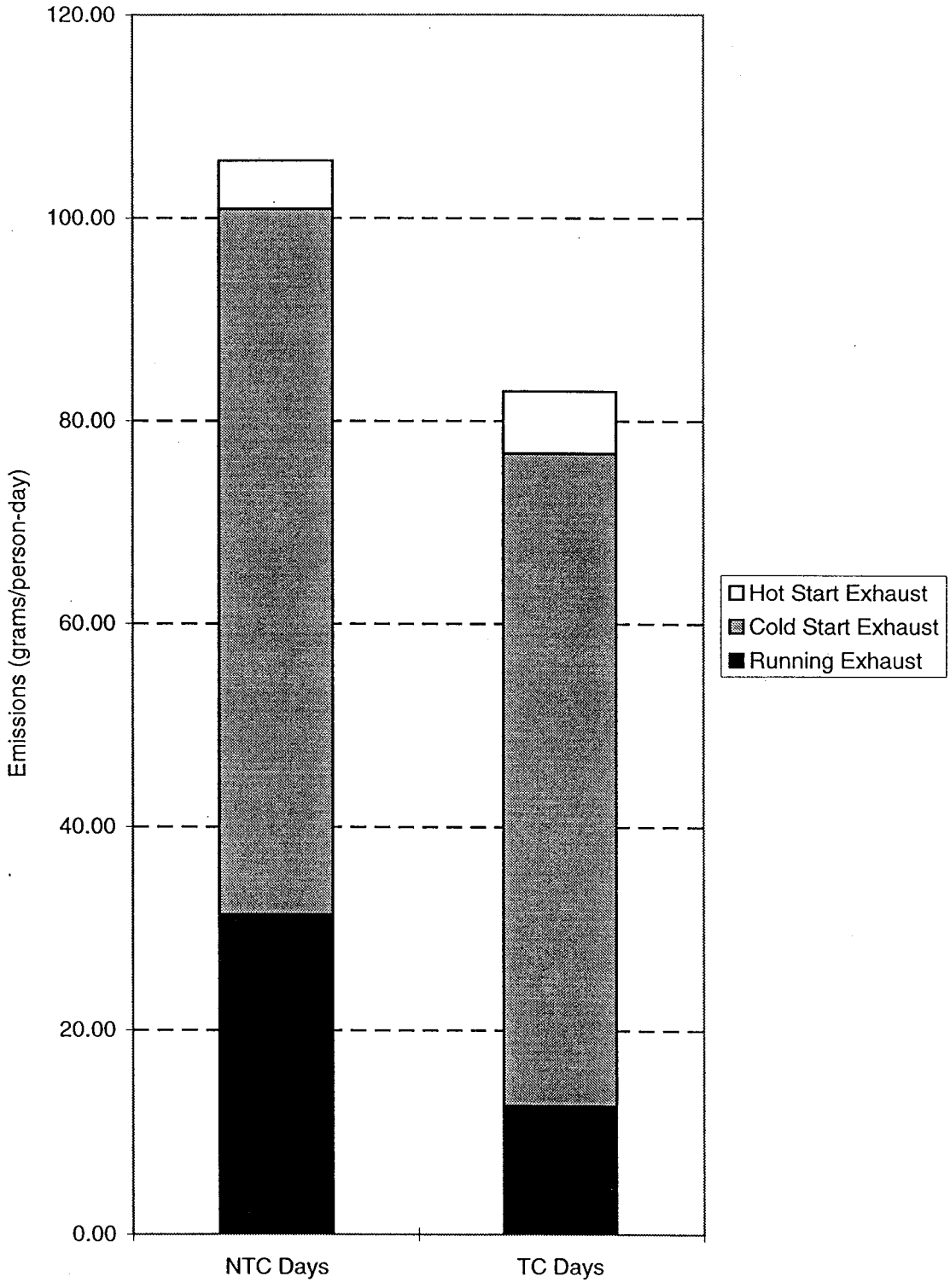


Figure 6-14: Oxides of Nitrogen

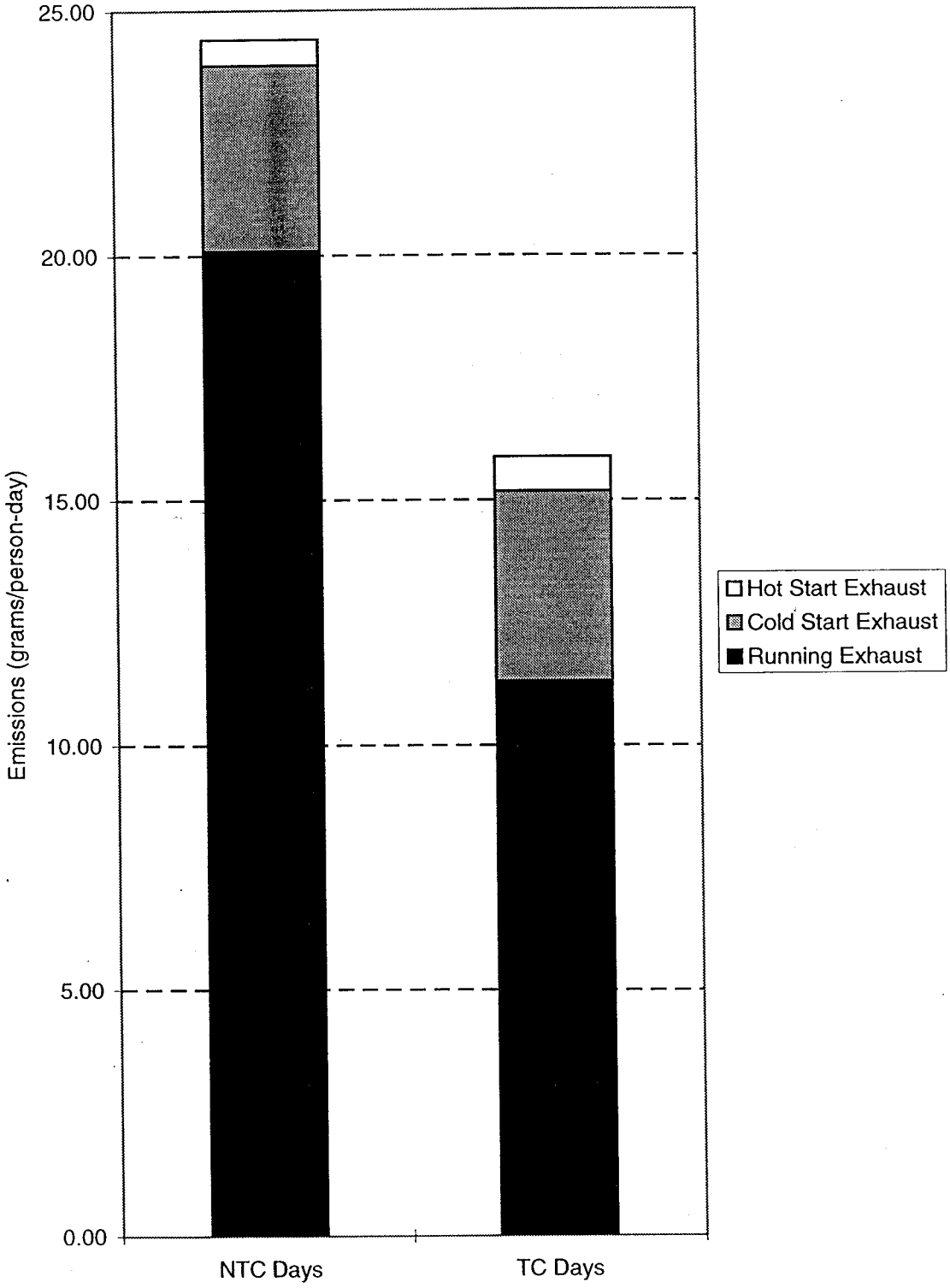
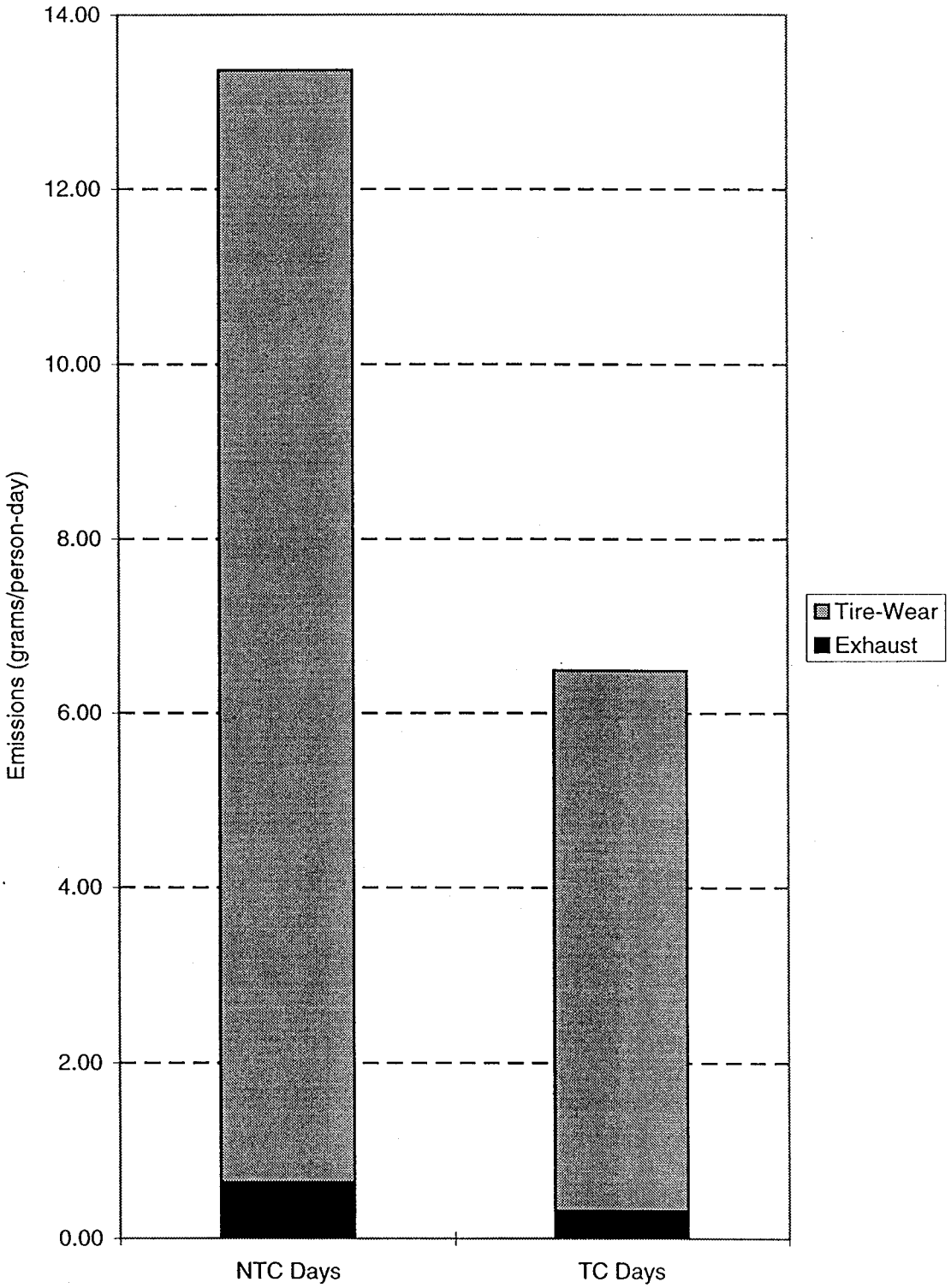


Figure 6-15: Particulate Matter



The distribution of cold starts by time of day was further studied to understand why cold start exhaust actually decreases (for TOG and CO) on telecommuting days despite the increase in the number of cold starts. Table 6-23 shows the distribution of cold starts throughout the day. The total at the bottom of each column represents the total number of cold starts per person-day for that particular group. It can be seen that telecommuting was effective in compressing cold starts towards the middle of the day with large reductions in the number of cold starts during the early morning (12 midnight - 6 a.m.) and late evening (6 p.m. - 12 midnight) periods. This reduction in the number of cold starts at lower ambient temperatures is probably the main reason for the slight decreases observed in cold start exhausts for TOG and CO.

Table 6-23: Number and Percent of Cold Starts per Person-day by Time of Day

	Telecommuters		Non-telecommuters (N = 107)
	NTC Days (N = 207)	TC Days (N = 116)	
12 midnight - 6 a.m.	0.27 (12.6%)	0.07 (3.1%)	0.10 (6.1%)
6 a.m. - 9 a.m.	0.60 (27.6%)	0.69 (30.6%)	0.46 (29.3%)
9 a.m. - 12 noon	0.17 (7.6%)	0.32 (14.4%)	0.13 (8.5%)
12 noon - 3 p.m.	0.21 (9.5%)	0.35 (15.5%)	0.12 (7.9%)
3 p.m. - 6 p.m.	0.70 (32.0%)	0.70 (31.0%)	0.59 (37.8%)
6 p.m. - 12 midnight	0.23 (10.7%)	0.12 (5.4%)	0.16 (10.4%)
Total	2.18 (100%)	2.26 (100%)	1.57 (100%)

The TOG, CO and NOx emission values obtained here are lower (by more than 50% for some pollutants) than those reported in some earlier studies (Henderson, *et al.*, 1996; Koenig, *et al.*, 1996). There could be a number of reasons for this, including different travel characteristics (earlier studies were for home-based telecommuting), air basins modeled and fleet mix. Since center-based telecommuting does not entirely eliminate the commute trip, the average number of trips is greater on center-based telecommuting days than on home-based telecommuting days. Therefore, it is reasonable to expect that emissions reductions due to center-based telecommuting would be lower than due to home-based telecommuting. The effects of differences in air basins modeled and fleet mix between the earlier studies and the current study were further explored. It was found that by changing the air basin from San Diego to Sacramento Valley (used in an earlier study), the emission value for TOG increased by 20%, CO increased by 10%, and there were no significant increases in NOx and PM. Also, five years was subtracted from the model year of each of the vehicles in the sample, to simulate a fleet mix closer to the time that data were collected for the previous studies. The resulting emissions obtained showed that, with the older fleet, TOG values increased by 100%, CO by 40% , NOx by 80% and PM did not increase significantly. This is not surprising since EMFAC7F attempts to reflect improvements in technology that result in newer vehicles polluting less. Hence, the differences between this study and earlier ones are plausible given the newer vehicle fleet seen here and the different air basin in which most trips took place.

Table 6-24 compares some of the results from the only earlier study on the emissions impacts of center-based telecommuting (Henderson and Mokhtarian, 1996) with those obtained from the current study. However, it should be noted that the earlier study was based on only 8 center-based telecommuters, whereas the current study is based on a much larger sample of 72 center-based telecommuters. From the table it can be seen that the emissions reductions are comparable between the two studies. The larger reductions in TOG and CO emissions on TC days in the current study are probably due to the fact that the percent increase in PV trips on TC days in the current study (10%) is lower than in the earlier study (20%).

Table 6-24: Comparison of Key Travel and Emissions Characteristics of Center-based Telecommuters on TC and NTC Days

	Henderson and Mokhtarian Study (8 Puget Sound Telecommuters)	Current Study (72 California Telecommuters)
VMT	54% decrease on TC days	53% decrease on TC days
PV trips	20% increase on TC days (NSD)	10% increase on TC days (NSD)
NOx	49% decrease on TC days	35% decrease on TC days
PM	53% decrease on TC days	51% decrease on TC days
TOG	4% decrease on TC days	15% decrease on TC days
CO	0% change on TC days	21% decrease on TC days

NSD: No significant difference.

6.4 Summary and Conclusions

This final section first presents a summary of the key findings from the travel and emissions analyses (6.4.1), then discusses additional analyses that could be performed on the travel diary data (6.4.2).

6.4.1 Summary

Travel analysis was conducted for three groups of people, namely, telecenter users, home-based telecommuters and non-telecommuters. Six fundamental travel indicators were studied for the three groups: person-trips, personal-vehicle trips, person-miles traveled (PMT), vehicle-miles traveled (VMT), cold starts, and hot starts. In addition, the impacts of center-based telecommuting on commute and non-commute travel, mode choice and commute mode choice were studied. An aggregate analysis of the travel impacts for center-based telecommuters was conducted by accounting for the frequency of telecommuting.

The travel characteristics for NTC days of telecenter users were significantly different from the NTC days of home-based telecommuters and also non-telecommuters. There were no significant differences between the non-telecommuters and the NTC days of home-based telecommuters. A comparison of the travel characteristics of center-based and home-based telecommuters on both NTC and TC days revealed that the impacts of home-based telecommuting and center-based

telecommuting on the number of trips were quite different. The number of trips decreased on TC days for home-based telecommuters, whereas the number of trips increased marginally on TC days for center-based telecommuters. However, both forms of telecommuting result in substantial reductions in PMT and VMT on TC days.

Comparison of commute and non-commute travel on telecommuting and non-telecommuting days for telecenter users showed that there was a substantial decrease in the commute PMT (44.9 miles) and VMT (33.5 miles) on telecommuting days. Also, the non-commute PMT decreased by six miles and non-commute VMT decreased by 1.7 miles on telecommuting days. The number of commute person-trips increased by 0.6 and the number of commute PV trips increased by 0.7 on telecommuting days. Also, the number of non-commute person-trips and non-commute PV trips decreased by 0.4 on telecommuting days. The mode choice analysis revealed that there was a significant increase in drive-alone commute trips on telecommuting days and a corresponding decrease in transit and rideshare trips.

To obtain a better understanding of the overall impact of telecommuting, the aggregate values of the travel indicators were studied. This was done by weighting the travel indicators for each individual by his or her corresponding telecommuting frequency, and averaging across the sample. At the current average frequency of telecommuting of 24.8% (1-1/4 days per week), there was a reduction of more than 11.9% in average work-week PMT and 11.5% in average work-week VMT compared to the no-telecommuting alternative. Also, in the aggregate there was only a marginal increase in person- (1.0%) and PV trips (6.0%) over a work week (at the current frequencies of telecommuting), compared to the no-telecommuting alternative.

Emissions analysis was conducted for center-based telecommuters, both on NTC days and TC days, and non-telecommuters. Comparing the grams/day emissions of telecommuters on TC days and NTC days showed that vehicle emissions were greatly reduced as a result of telecommuting. There was a 15% reduction for total organic gas emissions, 21% for carbon monoxide, 35% for the oxides of nitrogen, and 51% for particulate matter. The primary reason for the decrease in emissions of all pollutants was the 53% reduction in VMT which more than compensated for the marginal increase in number of trips (consequently, cold starts) on telecommuting days. Also, the analysis of the distribution of cold starts by time of day revealed that on telecommuting days the number of cold starts at lower ambient temperatures (early morning and late evening) decreased. This was the main reason for the decreases observed even in cold start exhausts for TOG and CO.

6.4.2 Directions for Future Research

To measure the effects of telecenter use on household travel, it is important to study the travel patterns of all members of the telecenter user household. The analysis of travel at the household level could provide valuable information to determine whether reductions in travel by the telecommuter are partially compensated for by increases in travel on the part of household members. Also, the emissions analysis would be more rigorous if all uses of a household vehicle were accounted for, thus allowing each particular trip to be more accurately classified as either a hot or cold start.

The travel diary data also allow for a spatial analysis of the travel impacts of telecenter use. Such an analysis would examine the extent to which new locations are visited after

telecommuting and the spatial orientation of those locations relative to home, telecenter, and regular workplace. Saxena and Mokhtarian (1997) have conducted such a study for home-based telecommuting; an interesting difference from that previous study is the introduction of the telecommuting center as a frequently-visited destination. This may lead to the identification of new destinations near the center, which has implications for the local economic development impacts of telecenters.

Future studies on emissions impacts of telecommuting will benefit from improvements to the EMFAC/BURDEN models. It is expected that the new (7G) versions of the models will increase predicted emissions levels to be more consistent with field-measured pollutant concentrations (Washington, 1994). These improvements will provide a more accurate assessment of the emissions benefits of telecommuting.

Finally, the results presented are based on the travel characteristics of a sample of the early adopters of center-based telecommuting. It is possible that future center-based telecommuters may exhibit trip-making behavior that is different from the current sample. This could result from a number of factors, including the location and density of future telecenters. The density of the current demonstration telecenters is very low and also most of them are located in suburban areas of metropolitan regions. As the density of telecenters increases it is possible that the commute distance to the center may further decrease, resulting in additional travel savings. On the other hand, as more telecenters are set up in urban areas (where the average commute distance to the regular workplace would be shorter than in suburban areas), the reductions in travel as a result of center-based telecommuting may turn out to be less dramatic than those currently observed. Therefore, it would be valuable to continue to monitor and analyze the travel characteristics of center-based telecommuters which will provide useful insights that can either confirm or counter the current results.

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CHAPTER 7

SUMMARY AND CONCLUSIONS

7. SUMMARY AND CONCLUSIONS

In this chapter, we first summarize the key findings from each of the chapters in the final report (Section 7.1), then discuss additional analyses that could be performed on these and future data (Section 7.2), and finally interpret the results to date (Section 7.3).

7.1 Summary

This report provides an evaluation of telecommuting center use and its impacts on work performance, job satisfaction, and travel behavior. To that end, four survey instruments were developed to measure telecenter use and its effects at both RABO (Residential Area-Based Offices) and non-RABO sites: an attitudinal survey, a travel diary, an attendance log, and an exit interview. The survey and diary were administered to participants once before and once after the start of telecommuting, the attendance log was used throughout the study period, and the exit interview was conducted when participants left the program. The results of this complex evaluation process were presented in the previous five chapters: procedural issues in the evaluation process, attitudinal survey analysis, analysis of telecommuting patterns, analysis of telecommuting retention, and travel and air quality impacts. Each of these chapters is summarized below.

7.1.1 Procedural Issues

The RABO Project not only provides information on the practice of telecommuting center use, it also provides valuable lessons in the process of evaluating the use of telecommuting centers. The procedural issues related in this chapter dealt with contractual compliance, site usage measurement, and modification of the survey process. Since telecommuting centers are a relatively new concept, the lessons learned here will help later evaluation programs be more effective.

Changes to the contracts with site developers were necessitated by problems with data collection. Some contracts did not directly tie the university to the administrators of the telecenter which resulted in poor communication and inadequate survey response rates. At all centers, survey response rates that were lower than desired led to modifications of the center funding policies. Telecommuters were only counted in funding invoices if they had completed the required surveys. This new policy also emphasized that, while participation itself was voluntary, survey completion was a mandatory element of participation. Additional methods for improving survey collection included shifting the duties of survey distribution and collection from the site administrator to the Evaluation Manager for those centers which did not want to handle these activities.

A specific definition of telecenter occupancy was developed to ensure that the measured rate of telecommuting reflected the goals of the study. The monthly site occupancy rate calculated to assess compliance with contractual targets included only the telecommuting occasions by project participants that lasted at least four hours. However, there were other meaningful (in terms of travel reduction) uses of the center that fell outside this narrow definition. As a result, uses by telecommuters for any length of time were documented and evaluated. Further, most sites set up at least some of their workstations for use by drop-in customers, and others specifically leased work space to particular companies (neither of those types of center users participated in the evaluation). Some participants who used the center as their primary place of business were included as project participants even though their situation was quite different than that of the typical telecommuter from a large organization. These participants may not have had managers or co-workers to

participate in surveys, may not have had travel reduction benefits, and during the demonstration period, may have been unfairly subsidized in terms of office space costs in relation to similar businesses. It is recommended that a screening process be used to give highest priority to those who are truly telecommuting, while still allowing other uses to continue at the site since a diversity of clients is a key to long-term operation.

Other issues involved in the evaluation process included changes to the survey procedure. Originally, focus groups were to be used to identify any problems or concerns that either the telecommuters or their managers may have had with the telecenters. However, problems with timing and scheduling caused the focus groups to be replaced by individual telephone interviews.

Additionally, the availability of a videoconferencing room at some telecommuting centers led to the development of a usage log for these facilities. The analysis of this data illustrates that the two most popular purposes for videoconferences were information exchange and teaching/instruction. Only two sites were involved with each videoconference and the average total attendance at each session was eight people (neglecting a single occasion with 47 people). The smaller-group sessions (less than eight) were centered around information exchange and the larger-group sessions (greater than or equal to eight) tended to be used for teaching/instruction purposes. The mean duration for videoconference sessions was approximately one and a half hours. About one-third of the sessions lasted one hour, mostly occurring at the Moorpark and Ventura Community College sites, corresponding to teaching/instruction purposes and the approximate one-hour length of most classes. Videoconference use was also mainly limited, geographically, to California. The technology at the centers did not yet seem to be used regularly on a national or international basis, which is not surprising in view of the relative novelty of the technology and the profile of the center users.

7.1.2 Attitudinal Survey Analysis

Similar attitudinal surveys were administered to three groups of participants (telecenter users, home-based telecommuters, and non-telecommuters) and their managers at two points in time (before the start of telecenter use and approximately six months afterwards). A sizable number of participants came from non-RABO sites and had already been telecommuting for sometime; before survey measures were not available for this group. The surveys collected data on attitudes toward telecommuting, work characteristics, travel characteristics, and demographic information. In the sections below, we discuss results for the telecenter employee survey, the manager survey for supervisors of telecenter users, and a comparison of employee and manager responses.

7.1.2.1 Employee Survey Results

In this final report, the analysis of the survey data is restricted to telecenter users only. Primarily, the data from the after-wave surveys were used to characterize center-based telecommuters (sample size of 69). However, where appropriate, data from both before and after waves were utilized to highlight changes related to the use of telecenters (a reduced sample size of 54 respondents who completed surveys in both waves). A summary of the results from the six parts of the survey is provided below.

In terms of demographics, there were half again as many female telecenter users as males, and nearly half the sample was between the ages of 35 to 44 years. The average household size of 2.7 persons was consistent with the fact that more than half of the respondents had children under 16 years of

age. Vehicle availability was high among the respondents with 2.2 vehicles per household and 1.1 vehicles per licensed driver. The telecenter users were highly educated (about 43% had additional schooling after college) and relatively affluent (about 70% had annual household incomes greater than $55,000).

Job characteristics varied among the center-based telecommuters. Slightly more than half of the sample held professional/technical positions which are usually easily adapted to telecommuting, and as a whole, they were experienced in their field with an average length of time in the profession of 10.5 years. Flexible schedules were common among the telecenter users, with more than 80% of the sample having some form of flextime or compressed work week schedule. Finally, the respondents spent a high proportion of their workday working independently (44%) or remotely (20%), both of which are good indicators of positions with telecommutable tasks.

The responses from the attitudinal sections on job performance and satisfaction and work environment characteristics showed primarily positive results. Telecenter users rated their job performance and satisfaction positively, and there was little change in these characteristics between survey waves suggesting that working from a telecommuting center did not drastically change these factors. The ratings on the statements about work characteristics also remained approximately the same between survey measurements. Finally, the most important work characteristics to the respondents were working effectively, having needed equipment, and having work judged by the results. The telecenter was rated most favorably of the three workplaces (telecenter, home, regular workplace) on the most important characteristic of working effectively.

The survey also measured the amount of telecommuting the telecenter users had done, were currently doing, and planned to do in the future. The average experience with telecommuting from a center was about one year (median of 9.0 months) at the time of the after survey, and more than one-third also had prior experience with home-based telecommuting. About a third of the respondents did not currently have the option to telecommute from home (based solely on job and manager considerations), which indicates that centers may help spread the transportation and other benefits of telecommuting to a larger segment of the workforce. With the time saved by telecommuting, the respondents most often spent time with family or friends, worked, got more sleep, and/or did housework/yardwork.

When distributing their work time in an ideal situation, the respondents preferred to work from the telecenter and the regular workplace about equal amounts, 41% to 43% of their time (each) on average. However, they reported actually telecommuting only about 33% of the time even though their jobs were suitable for telecommuting for about 44% of the time, on average (see Section 4.4.2 for actual telecommuting frequency based on attendance log data). The respondents predicted frequencies of future center-based telecommuting to be comparable to current levels (36%). Using the reduced data set, the expected frequency of telecommuting from the center (40%) on the after survey was substantially lower than was reported on the before survey (46%). However, it was close to actual frequency (38%), suggesting that respondents had adjusted their expectations realistically. Supervisors were willing for their employees to telecommute from home more frequently in the after survey than in the before, suggesting that the supervisors became more comfortable with telecommuting in general through their telecenter experience.

Setting an arbitrary frequency criterion of one day per month or more, the full after survey results show that more than four-fifths meet this level of telecommuting at the center and that one-third

currently telecommute from home at least this often. Almost a quarter of the respondents (of the full after survey data set) telecommute both at the telecenter and from home one day or more each per month. Overall, the results from the choice, preference, and expectation of telecommuting indicate that combined home and center telecommuting appears to be a popular option for many of the respondents. However, at least 41% of the respondents indicated that they did not want to work at home at all (31%) or wanted to work at home less than once a month (10%).

In the section on travel, the one-way commute to the regular workplace was reported as 42.3 miles in length, while the commute length to the telecommuting center was given as 7.5 miles, on average. The resulting average commute travel savings by using the center *instead of* going to the main office for the after survey respondents was 34.8 miles. Despite the reduction in travel, the majority of travel to the telecenter was on freeways. This was especially true of the respondents from non-RABO centers who had longer commutes than RABO telecommuters, on average, to both the regular workplace (51.7 vs. 41.4 miles) and the telecommuting center (12.9 vs. 5.2 miles). Additionally, telecenter use was not found to have much effect on residential relocation decisions in this short time frame.

Comparing the lunch break activities of the full set of after survey respondents on regular workplace and telecenter days, the most significant difference is that, proportionately, respondents ate lunch at home on days they worked at the telecenter nine times more often than on days they worked at the regular workplace (25.3% vs. 2.8%, respectively). Driving or riding to someplace other than home to buy lunch and/or run errands and bringing lunch from home were both popular activities on regular workplace as well as telecenter days. Respondents indicated buying lunch at the workplace less often when they were working from the telecenter.

7.1.2.2 Manager Survey Results

This section summarizes the survey results from the 56 supervisors of 62 center-based telecommuters (reported percentages are based on N = 62, as responses from the same manager could vary by employee). On the whole, the respondents reported an optimistic and positive attitude toward telecommuting. The analysis showed clearly that supervisors' opinions of the performance of their employees did not diminish with the introduction of telecommuting.

Characteristics dealing with the workplace atmosphere (such as motivation, professional appearance, and distractions) were considered to be similar at both the regular workplace and the telecenter. Areas in which the center was perceived less positively than the regular workplace concerned the supervisor-employee relationship (such as communication, availability, professional interaction, and administrative burden) as well as security of information and property. However, mean ratings for the telecenter on these characteristics were all neutral or better, indicating that the disadvantage is relative, not absolute. These attitudes seem to be generic to telecommuting in general since they tended to be even less favorable for home-based telecommuting.

Nearly all of the managers (89%) indicated having a positive attitude toward telecommuting in general, and 79% rated their level of satisfaction with center-based telecommuting as high or very high. A selection bias in these results must be noted, as managers who were dissatisfied with telecommuting would be less likely to have lasted long enough to complete an after survey. However, the exit interviews of managers indicate that even those managers whose employees quit telecommuting had a positive attitude toward telecommuting in general (91% of 90 responses) and

had a high or very high satisfaction with center-based telecommuting specifically (66% of 89 responses) (see Section 5.4). Six potential advantages were viewed by managers to be at least moderately significant following the introduction of center-based telecommuting: improved employee retention, improved ability to recruit employees, increased productivity, compliance with environmental regulation, improved employee relations, and (marginally) reduced absenteeism. However, from 8% to 21% of the managers reported "no opinion" on the four following potential advantages of telecommuting: savings on parking costs, reduced health costs, compliance with environmental regulations, and improved disaster response capability. This suggests the need to raise awareness of the potential benefits of telecommuting in these areas.

It is an important result that the perceived advantages of telecommuting are those for which the benefit is difficult to quantify (customer service and productivity), while telecommuting is not perceived to offer advantages on "hard" money items such as office space and parking costs. This will continue to make center-based telecommuting difficult to justify in purely economic terms. Indeed, while nearly half (48%) of the respondents indicated that the organization was likely to (continue to) offer center-based telecommuting, more than a third (37%) cited reduced costs, the ability to quantify the benefits, and increased manager acceptance as factors that needed to change before the organization would be likely to offer center-based telecommuting.

About half of the managers expected that more of the organization's workforce would be telecommuting from a center in the future. However, from 8% to 23% of the organizations themselves did not have official opinions on various potential advantages of telecommuting according to the respondents. When opinions by the management levels above the supervisors were expressed, they tended to be less positive than those of the supervisors. Indeed, it appears that some managers were supporting telecommuting for their staff in the face of actively negative attitudes on the part of upper management. This suggests the need for upper-level management to have increased exposure to the benefits of telecommuting.

Although the employees performed well at the telecenter and even better than they did at the regular workplace in some respects, managers still preferred telecommuting to be a part-time alternative for their employees. Very few managers expected their employees to be telecommuting from the center full-time. The managers' average ideal distribution of work time for their employees included nearly 62% at the regular workplace and 28% for center-based telecommuting. The current and the expected future telecommuting frequencies of 32% and 34% of work days, respectively (which is equivalent to 1.6 and 1.7 days per week) are consistent with the managers' ideal work time distribution. However, in the managers' perception, the appropriate telecommuting frequency for their employees was more constrained by job suitability (36% of work days on average) than by the managers' willingness (42% of work days). In any case, the managers still felt that the regular workplace is the primary work location, to be used three or more days out of the work week.

Home-based telecommuting was not perceived as positively as center-based telecommuting with respect to job suitability and permitted frequency, although the self-selection bias of the sample must be taken into account in interpreting this result. The managers were willing for the employees to telecommute more than five times as much from the center as from home. Also, some mixture of center and home-based telecommuting was considered ideal by nearly one-third of the managers.

This expectation of part-time telecommuting may act to inhibit the adoption of telecommuting centers. If employees are only using the center one or two days per week, there may be little

opportunity for their space at the regular workplace to be used for other purposes. If an organization must continue to offer the same amount of space at the regular workplace as before, plus pay rent on space at the telecenter, other telecommuting advantages will have to be that much stronger to compensate for the added cost.

7.1.2.3 Employee-Manager Comparison

This section summarizes the comparison of the matched responses from 47 center-based telecommuters and their managers. Not surprisingly, the preferred amount of telecommuting differs between employees and managers. On average, employees would ideally work less of their time at the regular workplace (45.5%) and more at the telecommuting center (44.6%) than managers would prefer them to (58.5% and 31.4% at the regular workplace and telecenter, respectively). Working at the main office and the telecenter proved to be the most preferred combination of workplaces for both groups. On average, employees believed that their jobs permitted more frequent center-based telecommuting (43%) than their managers did (39%). Although some of the telecommuting frequency averages are similar for employees and managers, the managers select lower telecommuting amounts when there are substantial differences between the two.

Responses for similar job performance and satisfaction questions were mostly similar for both study groups. The three job satisfaction factors that had significant differences were supervisor-employee communication, resource availability, and supervisor appreciation. Employees were less satisfied on the first two job factors and more satisfied on the remaining factor than the managers were.

A two-way analysis of variance showed significant differences between employees and supervisors and across the three work locations for 15 work environment characteristics. The effect of the workplace location was significant for all of the statements except for supervisor comfortable and work judged by results. Similar to the results for employees only, the effect of the status factor showed that supervisors were more confident than employees regarding employee overeating and indulging and also rated their employees as having more independence at the regular workplace than their employees did. Moreover, scheduling flexibility factors such as working while sick or disabled and scheduling freedom tended to be rated more highly by the managers than by their employees. Finally, on average, employees were less inclined than their managers to believe that their work would be judged by its results.

T-tests showed that employees and managers did not differ significantly on the mean frequency of center-based telecommuting allowed by the job or by the manager, chosen by the employee, or expected six months later. However, for home-based telecommuting, employees believed their jobs and their managers to permit telecommuting more frequently than their managers actually did.

7.1.3 Analysis of Telecommuting Patterns

In Chapter 4 the telecommuting patterns of center-based telecommuters were studied, based primarily on information compiled from the attendance logs at the telecenters. This analysis identified patterns of telecommuting duration and frequency that will increase our understanding of telecommuter working behavior on telecommuting days. Telecommuting patterns both at the aggregate (site) level and the disaggregate (individual) level were analyzed. Each will provide further insight into telecenter performance, identify individual choice patterns, help create effective marketing strategies, and improve the recruitment of participants.

For most of the telecenters, a usage rate of between 15% and 25% was maintained, with a somewhat lower occupancy rate ranging from 10% to 20%. Though the usage rates fluctuated, with an apparent seasonal effect or slump in the summer, overall growth was apparent. However, a drop in average utilization after 14 months of operation may indicate that marketing efforts were not keeping pace with attrition. As of the June 30, 1996 cutoff date for this report, the RABO telecenters had been open an average of 1.3 years, with a minimum of 3.8 months and a maximum of a little more than 2.7 years. The two non-RABO telecenters studied here, Highland and Ontario, have been operating for much longer, an average of 4.1 years.

The weighted average frequency of telecommuting at RABO and non-RABO telecenters combined was 22%, or about 1.1 days a week. Nearly 64% of the combined sample telecommuted less than one day a week. At RABO sites, the average telecommuting frequency was 28.2%, or 1.4 days per week. Nearly half of the telecommuters used the centers less than one day per week on average, and 29% telecommuted 1 to 2 days per week. The non-RABO telecommuters telecommuted less frequently than those who were at RABO sites; the average was 17.3%, with about 76% of non-RABO telecenter users telecommuting less than one day per week. A detailed comparison of these frequency results with those computed from the attitudinal survey, where respondents indicated how much they currently telecommuted from the center, showed no significant differences. The results suggest a relative stability in telecommuting over a six-month period, in the aggregate.

Attrition at the telecenters was relatively high, with 50% of all telecommuters quitting within the first nine months. Although little comparative data are available, this appears to be higher than for home-based programs. Reasons for quitting telecommuting are analyzed in Chapter 5. But in any case, the frequency and distribution of telecommuting are crucial factors to consider in any forecast of levels and impacts of telecommuting. Of the 123 RABO participants who telecommuted often enough to analyze, half telecommuted for at least 9 months, and more than 38% telecommuted for at least one year. At non-RABO sites, 50% of the 151 telecommuters analyzed telecommuted for at least 8 months, and 21% telecommuted for at least 2 years. There is no significant difference in the distributions of telecommuting durations between RABO and non-RABO sites, meaning that the operating length of the telecenter may not be an important factor in determining telecommuting duration.

Half of RABO telecommuters worked at the telecenters for at least 6 hours on average on their telecommuting days. The most common telecommuting pattern was to work entirely at the telecenter. Approximately 19% of the telecommuters at RABO sites telecommuted with this pattern on all of their telecommuting occasions, and an additional 24% did so at least 80% of the time. At least 31% usually worked at more than one work location, including 4% who always did. The second most common workplace combination was telecenter/other work location (i.e., other than home or the regular workplace). Contrary to expectation, center- and home-based telecommuting are not often combined on the same day; patterns involving these two locations occurred only 15% of the time at RABO sites and 1.1% of the time at non-RABO sites.

Driving alone was the dominant transportation mode used by the telecommuters in commuting to the center. About 46% of the RABO telecommuters drove alone to the center on all of their telecommuting occasions. Almost three-quarters drove alone to the center very frequently (more than 75% of their occasions).

7.1.4 Retention Analysis

Chapter 5 studied the attrition of telecenter users and the reasons for that attrition by examining the responses to three different survey instruments: the attitudinal survey, the sign-in or attendance log, and the exit interview. The first analysis compared the attitudes and preferences of stayers (N = 44) and quitters (N = 106) using the before employee survey. It was found, using this data instrument, that there were few significant differences between the two groups in their demographics, travel and work characteristics, or attitudes and preferences toward various work environments. Although the results of the attitudinal survey serve to characterize the stayers and quitters, they do not offer much insight into why some participants chose to quit. There is some indication of a predisposition or later-formed preference for home-based telecommuting being associated with quitting, but the evidence is not statistically strong. In fact, while some employees quit the center to take up home-based telecommuting, in general the quitters appeared still to like the center-based form at least as much (see below).

In the second analysis, the attendance or sign-in logs were used to compare the telecommuting frequency of stayers (N = 66) and quitters (N = 208). The average frequency of telecommuting for stayers (28.2%) was found to be somewhat higher and statistically different than that of quitters (20.2%), meaning that stayers telecommuted more often than quitters did. In this section, the exit interview was used to determine the ideal distribution of work time for quitters: 53.4% at the regular work place, 20.1% at the telecommuting center, and 14.2% from home. So, the quitters here still preferred to use the telecenter (over home-based telecommuting), but were not able to due to certain constraints.

In the third analysis, reasons for quitting were examined using employee (N = 144) and manager (N = 90) exit interviews. The most frequent type of reason given by employees for quitting was job-related (37.7%), followed by supervisor-related (14.9%). In the former case, employees quit telecommuting because they left the organization, changed positions or job duties within the company, or other related reasons. In the latter case, employees were required or encouraged to quit telecommuting by their manager or supervisor. Other major reasons for quitting were due to the telecenter closing (13.2%), employees switching to home-based telecommuting (8.8%), or individuals moving their residence (7.9%). In general, the results suggest that respondents did not quit center-based telecommuting because they did not like it (no one gave that as a reason), but rather that, in general, external constraints related to the job, manager, and telecenter prevented them from telecommuting. These results are substantiated by the response to a question about prospects for future telecommuting which showed that there is a preference for more telecenter use in the future.

The manager exit interview data seem to support the employee exit interview data in that most of the reasons managers gave for their employees quitting fell into the category of external constraints. Whether these external constraints included job or lifestyle changes, centers closing, or lack of support from upper management, they consistently outweighed problems at the telecenter, or with telecommuting in general from either employees or their managers.

Responses to questions about attitudes indicated that a majority of managers were satisfied with both telecommuting and telecenters, but that they were considerably more neutral about telecenters than about telecommuting in general. Specifically, though, two-thirds of the sample were highly satisfied with telecenters. When asked how likely their organization is to offer center-based telecommuting

in the future, however, just over half indicated that it was likely or very likely, which is quite a bit lower than the general satisfaction ratings of the managers with telecenters. Finally, the managers were asked to explain what would need to change to make center-based telecommuting more attractive to their organization and to identify which of these changes was most important. Managerial or organizational acceptance and location of the center were by far the most important changes indicated. Other important changes were equipment, cost, and the ability to quantify the benefits of center-based telecommuting to the organization. Eleven percent of the respondents indicated that no changes were needed (the organization already offered center-based telecommuting), and an equal percentage expressed the opposite extreme – that nothing would make the organization likely to offer it.

The responses to similarly-worded questions on the manager exit interview (N = 90) and manager after survey (N = 62) were compared. The data suggest, not surprisingly, that managers of quitters (based on the exit interview data) were more likely to favor home-based telecommuting and less likely to favor center-based telecommuting than after-survey manager respondents. Nevertheless, large majorities of both groups (89 - 91%) expressed positive views of telecommuting in general. Managers of quitters tended to be more certain about whether or not center-based telecommuting would be offered by the organization in the future, whether the answer was positive or negative. However, about half of both groups believed that the organization was likely or very likely to offer it (with the managers of quitters much more heavily concentrated in the "very likely" category than the after-survey managers).

7.1.5 Travel and Air Quality Impacts

Chapter 6 was divided into two parts. The first part examined the travel characteristics of telecenter users. In this section, seven fundamental travel indicators, namely the number of person trips, personal vehicle trips, person-miles traveled (PMT), vehicle-miles traveled (VMT), cold starts, hot starts, and commute mode choice, were studied. These results are summarized in Section 7.1.5.1. The second part of Chapter 6 examined the emissions and air quality impacts of telecenter use. These results are summarized in Section 7.1.5.2.

7.1.5.1 Travel Analysis

Travel analysis was conducted for three groups of people, namely, telecenter users, home-based telecommuters and non-telecommuters. Six fundamental travel indicators - number of person trips, personal vehicle trips, PMT (person-miles traveled), VMT (vehicle miles traveled), cold starts, and hot starts, - were studied for the three groups. In addition, the impacts of center-based telecommuting on commute and non-commute travel, mode choice and commute mode choice were studied. An aggregate analysis of the travel impacts for center-based telecommuters was conducted by factoring in the frequency of telecommuting.

The travel characteristics for non-telecommuting (NTC) days of telecenter users were significantly different from the NTC days of home-based telecommuters and also non-telecommuters. There were no significant differences between the non-telecommuters and the NTC days of home-based telecommuters. A comparison of the travel characteristics of center-based and home-based telecommuters on both NTC and telecommuting (TC) days revealed that the impacts of home-based telecommuting and center-based telecommuting on the number of trips were quite different. The number of trips decreases on TC days for home-based telecommuters, whereas the number of trips

increases marginally on TC days for center-based telecommuters. However, both forms of telecommuting result in drastic reductions in PMT and VMT on TC days.

From the results presented in Chapter 6, it is clear that center-based telecommuting has significant transportation impacts.

- Total person-trips increased by 0.2 trips (4.5%) on TC days, from 4.4 to 4.6 trips. However, the difference is not statistically significant at the 0.05 level (NSD).
- Commute person-trips increased by 0.6 trips (35.3%) on TC days, from 1.7 to 2.3 trips. The difference is statistically significant at the 0.05 level (SD).
- Non-commute person-trips decreased by 0.4 trips (14.8%) on TC days, from 2.7 to 2.3 trips (NSD).
- Total PV trips increased by 0.3 trips (10.0%) on TC days, from 3.0 to 3.3 trips (NSD).
- Commute PV trips increased by 0.7 trips (58.3%) on TC days, from 1.2 to 1.9 trips (SD).
- Non-commute PV trips decreased by 0.4 trips (22.2%) on TC days, from 1.8 to 1.4 trips (SD).

The increases in total and commute trips are contrary to original expectations. The primary reason for the increases appears to be telecenter users going home for lunch more often on telecommuting days, which, after all, is a desirable outcome suggesting an increased connection of the telecommuter to the family and/or neighborhood during the day.

- Total PMT decreased by 50.9 miles (58.0%) on TC days, from 87.8 to 36.9 miles (SD).
- Commute PMT decreased by 44.9 miles (71.7%) on TC days, from 62.6 to 17.7 miles (SD).
- Non-commute PMT decreased by 6.0 miles (23.8%) on TC days, from 25.2 to 19.2 miles (NSD).
- Total VMT decreased by 35.2 miles (53.0%) on TC days, from 66.4 to 31.2 miles (SD).
- Commute VMT decreased by 33.5 miles (67.4%) on TC days, from 49.7 to 16.2 miles (SD).
- Non-commute VMT decreased by 1.7 miles (10.2%) on TC days, from 16.7 to 15.0 miles (NSD).

As hypothesized, there is a sizable reduction in the commute PMT and VMT on telecommuting days. This reduction is mainly because the commute distance of telecenter users to the regular workplace is much greater than to the telecenter. There are non-significant decreases in non-commute PMT and VMT as well, contrary to the hypotheses of some researchers that telecommuting would generate non-work travel.

- With the current average telecommuting frequency of 24.8%, there is a reduction of more than 11.9% in average work-week PMT compared to the no-telecommuting alternative.
- Also, with the current frequency of telecommuting, there is a reduction of 11.5% in average work-week VMT compared to the no-telecommuting alternative.
- There is only a marginal increase in person- (1.0%) and PV trips (6.0%) over a work week with the current frequencies of telecommuting, compared to the no-telecommuting alternative.
- The mode choice analysis revealed that there is a substantial increase in the share of drive-alone commute trips on telecommuting days and a corresponding decrease in the share of transit and rideshare trips.

It is beyond the scope of the current study to analyze the total systemwide impacts of center-based telecommuting. As a fraction of total VMT from all sources (telecommuters, non-telecommuters, all days, for all purposes), current VMT reductions due to center-based telecommuting are negligible due to the low levels of this form of telecommuting. Other studies (Mokhtarian, 1998) suggest that

even if telecommuting (in either form) increases to well beyond today's levels, the aggregate impacts on travel are likely to be modest. Nevertheless, the overall impacts are likely to be beneficial, and of an order of magnitude similar to those of other transportation demand management strategies. Hence, it appears to be appropriate to support both forms of telecommuting as such a strategy.

7.1.5.2 Emissions Analysis

Emissions analysis was conducted for center-based telecommuters, both on NTC days and TC days, and non-telecommuters. Comparing the grams/day emissions of telecommuters on TC days and NTC days showed that vehicle emissions were greatly reduced as a result of telecommuting. There was a 15% reduction for total organic gas emissions, 21% for carbon monoxide, 35% for the oxides of nitrogen, and 51% for particulate matter. The primary reason for the decrease in emissions of all pollutants was the 53% reduction in VMT which more than compensated for the marginal increase in number of trips (consequently, cold starts) on telecommuting days. Also, the analysis of the distribution of cold starts by time of day revealed that on telecommuting days the number of cold starts at lower ambient temperatures (early morning and late evening) decreased. This was the main reason for the decreases observed even in cold start exhausts for TOG and CO.

7.2 Possible Future Analyses

The high-quality and multi-faceted data set provided by this study is expected to yield new insights into telecommuting for some time to come. Some potential future analyses of interest are described below and are classified by the survey instrument on which they are based.

7.2.1 Attitudinal Survey, Sign-in Log, and Exit Interview Data

Additional studies of the attitudes of employees and managers toward telecommuting are desirable. The three dimensions of the survey plan (before and after; employee and manager; and telecenter user, home-based telecommuter, and non-telecommuter) allow for a number of comparisons across groups. First, direct comparisons between the attitudes and characteristics of telecenter users and each control group would provide useful insights into the type of individual who wants to telecommute from a center as opposed to from home or not at all. Second, each employee could be matched with his or her manager to compare responses to telecommuting attitudes and work characteristics. Third, comparisons of before and after telecommuting can be performed as conducted in the evaluation reported here. For the last two comparisons, the control groups can be used to control for background changes in the workplace in order to isolate differences between employees and managers and between before and after telecommuting.

The after manager attitudinal survey data can be divided into two segments: managers of quitters (most of whom will have also completed an exit interview) and managers of stayers. Responses to questions about satisfaction with telecommuting can then be compared across three groups: managers of stayers (after survey), managers of quitters before they quit (after survey), and managers of quitters after they quit (exit interview). This would identify the extent to which changes in the manager's satisfaction with telecommuting are associated with the employee withdrawing from telecommuting.

Importantly, this data set provides for the modeling of telecommuting preference and choice. Although preference modeling has been performed using the interim before data (Ŝtanek and Mokhtarian, 1998), further studies of both telecommuting preference and choice can be conducted using the full before and after data sets. These models can be used to identify key factors in the decision-making process and to help predict the future amount of telecommuting by the workforce. In particular, the after data can be used to build binary and multinomial models of telecommuting choice and frequency. Furthermore, analyzing the before and after data together may offer a rare opportunity to calibrate a prospective expression of preference against the actually chosen telecommuting frequency. In addition, all models mentioned above can be applied both to the employee's decision to telecommute and to the manager's decision to have the employee telecommute.

As a precursor to the telecommuting choice models, factor analysis is used to reduce the responses on the job satisfaction and workplace attitudinal questions to their underlying perceptual dimensions. Scores on these dimensions or factors are then used as explanatory variables in preference and choice models. The factor analysis procedure can also be used to compare perceptual structures between employees and managers as well as to detect changes in these structures after the start of telecommuting.

The sign-in logs provide data for developing, for the first time, models to predict telecommuting duration as a function of hypothesized explanatory variables from the attitudinal surveys. The attendance logs also provide a supplementary source of telecommuting frequency data for choice models, and offer the opportunity for further analysis of temporal patterns of telecommuting.

7.2.2 Travel Diary Data

The travel diaries provide a rich source of information about the transportation impacts of telecommuting. This data, for example, could allow for a spatial analysis of the travel impacts of telecenter use. Such an analysis would examine the extent to which new locations are visited after telecommuting and the spatial orientation of those locations relative to home, telecenter, and regular workplace. Saxena and Mokhtarian (1997) have conducted such a study for home-based telecommuting; an interesting difference from that previous study is the introduction of the telecommuting center as a frequently-visited destination. This may lead to the identification of new destinations near the center, which has implications for the local economic development impacts of telecenters.

Additionally, in an attempt to measure the effects of telecenter use on household travel, travel diaries were administered to all members of the telecenter user households who were sixteen years of age or older. Using this additional data, an analysis of travel at the household level can be performed to examine whether reductions in travel by the telecommuter are partially compensated for by increases in travel on the part of household members. Also, the emissions analysis would be more rigorous if all uses of a household vehicle were accounted for, thus allowing each particular trip to be more accurately classified as either a hot or cold start. Although household member data are generally less complete, it may be possible in the larger final data set to identify a subsample with complete data that is large enough to analyze.

It would be of interest to examine potential regional differences in the travel patterns of telecenter users: respondents living on the urban fringe or in rural areas may have different patterns than those

living within heavily-urbanized areas. Finally, another useful direction involves compiling the travel diary data across a number of similar studies, including the State of California Telecommuting Project and the Puget Sound Telecommuting Demonstration Project as well as the current project. The sizable data set which would result may permit a number of analyses not undertaken so far, including an examination of changes in travel patterns by gender and by commute distance. In the latter case, the hypothesis is that short-distance commuters are more likely to make new non-work trips on their telecommuting days than long-distance commuters.

7.3 Discussion of Findings

Overall, the employee experience with telecommuting centers has been positive. Employee reactions to center-based telecommuting have been favorable, and no adverse impacts on productivity and job satisfaction were measured. There may be a selection bias in these results as these data were obtained only for employees remaining in the program. (The attitudes of employees who quit the program and their reasons for leaving are discussed below.) On average, telecenter users preferred to work from the regular workplace and the telecommuting center for approximately equal amounts, or about 40% of their time each. However, they reported actually telecommuting only about one-third of the time.

The transportation impacts of center-based telecommuting were complex. On one hand, there was an increase in drive-alone trips and a decrease in trip chaining on telecommuting days. Most commuting to the telecenter took place by driving alone, despite efforts to locate centers sufficiently close to residential areas that walking and biking would be attractive commute modes. Interestingly, there was a small increase (of 0.6, significant at $p = 0.00$) in the number of *commute* trips made on telecommuting days, apparently due to telecommuters making trips home for lunch and returning to the center in the afternoon. On the other hand, however, telecommuting did not adversely affect commute mode choices on non-telecommuting days. And most importantly, the number of person-miles traveled (PMT) decreased by an average of nearly 58% on telecommuting days, while the *total* number of trips made remained relatively constant. Additionally, the 53% reduction in VMT on telecommuting days resulted in a 15% reduction for total organic gas emissions, 21% for carbon monoxide, 35% for nitrogen oxides, and 51% for particulate matter.

To place the PMT reduction in the proper perspective, it is important to realize two things. First, the reduction represents a comparison between travel on non-telecommuting weekdays and telecommuting weekdays for center-based telecommuters. Thus, the overall impact on travel will be a function of the frequency of telecommuting. When travel indicators on telecommuting and non-telecommuting days were weighted by the average frequency with which each type of day occurs, an average reduction of more than 11.9% in work-week PMT and 11.5% in work-week VMT occurs (when compared to the no-telecommuting alternative).

Second, the telecommuters in this sample lived farther from work, and hence had a much greater average non-telecommuting day PMT, than the non-telecommuting control group members (87.8 vs. 48.7 miles). Although on telecommuting days the telecommuters traveled less than the control group, in the aggregate (telecommuting and non-telecommuting days combined) they still traveled more. If, in the future, telecommuting continues to be adopted primarily by long-distance commuters, the per capita reductions in travel will be considerable, but this change will be achieved by a limited segment of the market. If, on the other hand, the adoption of telecommuting is more universal, the per capita reductions in travel will be smaller, albeit achieved by a wider segment of

the market. In either case, the specific reductions measured in this study will not be representative of the impacts for the population as a whole.

On the organizational side, managers of telecenter users were generally supportive, with 89% having a positive attitude toward telecommuting in general, and 79% rating their level of satisfaction with center-based telecommuting as high or very high. A selection bias in these results must be noted, as managers who were dissatisfied with telecommuting would be less likely to remain in the program long enough to complete an after survey. However, the exit interviews from managers indicated that even those managers whose employees quit telecommuting from the center had a positive attitude toward telecommuting in general (91%) and had a high or very high satisfaction with center-based telecommuting specifically (66%). Opinions of upper management tended to be more neutral according to the immediate supervisors of telecommuters. The perceived advantages of telecommuting were those for which the benefit is difficult to quantify (customer service and productivity), while telecommuting is not perceived to offer advantages on "hard" money items, such as office space and parking costs. This will continue to make center-based telecommuting difficult to justify in purely economic terms. Indeed, while nearly half (48%) of the manager respondents indicated that the organization was likely to offer center-based telecommuting to its staff, more than a third (37%) cited lowering the cost, being able to quantify the benefits, and increased manager acceptance as factors that needed to change before the organization would be likely to offer center-based telecommuting.

Managers continued to view the regular workplace as the primary work location for their employees, to be used for at least three days per week on average. This expectation of part-time telecommuting may act to inhibit the adoption of the center-based form, as there will be little opportunity for the organization to re-use the telecommuter's space in the regular workplace.

Average site occupancies ranged between 10 and 20% of available workspace days, with a generally upward trend. As of June 30, 1996, the RABO telecenters had been open an average of 1.3 years, with a minimum operation of 3.8 months and a maximum of a little more than 2.7 years. For those who used the centers at least twice, telecommuting frequencies averaged 28.2% (1.4 days per week) at RABO sites and 17.3% at non-RABO sites.

Attrition at the telecenters was relatively high: 50% of all telecommuters quit within the first nine months. Although little comparative data are available, this appears to be higher than home-based programs. Results of exit interviews, conducted with the participants who quit after this program began and who could be reached, suggest that primary reasons for quitting were job-related (26.6%), followed by supervisor-related (11.2%), rather than due to employee dissatisfaction with telecommuting. Nevertheless, the frequency and duration of telecommuting are crucial factors to consider in any forecast of levels and impacts of telecommuting.

In summary, while transportation and other impacts are unequivocally positive on net for those who telecommute on the days they are telecommuting and for the duration of their telecommuting experience, concerns remain about high attrition among telecenter users and about the perceived cost-effectiveness of center-based telecommuting to organizations and their management.

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APPENDIX A

"AFTER" TELECOMMUTING CENTER EMPLOYEE SURVEY

APPENDIX A

"AFTER"
TELECOMMUTING CENTER
EMPLOYEE SURVEY

Name: _____ **Date:** _____
(please print) *(month / day / year)*

Employer: _____ **Work Phone:** (_____)_____

PART A
YOUR JOB CHARACTERISTICS

To begin, we would like to know about various aspects of your work.

1. Which of the following best describes your current work?

   ☐1 Manager / Administrator
   ☐2 Professional / Technical
   ☐3 Services / Repair
   ☐4 Other (*please specify*): _____
   ☐5 Administrative support
   ☐6 Sales / Marketing
   ☐7 Production / Construction / Crafts

2. How long have you worked. . .

   a. for your immediate supervisor? _____ years (*check here if self-employed*: ☐1)
   b. for your present employer? _____ years
   c. in your present occupation? _____ years

3. About how many people work for your organization at your regular workplace? (*This workplace may include multiple adjacent buildings occupied by the same organization.*)

   ☐1 1 - 9
   ☐2 10 - 49
   ☐3 50 - 99
   ☐4 100 - 499
   ☐5 500 - 999
   ☐6 1000 or more

4. At what time do you usually. . .

   a. arrive at work? _____ (*Please indicate a.m. or p.m.*)
   b. leave work? _____ (*Please indicate a.m. or p.m.*)

5. Please indicate your **normal, official** work hour arrangement. (*Check the single most appropriate response.*)

   ☐₁ **Part-time**: _____ hours per week (over ____ days)

   ☐₂ **Conventional** (full-time, with a start time between 8 and 9 a.m.)

   ☐₃ **Fixed flextime** (full-time, with a fixed start time outside 8 to 9 a.m.)

   ☐₄ **Variable flextime** (full-time, with a variable start time)

   ☐₅ **Compressed work week** (9 to 10 hours per day, with a day off every one or two weeks)

   ☐₆ **Other** (*please specify*): _____

6. The actual number of hours you work may differ from your official arrangement – for example, due to paid and unpaid overtime. Keeping in mind that **there are 75 - 80 work hours** in a full-time **two-week period**, how many hours in a **two-week** period do you usually work? (*Include paid and unpaid overtime.*)

   _____ hours in two weeks

7. Please indicate the approximate **percent of time** you generally spend on each of the following categories of work-related activities. If some of your activities fall into more than one category, please select the single most important category for that activity. **Your answers should add to 100%.**

   _____ Work you do **independently** (like reading, thinking, writing, planning)

   _____ Work you do with others, **face to face** (like face-to-face meetings or conversations)

   _____ Work you do with others, **remotely** (like making or receiving telephone calls)

   _____ Work that must be done at a **specific location** (like site visits, service or maintenance)

   _____ Work-related **travel** (only the actual time spent traveling)

   _____ Other (*please specify*): _____

   100%

8. Which of the following features did you use, did you need, or would you like to have available at the telecommuting center? (*Check all that apply.*)

	Used while at the center	*Needed, but did not have*	*Would like, but not essential*
a. Additional phone line	☐₁	☐₂	☐₃
b. Voice mail / Answering machine	☐₁	☐₂	☐₃
c. Call forwarding	☐₁	☐₂	☐₃
d. Call waiting	☐₁	☐₂	☐₃
e. Conference calling	☐₁	☐₂	☐₃

	Used while at the center	*Needed, but did not have*	*Would like, but not essential*
f. Video-conferencing	☐1	☐2	☐3
g. Personal computer or workstation	☐1	☐2	☐3
h. Software used at work	☐1	☐2	☐3
i. Electronic mail	☐1	☐2	☐3
j. Files or reference materials	☐1	☐2	☐3
k. Fax machine	☐1	☐2	☐3
l. Printer	☐1	☐2	☐3
m. Modem	☐1	☐2	☐3
n. Copier	☐1	☐2	☐3
o. Secretarial services	☐1	☐2	☐3
p. Document production services	☐1	☐2	☐3
q. Overnight package pick up / delivery	☐1	☐2	☐3
r. Private office	☐1	☐2	☐3
s. Lockable storage area	☐1	☐2	☐3
t. Child care	☐1	☐2	☐3
u. Restaurant / Cafeteria	☐1	☐2	☐3
v. Other (*please specify*): _____	☐1	☐2	☐3

9. Were there work-related activities that you expected to do while telecommuting that you were unable to do?

☐1 No ⟶ (*Go to Part B*) ☐2 Yes (*Answer Question 9a*)

↓

9a. Aside from responses you may have checked in Question 8, why were you unable to complete these tasks while telecommuting? (*Check all that apply.*)

☐1 The items checked in Question 8 were the only reasons.

☐2 Technical difficulties

☐3 Security concerns

☐4 Employer restrictions

☐5 Other (*please specify*): _____

☐6 Haven't telecommuted as much as expected.

☐7 Need for face-to-face interaction

☐8 Too many distractions

☐9 Not enough telecommuting experience

PART B
YOUR JOB SATISFACTION

Next, we would like to know how you feel about your job. There are no "right" or "wrong" answers; we want only your honest opinions. We remind you that your responses are strictly confidential.

1. Please rate **yourself** on the following aspects of your job.

	Terrible	*Poor*	*Average*	*Good*	*Excellent*
a. The amount of work you get done	☐1	☐2	☐3	☐4	☐5
b. The quality of your work	☐1	☐2	☐3	☐4	☐5
c. Your ability to meet deadlines	☐1	☐2	☐3	☐4	☐5
d. Your overall productivity	☐1	☐2	☐3	☐4	☐5

2. In your opinion, how would **your supervisor** rate you on the following aspects of your job?

	Terrible	*Poor*	*Average*	*Good*	*Excellent*
a. The amount of work you get done	☐1	☐2	☐3	☐4	☐5
b. The quality of your work	☐1	☐2	☐3	☐4	☐5
c. Your ability to meet deadlines	☐1	☐2	☐3	☐4	☐5
d. Your overall productivity	☐1	☐2	☐3	☐4	☐5

3. For each of the following statements, please check the answer that best expresses your opinion.

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
a. My supervisor and I don't communicate effectively.	☐1	☐2	☐3	☐4	☐5
b. I have the same opportunity for promotion as anyone who is similarly qualified (regardless of telecommuting).	☐1	☐2	☐3	☐4	☐5
c. I am frustrated by a lack of adequate resources to do my job.	☐1	☐2	☐3	☐4	☐5
d. My work team is effective.	☐1	☐2	☐3	☐4	☐5
e. My supervisor and I work well together.	☐1	☐2	☐3	☐4	☐5
f. My job is tedious and boring.	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
g. Working at my job gives me a sense of accomplishment.	☐1	☐2	☐3	☐4	☐5
h. My supervisor doesn't appreciate my work effort enough.	☐1	☐2	☐3	☐4	☐5
i. I am confident in my ability to do what is expected of me at work.	☐1	☐2	☐3	☐4	☐5
j. I don't get along well with my co-workers.	☐1	☐2	☐3	☐4	☐5
k. I am likely to look for a new job within the next six months.	☐1	☐2	☐3	☐4	☐5
l. I work well with those I supervise. (*check here if not applicable*: ☐6)	☐1	☐2	☐3	☐4	☐5
m. Customers or clients tend to make unreasonable demands on my time. (*check here if not applicable*: ☐6)	☐1	☐2	☐3	☐4	☐5
n. Overall, I am satisfied with my job.	☐1	☐2	☐3	☐4	☐5

PART C
DIFFERENT WORK ENVIRONMENTS

*This section asks for your opinions on various aspects of **three different workplaces**: the regular workplace, the telecommuting center, and home. Although you may not have previously telecommuted from home, you probably have an idea of what it would be like. Your opinions may depend on how much you would be telecommuting; assume that you would be doing as much or as little as you wanted to. Please answer the questions below **for each workplace**.*

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
1. It would be easy for me to be motivated when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
2. It would be stressful to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
3. My supervisor would be uncomfortable when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
4. The workplace would have a professional appearance at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
5. Distractions from other people would be a problem when I work at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
6. It would save me money to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
7. I wouldn't have enough space to work at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
8. I wouldn't have a lot of free time to be with my family and/or friends when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
9. I would have enough opportunities for social interaction with fellow employees and others at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
10. It would be convenient to run errands when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
11. I would probably overeat or indulge in other ways when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
12. It would be beneficial to the environment to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
13. I wouldn't be visible enough to management if I worked at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
14. I wouldn't have the needed equipment and services to work effectively at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
15. I would have difficulty keeping my home and work activities separate when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
16. I would have control over my work environment (temperature, noise, etc.) when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
17. It would cost me too much money to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
18. My commute would be a hassle when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
19. When sick or disabled, I would be able to work at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
20. I would have the freedom to adjust my work schedule when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
21. I would have the flexibility to handle dependent care (child or adult) when I work from (*check here if not applicable*: ☐6)					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
22. The merit of my work would be judged primarily by the results if I worked from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
23. I would have conflicts with members of my household when I work from (*check here if not applicable*: ☐6)					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
24. I would have relative independence in my day-to-day activities when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
25. It would take a lot of self-discipline to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
26. I wouldn't have enough opportunities for professional interaction at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
27. I would be able to dress the way I like at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
28. I could effectively balance work and household responsibilities when I work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
29. Communication with my supervisor would be a problem when I work at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
30. I would work effectively at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

PART D
AMOUNT OF TELECOMMUTING

This section asks about your experience with telecommuting and to what extent telecommuting is possible and desirable for you. It also asks about the time you may save by telecommuting.

1. Including all of your past telecommuting experiences, what total length of time have you telecommuted? (*Do not include overtime or self-employment at home.*)

   a. _____ years and _____ months from **home**

   b. _____ years and _____ months from a **telecommuting center**

2. Does your employer require you to telecommute? ☐1 No ☐2 Yes

3. Does your employer offer you the option to telecommute from home?

   ☐1 No ☐2 Yes

4. Is the telecommuting center your organization's primary local place of business?

   ☐$_1$ No ☐$_2$ Yes

5. Given your current circumstances, what would be the **ideal** distribution of your work time among each of the following locations? Please give the average percentage of time you would prefer to work at each location. **Your answers should add to 100%.**

   _____ regular workplace

   _____ telecommuting center

   _____ home

   _____ other (*please specify*): _____

   100%

6. If the telecommuting center were not available, what would be the ideal distribution of your work time among each of the following locations? **Your answers should add to 100%.**

   _____ regular workplace

   _____ home

   _____ other (*please specify*): _____

   100% of total work time

7. On days that you telecommute, how do you use the time you would normally spend commuting to the regular workplace? These activities may or may not take place during the actual times of the day that you formerly spent commuting. Please select the general types of activities below that best describe how you use any time you may save by telecommuting. (*Check all that apply.*)

   ☐$_1$ No significant time saved
   ☐$_2$ Work
   ☐$_3$ Shop
   ☐$_4$ Get more sleep
   ☐$_5$ Spend time with family / friends
   ☐$_6$ Spend time on a hobby
   ☐$_7$ Attend a class
   ☐$_8$ Participate in an outdoor activity / sport
   ☐$_9$ Exercise
   ☐$_{10}$ Housework / Yardwork
   ☐$_{11}$ Cook
   ☐$_{12}$ Support a cause I believe in
   ☐$_{13}$ Relax by myself (read, watch TV, etc.)
   ☐$_{14}$ Other (*please specify*): _____

8. From the list in Question 7 (items 1-14), please select the activity that you do most frequently with any time you may save by telecommuting. Enter a "1" if no significant time was saved.

   The number of the most frequent activity is _____.

*Please answer **each** question below, both for a telecommuting center and for home. By "**occasional partial days**" we mean a situation in which you telecommute for part of the work day and go to the regular workplace for the rest of the day.*

	Not at all	*Less than once a month*	*About 1-3 days a month*	*1-2 days a week*	*3-4 days a week*	*5 days a week*	*Occa-sional partial days*
9. Considering the requirements of your current job, how much do you think **the nature of your job** would allow you to telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
10. Considering the characteristics of your current supervisor, how much do you think **your supervisor** would let you telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
11. How much do you **currently** telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
12. Assuming that there are no work-related constraints, how much **would you like** to telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
13. Six months from now, how much **do you expect** to be telecommuting							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7

PART E
YOUR TRAVEL CHARACTERISTICS

Next, we would like some information about your travel to and from work.

1. On average, how long does it take for you to commute (one way) between home and. . .
   a. *the regular workplace?* _____ minutes
   b. *the telecommuting center?* _____ minutes

2. How far (one way) is your home from. . .
   a. *the regular workplace?* _____ miles
   b. *the telecommuting center?* _____ miles

3. Is public transit (bus, light rail, etc.) easily accessible from your home?
   ☐$_1$ No ☐$_2$ Yes ☐$_3$ Don't know

4. What is your approximate **cost per month** for each of the following **commute travel** expenses?
   $_____ fuel (commuting only) $_____ transit fare
   $_____ parking $_____ carpool / vanpool fee
   $_____ tolls $_____ other (*please specify*): _____

5. Have you changed where you live within the past year?
   ☐$_1$ No → (*Go to Question 6*) ☐$_2$ Yes, closer to work → (*Answer 5a and b*)
   ☐$_3$ Yes, farther from work → (*Answer 5a and b*)

   5a. Was the ability to telecommute an important factor in your decision to move?
   ☐$_1$ Not at all ☐$_3$ Very important
   ☐$_2$ Somewhat important ☐$_4$ The most important factor

   5b. Was the location of a telecommuting center an important factor in choosing **where** to move?
   ☐$_1$ Not at all ☐$_3$ Very important
   ☐$_2$ Somewhat important ☐$_4$ The most important factor

6. Are you considering changing where you live?

☐$_1$ No → (*Go to Question 7*)

☐$_2$ Yes, closer to work → (*Answer 6a and b*)

☐$_3$ Yes, farther from work → (*Answer 6a and b*)

☐$_4$ Yes, either closer or farther → (*Answer 6a and b*)

6a. Is the ability to telecommute an important factor in your consideration of **whether** to move?

☐$_1$ Not at all

☐$_2$ Somewhat important

☐$_3$ Very important

☐$_4$ The most important factor

6b. Is the location of a telecommuting center an important factor in considering **where** to move?

☐$_1$ Not at all

☐$_2$ Somewhat important

☐$_3$ Very important

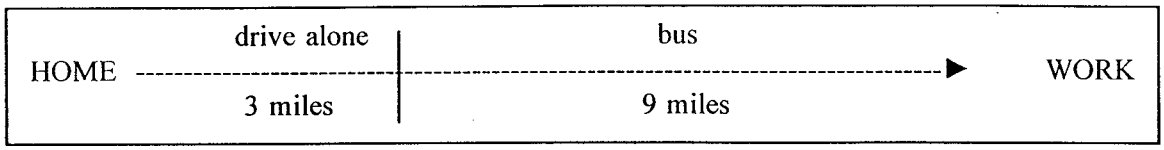
☐$_4$ The most important factor

7. In a typical month (think of it as 20 working days), how many times do you do each of the following during your lunch break? Please distinguish between days that you work from the regular workplace and days that you work from the telecommuting center.

	Regular Workplace	*Telecommuting Center*
a. Bring lunch from home	_____	_____
b. Buy lunch at the workplace	_____	_____
c. Eat at home	_____	_____
d. Walk someplace other than home to buy lunch and/or run errands	_____	_____
e. Drive or ride to someplace other than home to buy lunch and/or run errands	_____	_____
f. Take public transit to someplace other than home to buy lunch and/or run errands	_____	_____
g. Take a taxi to someplace other than home to buy lunch and/or run errands	_____	_____
h. Skip lunch	_____	_____
i. Other (*please specify*): _____	_____	_____
	---	---
20 days =	_____ +	_____

You probably use one or more of the following modes, or means of transportation, to get to work: driving alone, carpool, vanpool, bus, train, bicycle, jogging, or walking. We need to know what that trip looks like in terms of which modes you use. The simplest way to indicate that is through a diagram. For example, if you drive alone 3 miles to a park-and-ride lot, where you take a bus the rest of the way to work (say 9 miles), your diagram would look like this:

Example:



Of course, you may use more than one pattern on different occasions. For example, you may carpool 4 days a week and drive alone the other day. Or, you may take the bus 95% of the time, but about once a month, you need to drive your car to work. We are interested in these various patterns.

8. Please use the diagrams below to illustrate the one or two patterns you most often use to get to your **regular workplace**. Be sure that each diagram has (a) the **means of transportation** you use for each segment of the trip; (b) the approximate **length in miles** of each segment; and (c) the **percent of the time** you use this particular pattern in terms of the *total number of days that you commute to your regular workplace.*

% of commuting days this pattern is used

HOME ----------▶ REGULAR WORKPLACE _____

HOME ----------▶ REGULAR WORKPLACE _____

9. Using the same format as in the question above, illustrate the patterns you use most often to get to the **telecommuting center**. Be sure that each diagram has (a) the **means of transportation**; (b) the approximate **length in miles** of each segment; and (c) the **percent of the time** you use this particular pattern in terms of the *total number of days that you work from the telecommuting center.*

% of telecommuting days this pattern is used

HOME ----------▶ TELECOMMUTING CENTER _____

HOME ----------▶ TELECOMMUTING CENTER _____

PART F
GENERAL INFORMATION

In this section we ask for some background information about you and your household. By household members we mean "people who live together and share at least some activities and financial resources" (exclude ordinary roommates who simply share living expenses). Your answers to these questions are important to help us generalize the findings from this small sample to the population as a whole. Again, your responses are strictly confidential.

1. Please indicate the number of your household members (including yourself) which fall into the different age groups given below.

   _____ persons under 2 years old
   _____ persons 2 - 5 years old
   _____ persons 6 - 15 years old
   _____ persons 16 - 24 years old
   _____ persons 25 - 60 years old
   _____ persons older than 60 years

2. Is there anyone in your household (other than preschoolers) who needs special care?

   ☐$_1$ No ☐$_2$ Yes

3. How many full-time and part-time workers (including yourself) are there in your household?

   _____ full-time workers _____ part-time workers

4. Do you have a valid driver's license? ☐$_1$ No ☐$_2$ Yes

5. Not including yourself, how many **other** household members have a driver's license? _____

6. How many motor vehicles (motorcycles, cars, vans, and light duty trucks) are available to your household – whether owned, leased, or employer-provided? (*Exclude vehicles used only off-road.*)

   _____ gasoline or diesel vehicles (cars, vans, and light duty trucks)
   _____ alternative fuel vehicles (electric, methanol, natural gas, etc.)
   _____ motorcycles

7. Please check the category which contains your approximate **annual household** income **before** taxes.

   ☐$_1$ Less than $15,000
   ☐$_2$ $15,000 to $24,999
   ☐$_3$ $25,000 to $34,999
   ☐$_4$ $35,000 to $54,999
   ☐$_5$ $55,000 to $74,999
   ☐$_6$ $75,000 or more

COMMENTS: We would value any additional comments you may have. Please write them below, and/or attach another page. Thank you for your time and cooperation!

APPENDIX B

"AFTER" SURVEY FOR MANAGERS OF TELECOMMUTING CENTER USERS

APPENDIX B

"AFTER" SURVEY FOR MANAGERS OF TELECOMMUTING CENTER USERS

Your name: _____ (*please print*)

Date: _____ (*month / day / year*)

Employer: _____

Work phone: (_____)_____

Name of participating employee: _____

PART A
YOUR EMPLOYEE'S JOB

To begin, we would like to ask a couple of background questions about your employee's job.

1. The average number of hours in a full-time **two-week work period** is 75 - 80 hours. How many hours in a **two-week** period does your employee usually work? We are looking for the actual number of hours worked, including paid and unpaid overtime.

   _____ actual hours worked in two weeks

2. Which of the following items or services should a telecommuting center provide so that your employee could work **as effectively** as at the regular workplace? (*Check all items that apply.*)

☐$_1$	Additional phone line	☐$_{12}$	Printer
☐$_2$	Voice mail / Answering machine	☐$_{13}$	Modem
☐$_3$	Call forwarding	☐$_{14}$	Copier
☐$_4$	Call waiting	☐$_{15}$	Secretarial services
☐$_5$	Conference calling	☐$_{16}$	Document production services
☐$_6$	Video-conferencing	☐$_{17}$	Overnight package pickup / delivery
☐$_7$	Personal computer or workstation	☐$_{18}$	Private office
☐$_8$	Software used at work	☐$_{19}$	Lockable storage area
☐$_9$	Electronic mail	☐$_{20}$	Child care
☐$_{10}$	Files or reference materials	☐$_{21}$	Restaurant / Cafeteria
☐$_{11}$	Fax machine	☐$_{22}$	Other (*please specify*): _____

PART B
ASSESSMENT OF YOUR EMPLOYEE

Next, we would like to know how you view various aspects of your employee's work effectiveness, and your relationship with your employee. There are no "right" or "wrong" answers to the questions below. We want only your honest opinions. We remind you that your responses are strictly confidential.

1. Please rate **your employee** on the following aspects of his/her job.

		Terrible	*Poor*	*Average*	*Good*	*Excellent*
a.	Amount of work accomplished	☐1	☐2	☐3	☐4	☐5
b.	Quality of work	☐1	☐2	☐3	☐4	☐5
c.	Ability to meet deadlines	☐1	☐2	☐3	☐4	☐5
d.	Overall productivity	☐1	☐2	☐3	☐4	☐5

2. For each of the following statements, please check the answer that best expresses your opinion.

		Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
a.	My employee and I don't communicate effectively.	☐1	☐2	☐3	☐4	☐5
b.	Adequate resources are not available for my employee to do the job.	☐1	☐2	☐3	☐4	☐5
c.	My employee's work team is effective.	☐1	☐2	☐3	☐4	☐5
d.	My employee and I work well together.	☐1	☐2	☐3	☐4	☐5
e.	Customers or clients tend to make unreasonable demands on my employee's time. (*check here if not applicable*: ☐6)	☐1	☐2	☐3	☐4	☐5
f.	Overall, I am satisfied with my employee's performance.	☐1	☐2	☐3	☐4	☐5
g.	I don't express enough appreciation for my employee's work effort.	☐1	☐2	☐3	☐4	☐5
h.	My employee doesn't get along well with co-workers.	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
i. My employee has the ability to do what is expected at work.	☐1	☐2	☐3	☐4	☐5
j. My employee is likely to look for a new job in the next six months.	☐1	☐2	☐3	☐4	☐5
k. My employee works well with those he/she supervises. (*check here if not applicable*: ☐6)	☐1	☐2	☐3	☐4	☐5

PART C
DIFFERENT WORK ENVIRONMENTS

This section asks for your opinions on various aspects of ***three different workplaces****: the regular workplace, the telecommuting center, and the employee's home. Although your employee may not have previously telecommuted from home, you probably have an idea of how telecommuting would affect him/her. Assume* ***in this section*** *that your employee would telecommute "some, but not too much". (In Part E we ask you what amount of telecommuting, if any, would be ideal for your employee). Please answer the questions below* ***for each workplace****.*

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
1. It would be easy for my employee to be motivated when working from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
2. I would be uncomfortable when my employee worked from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
3. The workplace would have a professional appearance at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
4. Distractions from other people would be a problem when my employee worked at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
5. I am concerned that my employee would indulge in ways that would be detrimental to his/her health when working from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
6. My employee would have relative independence in his/her day-to-day activities when working from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
7. It would be beneficial to the environment for my employee to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
8. My employee wouldn't be visible enough to management if he/she worked at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
9. My employee wouldn't have the needed equipment and services to work effectively from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
10. I feel confident that my employee would work a full day when working from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
11. It would cost our organization too much money for my employee to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
12. When sick or disabled, I would offer my employee the option to work from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
13. My employee would have the freedom to adjust his/her work schedule when working from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
14. I'm concerned that my employee would often be unavailable when needed, while working at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
15. The merit of my employee's work would be judged primarily by the results if he/she worked from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
16. My employee wouldn't have enough opportunities for professional interaction at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
17. Communication with my employee would be a problem when he/she works at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
18. My employee would work effectively at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
19. It would be an administrative burden on me for my employee to work at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
20. Security of confidential information could be handled effectively when my employee worked from					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
21. Our organization's liability for worker's compensation would be high at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5
22. Our organization's property would be relatively secure from theft or damage at					
a. *the regular workplace.*	☐1	☐2	☐3	☐4	☐5
b. *the telecommuting center.*	☐1	☐2	☐3	☐4	☐5
c. *home.*	☐1	☐2	☐3	☐4	☐5

PART D
POTENTIAL ADVANTAGES OF TELECOMMUTING

Some of the statements in the previous section dealt with potential disadvantages of telecommuting. Here, we would like to focus on some of the potential advantages. How significant (if at all) are each of the following factors as ***advantages of telecommuting****? Your personal views of the importance of these factors may differ from what your organization has officially expressed. Please rate each factor first according to your* ***personal opinion,*** *and second according to the* ***official view*** *of your organization. (Note: please distinguish between* ***"no opinion"*** *and the opinion that the factor is* ***"not a significant advantage"****).*

	No Opinion	*Not Significant*	*Moderately Significant*	*Extremely Significant*
1. Improved employee retention (reduced turnover)				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
2. Savings on office space costs				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
3. Better customer service				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4

	No Opinion	*Not Significant*	*Moderately Significant*	*Extremely Significant*
4. Improved ability to recruit employees				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
5. Increased productivity				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
6. Savings on parking costs				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
7. Improved disaster response capability				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
8. Reduced absenteeism				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
9. Reduced health costs				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
10. Compliance with environmental regulations				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
11. Improved employee relations				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4
12. Other (*please specify*): _____				
a. *Your opinion*	☐1	☐2	☐3	☐4
b. *Official viewpoint*	☐1	☐2	☐3	☐4

PART E
TELECOMMUTING AS A WORK OPTION

This section asks about your experience with telecommuting, and to what extent telecommuting may be possible or desirable for your organization in general and your employee in particular. Also, we ask about your reactions and those of your organization to telecommuting from a center.

1. Is there a formal policy addressing the issue of telecommuting within your organization? (*Please answer separately for each level.*)

	No	*Yes, Against Telecommuting*	*Yes, Supporting Telecommuting*	*Don't Know*
a. Organization-wide	☐1	☐2	☐3	☐4
b. Your supervisor	☐1	☐2	☐3	☐4
c. Yourself	☐1	☐2	☐3	☐4

2. Regardless of the existence of a formal policy, what is the general attitude toward telecom-muting at each of the following levels?

	Negative	*Neutral*	*Positive*	*Don't Know*
a. Organization	☐1	☐2	☐3	☐4
b. Your supervisor	☐1	☐2	☐3	☐4
c. Yourself	☐1	☐2	☐3	☐4

3. Including all of your past experience as a manager, what total length of time have you supervised employees who telecommute. . .

   a. from a **telecommuting center**? _____ years and _____ months

   b. from **home**? _____ years and _____ months

4. Within the next two years, what change do you expect to see in the proportion of your organization's workforce allowed to telecommute. . .

	Decrease	*No Change*	*Increase*	*Don't Know*
a. from a **telecommuting center**?	☐1	☐2	☐3	☐4
b. from **home**?	☐1	☐2	☐3	☐4

5. Overall, how would you rate **your level of satisfaction** with center-based telecommuting?

   ☐1 Very low ☐2 Low ☐3 Neutral ☐4 High ☐5 Very high

6. With the center in its current state, how likely is your organization to offer center-based telecommuting to other employees?

☐$_1$ Very unlikely ☐$_2$ Unlikely ☐$_3$ Not sure ☐$_4$ Likely ☐$_5$ Very likely

7. What, if anything, would need to change to make your organization **likely** to offer center-based telecommuting? Please explain **how** and/or **why** the indicated item would need to change. (*Check all that apply.*)

		Explanation
☐$_1$	Nothing would make the organization likely to offer it	_____
☐$_2$	Nothing more is needed, we are already likely to offer it	_____
☐$_3$	The cost	_____
☐$_4$	The ability to quantify benefits to the organization	_____
☐$_5$	Security	_____
☐$_6$	Use of the center by competitors	_____
☐$_7$	Private offices	_____
☐$_8$	Appearance of the center	_____
☐$_9$	Size of the center	_____
☐$_{10}$	Location of the center	_____
☐$_{11}$	Equipment	_____
☐$_{12}$	Site administration	_____
☐$_{13}$	Clerical support	_____
☐$_{14}$	Manager acceptance	_____
☐$_{15}$	Employee acceptance	_____
☐$_{16}$	Support on selection and training of telecommuters	_____
☐$_{17}$	Other (*please specify*): _____	_____

8. From the list in Question 7 (items 1-17), please select the most important factor that would make your organization likely to offer center-based telecommuting. Enter a "1" if nothing would make the organization likely to offer it and a "2" if the organization is already likely to offer it.

The number of the most important factor is _____.

9. Given the current circumstances, what would be the ideal distribution of your employee's time among each of the following work locations? Please give the **average percentage of time** you would prefer your employee to work at each location. **Your answers should add to 100%.**

_____ regular workplace _____ home

_____ telecommuting center _____ other (*please specify*): _____

*Please answer **each** question below, both for a telecommuting center and for home. By "**occasional partial days**" we mean a situation in which your employee telecommutes for part of the work day and then goes to the regular workplace for the rest of the day.*

	Not at all	*Less than once a month*	*About 1-3 days a month*	*1-2 days a week*	*3-4 days a week*	*5 days a week*	*Occa-sional partial days*
10. Considering the requirements of your employee's current job, how much do you think **the nature of the job** would allow him/her to telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
11. How much does your employee **currently** telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
12. How much **would you allow** your employee to telecommute							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
13. Six months from now, how much **do you expect** your employee to be telecommuting							
a. *from a telecommuting center?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7
b. *from home?*	☐1	☐2	☐3	☐4	☐5	☐6	☐7

PART F
GENERAL INFORMATION

In this section we ask for some background information about yourself and your organization. Your answers to these questions are important to help us generalize the findings from this small sample to the population as a whole. Again, your responses are strictly confidential.

1. About how many people work for your organization at your regular workplace? (*This workplace may include multiple adjacent buildings occupied by the same organization.*)

   ☐₁ 1 - 9 ☐₂ 10 - 49 ☐₃ 50 - 99 ☐₄ 100 - 499 ☐₅ 500 or more

2. What is your gender? ☐₁ Female ☐₂ Male

3. What is your age?

   ☐₁ 24 or younger ☐₃ 35 - 44 ☐₅ 55 - 64
   ☐₂ 25 - 34 ☐₄ 45 - 54 ☐₆ 65 or older

4. How long have you. . .

   a. been a manager? _____ years
   b. worked for this organization? _____ years

5. What is your educational background? (*Check the highest level.*)

   ☐₁ Some grade school or high school
   ☐₂ High school graduate
   ☐₃ Some college or technical school
   ☐₄ Four-year college, university, or technical school graduate
   ☐₅ Some graduate school
   ☐₆ Completed graduate degree(s)

6. How much do you **personally** use a computer on the job?

   ☐₁ Not at all
   ☐₂ Some (up to several hours a week)
   ☐₃ A lot (several hours a day)

COMMENTS: We would value any additional comments you may have. Please write them in the space provided below. Thank you for your time and cooperation!

APPENDIX C

SELECTED TRAVEL DIARY PAGES

TELECOMMUTING CENTERS EVALUATION PROJECT
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, DAVIS, CA 95616-8762
(916) 752-5391

TRAVEL DIARY

OF

_____

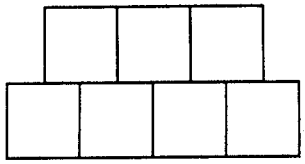
(YOUR FULL NAME)

FOR THE DATES OF

_____ ____, 19_____

_____ ____, 19_____

and _____ ____, 19_____
(MONTH) (DAY) (YEAR)



GENERAL GUIDELINES FOR COMPLETING THE TRAVEL DIARY

Thank you for participating in the Telecommuting Centers Evaluation Project.

Please make sure that **each member of your household who is age 16 and older** fills out a travel diary. If your household needs more travel diaries or if you have any other questions about the travel diary, please call the Institute of Transportation Studies (ITS) office at (916) 752-5391. The travel diary is a record of each trip you make in a **consecutive** three-day period. The information that you provide will help us learn more about the travel impacts of telecommuting. Please **fill out your diary** as **completely and accurately** as possible, preferably **at the time you take each trip.**

In the diary, your travel is broken down into **trip segments**. **A trip segment is defined as travel from one place to another *by any means for any purpose.*** The following are examples of trip segments: a bicycle ride to the park, a drive to work, a walk to the grocery store.

The trickiest part of completing the diary is **making sure each trip segment is recorded** and **assigning an appropriate purpose** to each segment. The examples given below show how to classify your trip segments.

- **On the way home from work, you stop at the dry cleaners to pick up some clothes, then drop by the grocery store for some milk, and finally you drive on home.**

This trip is recorded as **three *separate* trip segments.**

TRIP SEGMENT 1: Drive from work to the dry cleaners.
purpose --*personal business*
TRIP SEGMENT 2: Drive from the dry cleaners to the grocery store.
purpose -- *shopping.*
TRIP SEGMENT 3: Drive from the grocery store to home.
purpose -- *return home.*

EXCEPTION: If the dry cleaners and grocery store were located in the same shopping center **and you walked from one to the other**, then you need not record them as separate trip segments since they are made within the same complex (the shopping center). However, **if you were to start the car again**, it should be **recorded as a separate trip segment**.
The following examples are provided to clarify the **classification of trip segments** and their purposes.

- **A walk to the bus stop followed by a bus ride to work is recorded as two trip segments.**

TRIP SEGMENT 1: Walk from home to the bus stop.
purpose -- *change to other means of travel*
TRIP SEGMENT 2: Bus ride from bus stop to work.
purpose -- *commute to work*

- **Dropping a child off at school and then driving back home is also recorded as two trip segments.**

TRIP SEGMENT 1: Drive from home to school.
purpose -- *drop off passenger*
TRIP SEGMENT 2: Drive from school back to home.
purpose -- *return home*

- **However, if you go for a morning jog or an evening walk for exercise, record just one trip segment** (because the starting and ending point are the same).

TRIP SEGMENT: Walk from home to home.
purpose -- *social / recreation.*

The next page has **step-by-step instructions** on how to fill out the travel diary including the definitions of the purposes of trip segments. Please read the instructions carefully. An **example of a completed diary page** is provided on the following page.

The last seven pages are your diary pages, two for each day of the survey plus an extra page, if needed. If you have any other information that you would like to add, please use the space provided for comments on the inside back cover.

Thanks again for filling out your diary!

STEP-BY-STEP INSTRUCTIONS FOR COMPLETING THE TRAVEL DIARY

BACKGROUND INFORMATION. Please write your ***full name*** on the first page of the travel diary. Check the appropriate boxes that correspond to ***your relationship with project participant, age, gender, and employment status.*** Please enter your ***home, primary work place, and school addresses*** (as applicable).

USE ONE OR TWO DIARY PAGES PER DAY AND ONE LINE FOR EACH TRIP SEGMENT. Please record all the trip segments you make during the selected period of three consecutive days. Always start a new day on a new page. If you make more than 18 trip segments in one day (9 trip segments per page), record the additional segments on the last diary page. ***A trip segment is defined as travel from one place to another, for any purpose and by any means.***

(A) Please enter the ***date*** when the trip segments are made. If you did not make **any** trips that day, check the box provided.

(B) Circle the appropriate ***day of week*** for that date.

(C) Enter the ***make, model, and year*** of all motor vehicles available to your household. Available vehicles include those that the household owns (or leases) and those provided by an employer. Include information on available ***motorcycles, cars, light duty trucks, and passenger vans.***

(D) Check appropriate box(es) indicating your work location(s) on that day. Check ***"Not working"*** if retired, sick, on vacation, or otherwise not working that day. ***"Other location"*** includes working while traveling, in the field, or at a client's office. ***"Telecenter"*** is short for telecommuting center.

(E) Please enter the address (or the cross streets of the nearest intersection) and the name of city where trip segment **began**. (**NOTE:** If the trip begins or ends at **home, work, telecommuting center,** or **school**, then the address need not be repeated. Enter "home", "work", "telecenter", or "school", as applicable.)

(F) Please enter the address (or the cross streets of the nearest intersection) and the name of city where trip segment **ended.** ***The next trip segment should always begin where the preceding segment ended.***

(G) In the given space, enter the ***time of day*** when the trip segment began and when it ended. Check "AM" if morning and "PM" otherwise. Enter noon as 12 a.m. and midnight as 12 p.m.

(H) The purpose of a trip segment is defined by the main activity at the place where your trip segment ends. Please enter the appropriate code (1 through 12) for each ***trip segment purpose*** as indicated in the table located in the ***upper left*** corner of the diary page. The trip segment purpose definitions are given on the Background Information page. ***If a trip segment has more than one purpose, enter the most important one.***

(I) Enter the code (1 through 10) for ***means of travel*** as indicated in the table located in the ***upper right*** corner of the diary page. ***NOTE: Bicycle and walk trips should be included.***

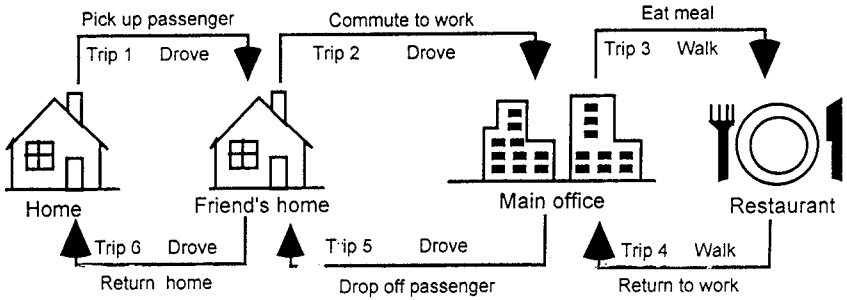
(J) If the ***means of travel code was 1, 2, or 3*** (drove or rode in private vehicle), enter the ***vehicle code*** as shown in (C) and the ***number of people*** in the vehicle ***including yourself.***

(K) If your ***means of travel code was 1, 2, or 3,*** enter the ***starting*** and ***ending odometer readings*** for the trip segment ***(to the nearest 0.1 mile).***

(L) Please enter the ***total distance*** traveled and the ***distance traveled on freeway (to the nearest 0.1 mile).*** If the trip did not involve any freeway miles, enter "0" for that column.

(M) In this column enter any incidental fees including out-of-pocket ***fares*** (bus, rail, other transit, etc.), ***parking charges***, and ***tolls*** incurred during this trip segment (in dollars and cents). ***Do not include prepaid parking or passes, etc.***

EXAMPLE (see next page for Mr. Smith's completed diary page):
Mr. Smith leaves home in the morning, and on his way to work he picks up a friend. At noon, he walks to a nearby restaurant for lunch and then walks back to his office. At about 5 p.m., Mr. Smith leaves work and drops his friend off on his way back home. In all, he makes six trip segments and fills in 6 lines of his diary page for that day.



BACKGROUND INFORMATION

Your full name: _____

Project participant's full name: _____

Your relationship to project participant:
- ☐ Self
- ☐ Spouse / Significant other
- ☐ Son / Daughter
- ☐ Other

Your gender:
- ☐ Female
- ☐ Male

Your age:
- ☐ 16-24 years
- ☐ 25-34 years
- ☐ 35-44 years
- ☐ 45-54 years
- ☐ 55-64 years
- ☐ 65 and over

Your employment status:
- ☐ Self-employed
- ☐ Salaried or Hourly wage
- ☐ Homemaker
- ☐ Retired
- ☐ Student
- ☐ Unemployed
- ☐ Other (please specify): _____

Your home address:

_____, _____
(Address or cross streets of nearest intersection) (City)

Your primary work address (if applicable):

_____, _____
(Address or cross streets of nearest intersection) (City)

Your school address (if applicable):

_____, _____
(Address or cross streets of nearest intersection) (City)

TRIP SEGMENT PURPOSE DEFINITIONS

PURPOSE	DEFINITION
COMMUTE TO WORK	The first trip segment of the day made to your primary place of employment or to the telecommuting center.
RETURN HOME	Any trip segment that ends at home; not necessarily the last trip segment of the day.
RETURN TO WORK	All other trip segments after the first that end at your primary place of employment or at the telecommuting center.
WORK-RELATED	Trip segments made to carry out business at places other than the primary place of employment or the telecommuting center (for example, attending business meetings).
DROP OFF / PICK UP PASSENGER	The purpose of the trip segment is to drop off or pick up one or more passengers.
EAT MEAL	A trip segment made to a conventional or fast food restaurant to eat in or take out.
SHOPPING	Trip segments made for the purpose of shopping which includes both window shopping and purchasing goods (groceries, clothes, gasoline, etc.).
SOCIAL / RECREATION	Trip segments made to visit friends, see a movie, attend a sporting event, go camping, and so on.
PERSONAL BUSINESS	This includes trip segments made to carry out personal business (for example, medical / dental appointments).
SCHOOL / EDUCATION	Trip segments made to attend classes as a full-time or part-time student.
CHANGE TO DIFFERENT MEANS OF TRAVEL	Trip segments made for the purpose of changing your means of travel on your way to a final destination (for example, driving to a bus stop to take a bus to work).
OTHER	A trip segment made for purposes not defined above (for example, charitable, political, or religious activities).

Trip segment purposes

1. Commute to work
2. Return home
3. Return to work
4. Work-related
5. Drop off/pick up passenger
6. Eat meal
7. Shopping
8. Social/recreation
9. Personal business
10. School/education
11. Change to different means of travel
12. Other

Ⓐ TRIPS MADE ON _____ (month / day / year)

☐ Did not make any trips today

Means of travel

1. Drove conventional motor vehicle
2. Rode in conventional motor vehicle
3. Drove/rode in electric vehicle
4. Bus
5. Light rail/trolley
6. BART/Metro Red Line
7. Commuter rail
8. Bicycle
9. Walk
10. Other

Ⓒ Motor vehicle information (including motorcycles)

Vehicle code	Make	Model	Year
A			
B			
C			
D			

Ⓑ Day of the week trips made (circle one)

Su Mo Tu We Th Fr Sa

Ⓓ Today I am working from (check all that apply):

☐ Not working ☐ Primary office ☐ Telecenter ☐ Other location ☐ Home

Trip segment	Ⓔ Trip segment began from	Ⓕ Trip segment ended at	Ⓖ Starting and ending time of trip segment		Ⓗ Purpose	Ⓘ Means of travel	Ⓙ Veh. code & No. of people		Ⓚ Odometer reading (nearest 0.1 mile)		Ⓛ Distance traveled (nearest 0.1 mile)		Ⓜ Incidental costs (in dollars and cents)		
Use one line per trip segment	Please indicate: • *Address or cross streets of nearest intersection to where trip segment began* • *City where trip segment began*	Please indicate: • *Address or cross streets of nearest intersection to where trip segment ended* • *City where trip segment ended*	Please indicate: • *Time of day* • *AM or PM*		Enter codes 1 to 12	Enter codes 1 to 10	If you drove or rode in a personal vehicle (*means of travel is 1, 2, or 3*) (see Part Ⓒ)				Please indicate: • *Total distance* • *Distance on freeway*		Please indicate: • *Fares* (bus, rail, etc.) • *Parking charges* • *Tolls*		
			Starting time	*Ending time*	*From above left*	*From above right*	*Veh. code*	*No. of people*	*Beginning*	*Ending*	*Total*	*Freeway*	*Fares*	*Parking*	*Tolls*
1			☐ AM ☐ PM	☐ AM ☐ PM											
2			☐ AM ☐ PM	☐ AM ☐ PM											
3			☐ AM ☐ PM	☐ AM ☐ PM											
4			☐ AM ☐ PM	☐ AM ☐ PM											
5			☐ AM ☐ PM	☐ AM ☐ PM											
6			☐ AM ☐ PM	☐ AM ☐ PM											
7			☐ AM ☐ PM	☐ AM ☐ PM											
8			☐ AM ☐ PM	☐ AM ☐ PM											
9			☐ AM ☐ PM	☐ AM ☐ PM											

APPENDIX D

SIGN-IN LOG

APPENDIX D: SIGN-IN LOG

Telecommuting Center Employee Sign-in

DATE (mo./day)	NAME	WORK HOURS AT EACH LOCATION TODAY				HOW DID YOU GET HERE TODAY?						
		Here	Main Office	Home	Other	Walk/ Bike	Alt. Fuel Veh.	Drive Alone	Carpool	Public Transit	Dropped Off	Other
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐
						☐	☐	☐	☐	☐	☐	☐

APPENDIX E

SAMPLE MEMORANDUM OF UNDERSTANDING

APPENDIX E: SAMPLE MEMORANDUM OF UNDERSTANDING

THE CITY OF CHULA VISTA TELECENTER TELECOMMUTER AGREEMENT

Revised: January 15, 1997

This Telecommuter Agreement ("Agreement") is entered into, effective as of _____ _____, 1997, by and between the City of Chula Vista ("CITY") and _____,("USER").

This Agreement addresses the respective responsibilities of the CITY, as operator of the Chula Vista Telecenter ("Telecenter"), and the USER and its employees, as users of the Telecenter. This AGREEMENT shall have no effect on the relationship, duties, responsibilities, or conditions of employment between the USER and the employee(s) that it may assign to the Telecenter.

The parties hereto expressly acknowledge and agree that this Agreement conveys no exclusive property or possessory interest in CITY's real or personal property to USER, but rather licenses to USER the non-exclusive use of certain property on the terms set forth herein.

COSTS

USER shall not be responsible for workstation or equipment rental costs. Such costs shall be underwritten by the Neighborhood Telecenters Program to the extent that funds are available. USER will be responsible for payment to CITY of costs which are directly related to the work of its employees at the Telecenter. These costs will consist of:

Telecommunications Charges: These will include all telephone expenses for voice and data communication (i.e. phone, modem, and fax use fees).

Copy and Laser Print Charges: A copy machine and laser printer will be on-site for use by the USER. The USER will be charged for any copies and laser prints made at a rate designated by the Telecenter.

All invoices will be due in full 30 days from the date of invoice. If USER fails to pay amounts owed when due, CITY shall have the right to terminate this Agreement.

CITY reserves the right to change the fee structure for the Telecenter at any time by giving 30 days written notice to USER.

PERSONNEL

USER will be responsible for choosing which of its employees will telecommute. To the extent possible, employees who use the Telecenter will use it a minimum of one (1) day each week. Prior to commencing use of the Telecenter, USER and its employees shall review and sign a copy of the existing Telecenter Policies/Rules, thereby agreeing to abide by them.

USER and employees also agree to participate in telecommuter and supervisor orientation and surveys, focus groups, and inquiries conducted as part of the evaluation of the program. Individual response to any material shall remain anonymous, but the data compiled may be made

available to the public. Orientation for the telecommuters and their supervisors will be conducted prior to occupancy, if possible. In the event that orientation is not possible, then it will be conducted as soon as is convenient after occupancy.

EQUIPMENT

All equipment, software, or other items provided by the Telecenter will remain the property of the Telecenter (subject to agreements CITY may have with specific providers), and may not be moved, removed or altered in any way without written permission from the CITY. Telecommuters will use only the equipment at their assigned workstation and that which is provided for general use. USER acknowledges that all work space and equipment provided by the Telecenter are non-exclusive and shall be shared by other Telecenter users in accordance with Telecenter policies and rules.

USER may choose to use the hardware and software provided by the Telecenter, or provide its own equipment and/or software. If USER provides hardware and/or software, this equipment must be used and maintained in a safe and responsible manner.

CITY will provide for use by USER's employee(s) the following:

- Use of a workstation for each person assigned to the Telecenter
- Access to a conference room
- Use of available computer hardware and software
- Use of lunch area
- Telephone
- Janitorial services
- Access to laser printer, copier and fax machine
- Building maintenance
- Office furniture
- Telecenter management

USER will provide the following for its employees:

- Employee supervision
- Daily office supplies, e.g. stapler, tape, paper clips, etc.
- Any hardware, software, or other equipment or supplies needed by employee(s) that are not already provided at the Telecenter

TIME/SECURITY

Normal business hours will be 8:00 a.m. to 5:00 p.m, Monday - Friday. To the extent possible, the Telecenter Manager or another City employee will be available to Telecenter users during these hours. Access to the Telecenter at other times will be arranged as necessary by the Telecenter Director.

CITY will provide all reasonable equipment and policies to ensure the confidentiality of data and documents used at the Telecenter. However, USER agrees to hold CITY harmless for any costs, damages or losses of USER or its employees related to use of confidential information at the Telecenter.

LIABILITY/INSURANCE

USER agrees to protect, defend, indemnify and hold harmless the CITY, the Telecenter, the program sponsors, and their respective agents and employees from and against any and all personal and property claims, demands, liability, losses and damages (including any related losses, costs, expenses, or attorney's fees) suffered by USER, its employees, or any third party, resulting from or arising in connection with USER's or its employees' use of or conduct at the Telecenter.

CITY will not be responsible for any damage, loss, or theft of equipment or personal belongings of USER or be liable for damage caused by USER's employees or faulty equipment while they are located in the Telecenter. All USERs and their employees using the Telecenter must comply with all legal mandates, such as using only legally purchased software, complying with copyright laws, and all federal, state and local laws.

USER agrees to carry and maintain during the term of this agreement, comprehensive general liability insurance covering its employees' use of the Telecenter, including coverage for bodily injury, property damage and personal injury (employee and contractual liability exclusions deleted), with not less than the following limits of liability: One million dollars ($1,000,000) each occurrence combined single limit bodily injury, property damage and personal injury; Two million dollars ($2,000,000) aggregate. All such insurance shall be procured from a responsible insurance company authorized to do business in California. Such insurance may be part of any existing or blanket coverage obtained or maintained by USER. USER will demonstrate proof of required coverage by providing a copy of a certificate of insurance to this Agreement with policy endorsement naming the City as additional insured. USER's personal property and equipment will be insured by USER.

RIGHT TO TERMINATE

This Agreement may be terminated by USER with 30 days written notice to CITY for any reason.

This Agreement may be terminated by CITY with 2 days written notice to USER for any reason including, but not limited to the following:

a.) Failure by USER to pay fees as stated in this Agreement;

b.) Gross or repeated violation of Telecenter Policies/Rules and/or misuse of Telecenter property;

c.) Loss of funding for the Telecenter.

CHANGES TO AGREEMENT

Any changes to this agreement must be approved and signed by both parties.

Consent to this Agreement indicates that CITY and USER have read and understood this document thoroughly. It is advisable for USER to have the Agreement reviewed by legal counsel. This Agreement becomes effective when signed by an authorized representative of CITY and USER.

TELECENTER USER

_____
Company Name

_____ _____ _____
Authorized Representative Title Date

_____
Please Print Name

CITY OF CHULA VISTA

_____ _____ _____
Name Title Date

APPENDIX F

VIDEOCONFERENCE REPORT

APPENDIX F:

VIDEOCONFERENCE REPORT

Location: _____ Date: _____

Start Time: _____ End Time: _____

Moderator: _____ Number of people at this location: _____

Primary reason for the meeting:

- ☐ Negotiation/Persuasion
- ☐ Information Exchange
- ☐ Teaching/Instruction
- ☐ Other: _____

Relationship of participants:

- ☐ Co-workers from same organization
- ☐ Client/contractor
- ☐ Peers from multiple organizations
- ☐ Other: _____

List all other participating sites: **Site Name** **City/State**	**Number of people at this site**
1.	
2.	
3.	
4.	
5.	
6.	

APPENDIX G

SELECTED ATTITUDINAL SURVEY TABULATIONS FOR AFTER EMPLOYEE DATA

APPENDIX G: SELECTED ATTITUDINAL SURVEY TABULATIONS FOR AFTER EMPLOYEE DATA

In this appendix, selected questions from the after attitudinal survey of telecenter users, which are described in Chapter 3, are tabulated. Except where noted, the sample is composed of the 69 respondents to the after telecenter user survey. Tables G-1 and G-2 report the mean response from a 5-point scale that runs from strongly disagree (1) to strongly agree (5). Figure G-1 presents charts of the mean responses to the work environment characteristics listed in Table G-2. Table G-3 reports the results from a one-way analysis of variance (ANOVA) testing each statement from Table G-2 for significantly differing means across workplaces. Means which differ at a level of significance of 0.05 are marked in boldface type.

Table G-1: Employee Job Performance and Satisfaction Questions

1. Respondent's Opinion of Self (N = 69)	Mean	Standard Deviation
a. Amount of work	4.25	0.58
b. Quality of work	4.42	0.53
c. Ability to meet deadlines	4.23	0.77
d. Overall productivity	4.30	0.55
2. Opinion of Supervisor's Rating (N = 67)		
a. Amount of work	4.25	0.66
b. Quality of work	4.34	0.69
c. Ability to meet deadlines	4.24	0.74
d. Overall productivity	4.25	0.66
3. Satisfaction Components (N = 69)		
a. Supervisor communication[1, 5]	4.04	1.04
b. Promotion opportunity[2]	3.58	1.21
c. No lack of resources[5]	3.54	1.15
d. Work team is effective	3.71	0.89
e. Work well with supervisor[1]	4.03	0.91
f. Job not boring and tedious[5]	4.19	0.69
g. Get a sense of accomplishment	4.01	0.87
h. Supervisor appreciation[1, 5]	3.94	1.10
i. Confident in abilities	4.54	0.53

Table G-1: Employee Job Performance and Satisfaction Questions (Continued)

3. Satisfaction Components (N = 69)	Mean	Standard Deviation
j. Get along well with co-workers[5]	4.39	0.83
k. Unlikely to look for a new job[5]	3.75	1.14
l. Work well with those supervised[3]	4.00	0.82
m. Clients are not unreasonable[4, 5]	3.39	0.88
n. Overall satisfaction	4.00	0.82

[1] N = 68 [2] N = 67
[3] N = 28 (39 not applicable and 2 missing) [4]N = 46 (22 not applicable and 1 missing)
[5] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table G-2: Employee Work Environment Questions (N = 69)

Question	Location	Mean	Standard Deviation
1. Easy to be motivated	Reg. Workplace	3.87	0.87
	Telecenter	4.36	0.51
	Home	3.16	1.15
2. Not stressful to work[7]	Reg. Workplace[1]	2.93	1.16
	Telecenter[1]	4.19	0.72
	Home[1]	3.32	1.01
3. Supervisor comfortable[7]	Reg. Workplace[2]	4.21	0.90
	Telecenter[2]	3.87	0.89
	Home[2]	3.16	1.12
4. Professional appearance	Reg. Workplace	3.99	0.76
	Telecenter	4.10	0.71
	Home	2.68	1.05
5. Distractions from others not a problem[7]	Reg. Workplace	2.30	1.14
	Telecenter	3.84	0.95
	Home	3.19	1.19
6. Free time[7]	Reg. Workplace	2.16	1.04
	Telecenter	3.72	1.07
	Home[1]	3.88	0.95

Table G-2: Employee Work Environment Questions (Continued)

Question	Location	Mean	Standard Deviation
7. Would not overeat or indulge[7]	Reg. Workplace	3.88	0.81
	Telecenter	4.00	0.57
	Home	3.13	1.18
8. Social interaction	Reg. Workplace	3.90	0.83
	Telecenter	3.00	0.96
	Home	2.35	0.89
9. Relative independence	Reg. Workplace	3.19	1.09
	Telecenter	4.06	0.71
	Home	4.06	0.80
10. Convenient to run errands	Reg. Workplace	2.67	1.12
	Telecenter	3.80	0.82
	Home	3.80	0.95
11. Enough space[7]	Reg. Workplace	3.81	0.91
	Telecenter	4.01	0.76
	Home	3.20	1.24
12. Good for the environment	Reg. Workplace	2.07	0.98
	Telecenter	4.17	0.79
	Home	4.32	0.70
13. Visible to management[7]	Reg. Workplace[1]	4.03	0.93
	Telecenter[1]	3.00	1.07
	Home[1]	2.56	1.08
14. Have needed equipment[7]	Reg. Workplace	4.09	0.78
	Telecenter	3.93	0.86
	Home	2.72	1.29
15. Easy to keep home and work separate[7]	Reg. Workplace	4.22	0.73
	Telecenter	4.27	0.59
	Home	2.84	1.31

Table G-2: Employee Work Environment Questions (Continued)

Question	Location	Mean	Standard Deviation
16. Control over environment	Reg. Workplace	2.64	1.18
	Telecenter	3.09	1.08
	Home	3.71	1.03
17. Would not cost too much[7]	Reg. Workplace	2.75	1.17
	Telecenter	3.96	0.81
	Home	3.90	1.02
18. Commute is not a hassle[7]	Reg. Workplace	1.78	0.97
	Telecenter	4.26	0.78
	Home	4.49	0.74
19. Work while sick or disabled	Reg. Workplace[1]	2.00	0.95
	Telecenter[1]	3.16	1.21
	Home	4.15	0.96
20. Scheduling freedom	Reg. Workplace	3.13	1.08
	Telecenter	3.88	0.90
	Home	4.06	0.82
21. Can handle dependent care	Reg. Workplace[3]	2.49	1.10
	Telecenter[3]	3.80	0.99
	Home[4]	4.06	0.79
22. Work judged by results	Reg. Workplace	3.67	1.07
	Telecenter	3.87	1.00
	Home	3.81	1.00
23. Household conflicts not a problem[7]	Reg. Workplace[5]	3.86	1.03
	Telecenter[5]	4.30	0.58
	Home[5]	3.06	1.32
24. Save me money	Reg. Workplace	1.81	0.81
	Telecenter	4.17	0.94
	Home	4.19	0.91

Table G-2: Employee Work Environment Questions (Continued)

Question	Location	Mean	Standard Deviation
25. Would not require self-discipline[7]	Reg. Workplace	3.75	1.05
	Telecenter	3.55	1.11
	Home	2.52	1.31
26. Professional interaction[7]	Reg. Workplace	3.97	0.95
	Telecenter	3.26	1.00
	Home	2.52	1.04
27. Dress the way I like	Reg. Workplace[2]	2.75	1.15
	Telecenter[2]	3.84	0.88
	Home[2]	4.25	0.82
28. Balance responsibilities	Reg. Workplace[2]	2.88	1.16
	Telecenter[2]	3.91	0.85
	Home[2]	3.55	1.09
29. Supervisor communication not a problem[7]	Reg. Workplace[6]	4.01	0.85
	Telecenter[6]	3.91	0.89
	Home[6]	3.59	1.02
30. Work effectively	Reg. Workplace[2]	4.12	0.79
	Telecenter[2]	4.43	0.58
	Home[2]	3.67	1.15

[1] N = 68 [2] N = 67 [3] N = 35 [4] N = 36 [5] N = 50 [6] N = 66

[7] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table G-3: Work Environment Characteristics - ANOVA Results (P-values)[1]

Question	Workplace Effect	Question	Workplace Effect
1. Easy to be motivated	**.000**	16. Control over environment	**.000**
2. Not stressful to work[2, 8]	**.000**	17. Would not cost too much[8]	**.000**
3. Supervisor comfortable[3, 8]	**.000**	18. Commute is not a hassle[8]	**.000**
4. Professional appearance	**.000**	19. Work while sick or disabled[4]	**.000**
5. Distractions from others not a problem[8]	**.000**	20. Scheduling freedom	**.000**
6. Free time[8]	**.000**	21. Can handle dependent care[5]	**.000**
7. Would not overeat or indulge[8]	**.000**	22. Work judged by results	.488
8. Social interaction	**.000**	23. Household conflicts not a problem[6, 8]	**.000**
9. Relative independence	**.000**	24. Save me money	**.000**
10. Convenient to run errands	**.000**	25. Wouldn't require self-discipline[8]	**.000**
11. Enough space[8]	**.000**	26. Professional interaction[8]	**.000**
12. Good for the environment	**.000**	27. Dress the way I like[3]	**.000**
13. Visible to management[2, 8]	**.000**	28. Balance responsibilities[3]	**.000**
14. Have needed equipment[8]	**.000**	29. Supervisor communication not a problem[7,8]	**.025**
15. Easy to keep home & work separate[8]	**.000**	30. Work effectively[3]	**.000**

[1] The sample size (N) is 207, or three times the number of respondents (69), because each question is asked once for each of the three workplaces.

[2] N = 204 (3 missing observations) [3] N = 201 (6 missing observations)

[4] N = 205 (2 missing observations) [5] N = 106 (2 missing and 99 not applicable observations)

[6] N = 150 (0 missing and 57 not applicable observations) [7] N = 198 (9 missing observations)

[8] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Figure G-1: Mean Ratings on Work Environment Characteristics

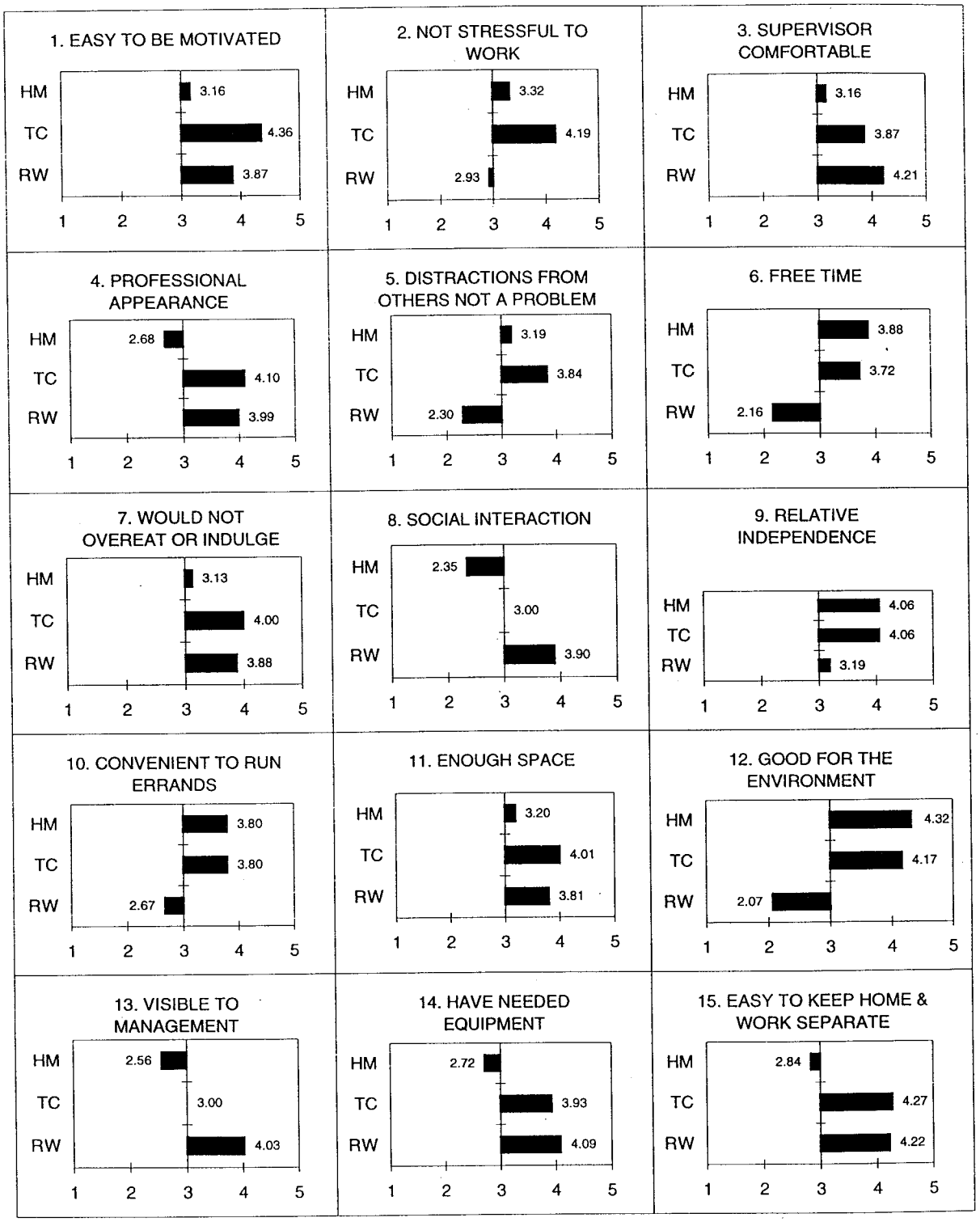
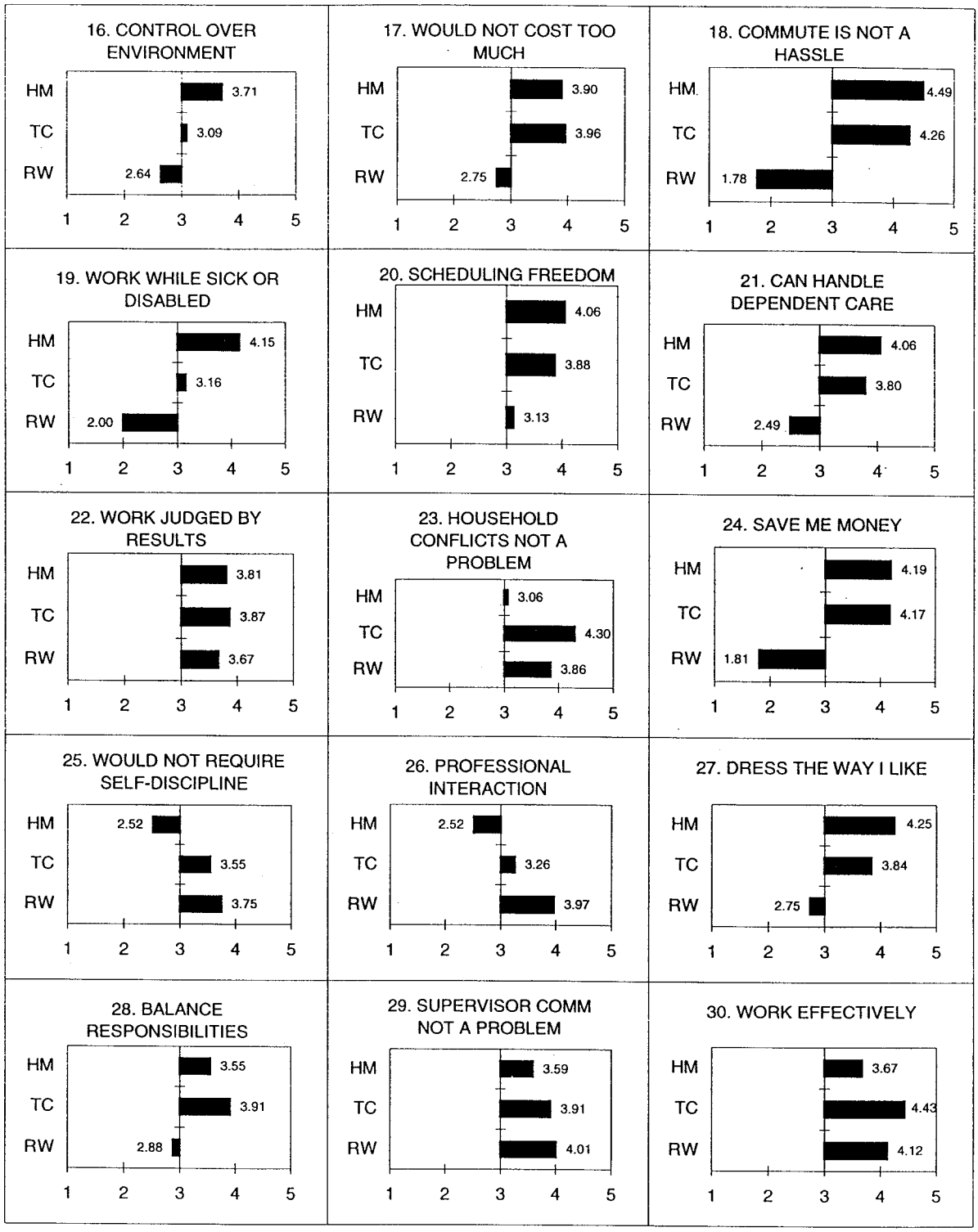


Figure G-1: Mean Ratings on Work Environment Characteristics (Continued)



APPENDIX H

STATISTICAL TEST RESULTS FOR BEFORE/AFTER COMPARISONS OF EMPLOYEE DATA

APPENDIX H: STATISTICAL TEST RESULTS FOR BEFORE/AFTER COMPARISONS OF EMPLOYEE DATA

This appendix also tabulates selected questions from the attitudinal surveys of telecenter users, which are described in Chapter 3. In contrast to Appendix G, the sample comprises those who responded to these questions on both the before and after versions of the telecenter user survey: the sample size is 54, except where noted. Means which differ at a level of significance of 0.05 are marked in boldface type. Tables H-1 and H-3 report mean responses for a 5-point scale that runs from strongly disagree (1) to strongly agree (5). Table H-4 reports mean responses for a 4-point scale that runs from not at all important (1) to extremely important (4). Table H-2 presents results from a two-way analysis of variance (ANOVA) testing employee attitudes toward work environments. The calculation for telecommuting frequency (in terms of percent of days) given in Table H-5 is described in Table 3-12.

Table H-1: Job Performance and Satisfaction Means

1. Respondent's Opinion of Self (N = 54)	Before	After	T-statistic	P-value
a. Amount of work	4.19	4.30	0.95	0.348
b. Quality of work	4.35	4.43	0.66	0.510
c. Ability to meet deadlines	4.22	4.35	1.02	0.312
d. Overall productivity	4.19	4.37	1.75	0.086
2. Supervisor's Opinion (N = 51)	Before	After	T-statistic	P-value
a. Amount of work	4.22	4.24	0.17	0.864
b. Quality of work	4.43	4.31	-1.00	0.322
c. Ability to meet deadlines	4.37	4.27	-0.87	0.389
d. Overall productivity	4.31	4.22	-0.87	0.389
3. Satisfaction Components (N = 54)	Before	After	T-statistic	P-value
a. Supervisor communication[1, 5]	4.23	3.98	-1.28	0.208
b. Promotion opportunity[1]	3.91	3.51	-1.93	0.060
c. No lack of resources[5]	3.61	3.48	-0.59	0.558
d. Work team is effective	3.87	3.72	-1.00	0.322
e. Work well with supervisor[2]	4.17	3.96	-1.36	0.182
f. Job is not tedious and boring[5]	4.19	4.19	0.00	1.000
g. Get a sense of accomplishment	4.20	3.96	-1.52	0.135
h. Supervisor appreciation[2,5]	**4.21**	**3.87**	**-2.13**	**0.038**

Table H-1: Job Performance and Satisfaction Means (Continued)

3. Satisfaction Components (Cont.)	Before	After	T-statistic	P-value
i. Confident in abilities	4.50	4.52	0.17	0.868
j. Get along well with co-workers[5]	4.57	4.50	-0.57	0.569
k. Unlikely to look for a new job[5]	3.50	3.69	0.92	0.362
l. Work well with those supervised[3]	4.27	4.27	0.00	1.000
m. Clients are not unreasonable[4,5]	3.57	3.43	-0.72	0.475
n. Overall satisfaction[1]	4.08	3.94	-0.84	0.405

[1] N = 53 [2] N = 52 [3] N = 11 [4] N = 28

[5] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table H-2: Two-way ANOVA Results for Employees' Attitudes toward Different Work Environments in Both Survey Waves (N = 324 Observations; 54 Respondents)

Statement	Workplace Factor[1]	Wave Factor[2]	Inter-action[3]
1. Easy to be motivated	**0.000**	0.238	0.469
2. Not stressful to work	**0.000**	0.469	0.647
3. Supervisor comfortable[4]	**0.000**	0.639	0.864
4. Professional appearance	**0.000**	0.686	0.772
5. Distractions from others not a problem	**0.000**	1.000	0.404
6. Free time[5]	**0.000**	0.484	0.986
7. Would not overeat or indulge	**0.000**	0.301	0.828
8. Social interaction	**0.000**	**0.039**	0.668
9. Relative independence	**0.000**	0.057	0.302
10. Convenient to run errands	**0.000**	0.425	0.718
11. Enough space	**0.000**	0.055	0.841
12. Good for the environment[6]	**0.000**	0.262	0.287
13. Visible to management[7]	**0.000**	0.318	0.929
14. Have needed equipment[5]	**0.000**	0.076	0.978
15. Easy to keep home & work separate	**0.000**	0.861	0.930
16. Control over environment[5]	**0.000**	0.802	0.099

Table H-2: Two-way ANOVA Results for Employees' Attitudes toward Different Work Environments in Both Survey Waves (Continued)

Statement	Workplace Factor[1]	Wave Factor[2]	Inter-action[3]
17. Would not cost too much	**0.000**	0.631	0.729
18. Commute is not a hassle	**0.000**	0.946	0.473
19. Work while sick or disabled[8]	**0.000**	0.361	0.871
20. Scheduling freedom	**0.000**	0.866	0.711
21. Can handle dependent care[9]	**0.000**	0.149	0.203
22. Work judged by results[7]	0.719	0.230	0.589
23. Household conflicts not a problem[10]	**0.000**	0.974	0.583
24. Save me money[5]	**0.000**	0.905	0.703
25. Wouldn't require self-discipline	**0.000**	0.926	0.715
26. Professional interaction[6]	**0.000**	0.712	0.750
27. Dress the way I like[4]	**0.000**	0.055	0.719
28. Balance responsibilities[4]	**0.000**	0.557	0.156
29. Supervisor communication not a problem[11]	**0.031**	**0.033**	0.720
30. Work effectively[4]	**0.000**	0.509	0.802

[1] The numbers given are the p-values of the F-test for equality of means across workplaces. Values in boldface type are significant at $\alpha \leq 0.05$.

[2] The numbers given are the p-values of the F-test for equality of means across survey waves. Values in boldface type are significant at $\alpha \leq 0.05$.

[3] The numbers given are the p-values of the F-test for the interaction between the workplace and wave factors.

[4] N = 318 (6 missing observations)

[5] N = 323 (1 missing observation)

[6] N = 322 (2 missing observations)

[7] N = 321 (3 missing observations)

[8] N = 320 (4 missing observations)

[9] N = 184 (8 missing observations and 132 not applicable observations)

[10] N = 241 (5 missing observations and 78 not applicable observations)

[11] N = 313 (11 missing observations)

Table H-3: Work Environment Characteristic Means (N = 54)

Question	Location	Before	After	T-statistic	P-value
1. Easy to be motivated	Reg. Workplace	3.67	3.94	1.49	0.141
	Telecenter	4.30	4.43	1.07	0.290
	Home	3.22	3.19	-0.19	0.849
2. Not stressful to work[8]	Reg. Workplace	3.19	2.94	-0.92	0.359
	Telecenter	4.22	4.24	0.14	0.886
	Home	3.37	3.33	-0.19	0.852
3. Supervisor comfortable[8]	Reg. Workplace[1]	4.17	4.13	-0.21	0.832
	Telecenter[1]	3.81	3.87	0.36	0.718
	Home[1]	3.21	3.17	0.27	0.788
4. Professional appearance	Reg. Workplace	4.11	3.98	-1.02	0.312
	Telecenter	4.09	4.09	0.00	1.000
	Home	2.70	2.72	0.09	0.927
5. Distractions from others not a problem[8]	Reg. Workplace	2.43	2.39	-0.16	0.877
	Telecenter	3.98	3.80	-0.98	0.311
	Home	2.98	3.20	0.91	0.365
6. Free time[8]	Reg. Workplace	2.22	2.13	-0.41	0.682
	Telecenter	3.81	3.72	-0.48	0.633
	Home[2]	3.83	3.79	-0.22	0.830
7. Would not overeat or indulge[8]	Reg. Workplace	3.74	3.89	0.92	0.364
	Telecenter	4.04	4.06	0.17	0.868
	Home	3.00	3.17	0.76	0.450
8. Social interaction	Reg. Workplace	3.94	3.85	-0.66	0.513
	Telecenter	3.41	3.09	-1.55	0.126
	Home	2.65	2.43	-1.33	0.265
9. Relative independence	Reg. Workplace	3.70	3.33	-1.92	0.060
	Telecenter	4.28	4.13	-1.21	0.231
	Home	4.09	4.07	-0.13	0.894

Table H-3: Work Environment Characteristic Means (Continued)

Question	Location	Before	After	T-statistic	P-value
10. Convenient to run errands	Reg. Workplace	2.83	2.83	0.00	1.000
	Telecenter	3.65	3.87	1.18	0.243
	Home	3.70	3.76	0.28	0.777
11. Enough space[8]	Reg. Workplace	3.61	3.81	0.98	0.330
	Telecenter	**3.72**	**4.06**	**2.30**	**0.025**
	Home	2.96	3.13	0.72	0.475
12. Good for the environment	Reg. Workplace[1]	1.88	1.98	0.48	0.630
	Telecenter	4.39	4.20	-1.35	0.184
	Home	4.50	4.30	-1.63	0.109
13. Visible to management[8]	Reg. Workplace[2]	4.00	3.94	-0.32	0.754
	Telecenter[2]	3.28	3.09	-0.91	0.366
	Home[2]	2.78	2.64	-0.63	0.530
14. Have needed equipment[8]	Reg. Workplace	4.28	4.06	-1.69	0.096
	Telecenter[2]	4.17	3.96	-1.56	0.125
	Home	2.81	2.65	-0.70	0.489
15. Easy to keep home and work separate[8]	Reg. Workplace	4.19	4.19	-0.00	1.000
	Telecenter	4.24	4.26	0.15	0.880
	Home	2.98	2.91	-0.29	0.775
16. Control over environment	Reg. Workplace	2.46	2.80	1.55	0.127
	Telecenter[2]	3.15	3.21	0.29	0.773
	Home	3.94	3.65	-1.55	0.128
17. Would not cost too much[8]	Reg. Workplace	2.72	2.72	0.00	1.000
	Telecenter	4.04	4.02	-0.12	0.907
	Home	3.65	3.83	0.95	0.345
18. Commute is not a hassle[8]	Reg. Workplace	1.65	1.80	0.76	0.451
	Telecenter	4.35	4.30	-0.43	0.666
	Home	4.57	4.46	-0.81	0.419

Table H-3: Work Environment Characteristic Means (Continued)

Question	Location	Before	After	T-statistic	P-value
19. Work while sick or disabled	Reg. Workplace[1]	1.98	2.06	0.42	0.674
	Telecenter[1]	3.15	3.25	0.47	0.643
	Home	4.04	4.22	1.20	0.235
20. Scheduling freedom	Reg. Workplace	3.26	3.17	-0.35	0.729
	Telecenter	3.93	3.94	0.10	0.920
	Home	4.02	4.15	0.82	0.418
21. Can handle dependent care	Reg. Workplace[3]	**1.87**	**2.80**	**2.71**	**0.017**
	Telecenter[3]	3.47	3.80	1.16	0.265
	Home[3]	4.33	4.07	-1.07	0.301
22. Work judged by results	Reg. Workplace[2]	3.92	3.62	-1.50	0.139
	Telecenter[2]	3.91	3.87	-0.19	0.851
	Home[2]	3.87	3.79	-0.39	0.702
23. Household conflicts not a problem[8]	Reg. Workplace[4]	3.93	4.00	0.28	0.783
	Telecenter[5]	4.04	4.29	1.37	0.183
	Home[5]	3.07	3.21	0.45	0.655
24. Save me money	Reg. Workplace[2]	1.96	1.87	-0.55	0.588
	Telecenter	4.13	4.22	0.60	0.552
	Home	4.09	4.15	0.34	0.754
25. Would not require self-discipline[8]	Reg. Workplace	3.72	3.78	0.24	0.812
	Telecenter	3.76	3.59	-0.71	0.481
	Home	2.52	2.59	0.28	0.780
26. Professional interaction[8]	Reg. Workplace	4.04	3.87	-0.94	0.350
	Telecenter[2]	3.32	3.32	0.00	1.000
	Home[2]	2.60	2.60	0.00	1.000
27. Dress the way I like	Reg. Workplace[1]	3.17	2.83	-1.39	0.170
	Telecenter[1]	4.10	3.92	-1.16	0.253
	Home[1]	4.38	4.27	-0.86	0.392

Table H-3: Work Environment Characteristic Means (Continued)

Question	Location	Before	After	T-statistic	P-value
28. Balance respon-sibilities	Reg. Workplace[6]	3.19	2.87	-1.57	0.123
	Telecenter[6]	4.00	3.90	-0.57	0.574
	Home[6]	3.33	3.56	1.08	0.286
29. Supervisor communi-cation not a problem[8]	Reg. Workplace[6]	4.16	3.98	-1.05	0.297
	Telecenter[7]	4.10	3.94	-0.96	0.344
	Home[7]	3.94	3.58	-1.69	0.098
30. Work effectively	Reg. Workplace[1]	4.15	4.19	0.25	0.802
	Telecenter[1]	4.44	4.44	0.00	1.000
	Home[1]	3.54	3.71	0.72	0.475

[1] N = 52 [2] N = 53 [3] N = 15 [4] N = 29 [5] N = 28 [6] N = 51 [7] N = 50

[8] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table H-4: Work Environment Characteristic Importance Ratings (N = 54)

Statement	Mean	Standard Deviation
1. Being motivated to work	3.44	0.82
2. Working with little stress	3.07	0.87
3. Having supervisor be comfortable with my work	3.69	0.51
4. Working in a professional-appearing environment	2.81	0.95
5. Working without distractions from others	3.09	0.78
6. Spending time with family and/or friends	3.37	0.76
7. Not overeating or over-indulging	2.96	1.06
8. Interacting socially at work	2.63	0.78
9. Having independence in day-to-day work activities	3.56	0.50
10. Running errands while commuting to or from work	2.41	0.96
11. Having enough work space	3.41	0.63
12. Benefitting the environment	3.22	0.82
13. Being visible to management	2.35	0.89

Table H-4: Work Environment Characteristic Importance Ratings (Continued)

Statement	Mean	Standard Deviation
14. Having the equipment and services needed to work effectively	3.80	0.49
15. Separating work and home activities	3.15	0.92
16. Having control over my work environment	3.35	0.68
17. Not having to spend own money on work	3.13	0.88
18. Commuting to work without a hassle	3.54	0.72
19. Working while sick or disabled	2.46	0.91
20. Having ability to adjust own work schedule	3.41	0.66
21. Having the ability to care for dependent(s)	2.46	1.27
22. Having work judged by its results	3.76	0.51
23. Minimizing household conflicts	3.04	0.93
24. Saving money on work-related expenses	3.30	0.77
25. Having strong self-discipline	3.54	0.61
26. Interacting socially at work	3.19	0.78
27. Dressing the way I like at work	2.81	0.89
28. Balancing work and household responsibilities	3.00	0.85
29. Communicating with supervisor	3.54	0.77
30. Working effectively	3.91	0.29

[1] N = 53

Table H-5: Relative Telecommuting Frequency Means (N = 53)

Question	Before	After	T-statistic	P-value
Job suitability from a center	46.99	48.59	0.45	0.655
Job suitability from home[1]	28.94	33.75	1.08	0.286
Manager support from a center[1]	47.01	48.50	0.33	0.741
Manager support from home[2]	**22.59**	**33.42**	**2.17**	**0.035**
Choice from a center	**19.67**	**37.72**	**3.59**	**0.001**
Choice from home[3]	12.00	16.20	0.91	0.369
Preference from a center	54.17	56.07	0.50	0.616
Preference from home[4]	17.83	27.72	1.56	0.125
Expected in six months from a center	45.73	39.46	-1.45	0.154
Expected in six months from home[5]	14.07	16.52	0.53	0.598

[1] N = 52 [2] N = 51 [3] N = 49 [4] N = 48 [5] N = 50

APPENDIX I

SELECTED ATTITUDINAL SURVEY TABULATIONS FOR MANAGER DATA

APPENDIX I: SELECTED ATTITUDINAL SURVEY TABULATIONS FOR MANAGER DATA

This appendix presents the responses to selected questions from the attitudinal survey of the managers of telecenter users, as described in Section 3.3. Except where noted, the sample size is 62. Table I-1 reports the mean responses on a 5-point scale that runs from strongly disagree (1) to strongly agree (5). Figure I-1 presents charts of the mean responses to the work environment characteristics listed in Table I-1. Figure I-2 presents charts of the mean responses for questions with significant wave effects as shown in Table 3-20.

Table I-1: Supervisor Work Environment Questions

Question	Location	Mean	Standard Deviation
1. Easy to be motivated	Reg. Workplace	4.08	0.73.
	Telecenter	4.26	0.57
	Home	3.63	0.94
2. Supervisor comfortable[4]	Reg. Workplace	4.19	0.96
	Telecenter	4.05	0.91
	Home	3.32	1.25
3. Professional appearance	Reg. Workplace[1]	4.02	0.72
	Telecenter[1]	3.87	0.69
	Home[1]	2.62	0.82
4. Distractions from others not a problem[4]	Reg. Workplace[1]	3.08	1.17
	Telecenter[1]	3.87	0.76
	Home[2]	2.82	1.05
5. Would not overeat or indulge[4]	Reg. Workplace[1]	4.20	0.68
	Telecenter[1]	4.21	0.58
	Home[1]	4.03	0.71
6. Relative independence	Reg. Workplace	3.81	0.94
	Telecenter	4.15	0.74
	Home	3.94	0.87

Table I-1: Supervisor Work Environment Questions (Continued)

Question	Location	Mean	Standard Deviation
7. Good for the environment	Reg. Workplace	3.02	1.02
	Telecenter	3.87	0.76
	Home	3.77	0.93
8. Visible to management[4]	Reg. Workplace	4.21	0.66
	Telecenter	3.26	1.05
	Home	2.79	1.19
9. Have needed equipment[4]	Reg. Workplace	4.32	0.65
	Telecenter	3.77	0.78
	Home	2.77	1.09
10. Supervisor confident	Reg. Workplace	4.44	0.56
	Telecenter	4.34	0.54
	Home	3.79	0.94
11. Would not cost too much[4]	Reg. Workplace[1]	4.10	0.77
	Telecenter[1]	3.89	0.69
	Home[1]	3.41	0.97
12. Work while sick or disabled	Reg. Workplace[1]	3.57	1.06
	Telecenter	3.81	0.92
	Home	3.82	0.82
13. Scheduling freedom	Reg. Workplace	3.53	0.95
	Telecenter[1]	3.85	0.85
	Home[1]	3.85	0.83
14. Employee available[4]	Reg. Workplace	4.16	0.61
	Telecenter	3.60	0.95
	Home	3.16	1.06

Table I-1: Supervisor Work Environment Questions (Continued)

Question	Location	Mean	Standard Deviation
15. Work judged by results	Reg. Workplace	4.26	0.89
	Telecenter	4.37	0.79
	Home	4.26	0.85
16. Professional interaction[4]	Reg. Workplace[1]	4.31	0.53
	Telecenter[1]	2.95	0.99
	Home[1]	2.46	1.04
17. Employee communication not a problem[4]	Reg. Workplace	4.27	0.75
	Telecenter	3.79	0.93
	Home	3.48	0.97
18. Work effectively	Reg. Workplace	4.37	0.58
	Telecenter	4.27	0.63
	Home	3.81	0.85
19. No administrative burden[4]	Reg. Workplace	4.31	0.56
	Telecenter	3.94	0.74
	Home	3.56	0.93
20. Security of information	Reg. Workplace	4.15	0.70
	Telecenter	3.74	0.87
	Home	3.63	0.93
21. Worker's compensation liability not a problem[4]	Reg. Workplace[1]	3.48	0.85
	Telecenter[1]	3.33	0.83
	Home[1]	3.23	0.84
22. Property secure	Reg. Workplace[2]	3.97	0.76
	Telecenter[3]	3.49	0.70
	Home[3]	3.47	0.75

[1] N = 61 [2] N = 60 [3] N = 59

[4] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Figure I-1: Supervisor Work Environment Characteristics Charts

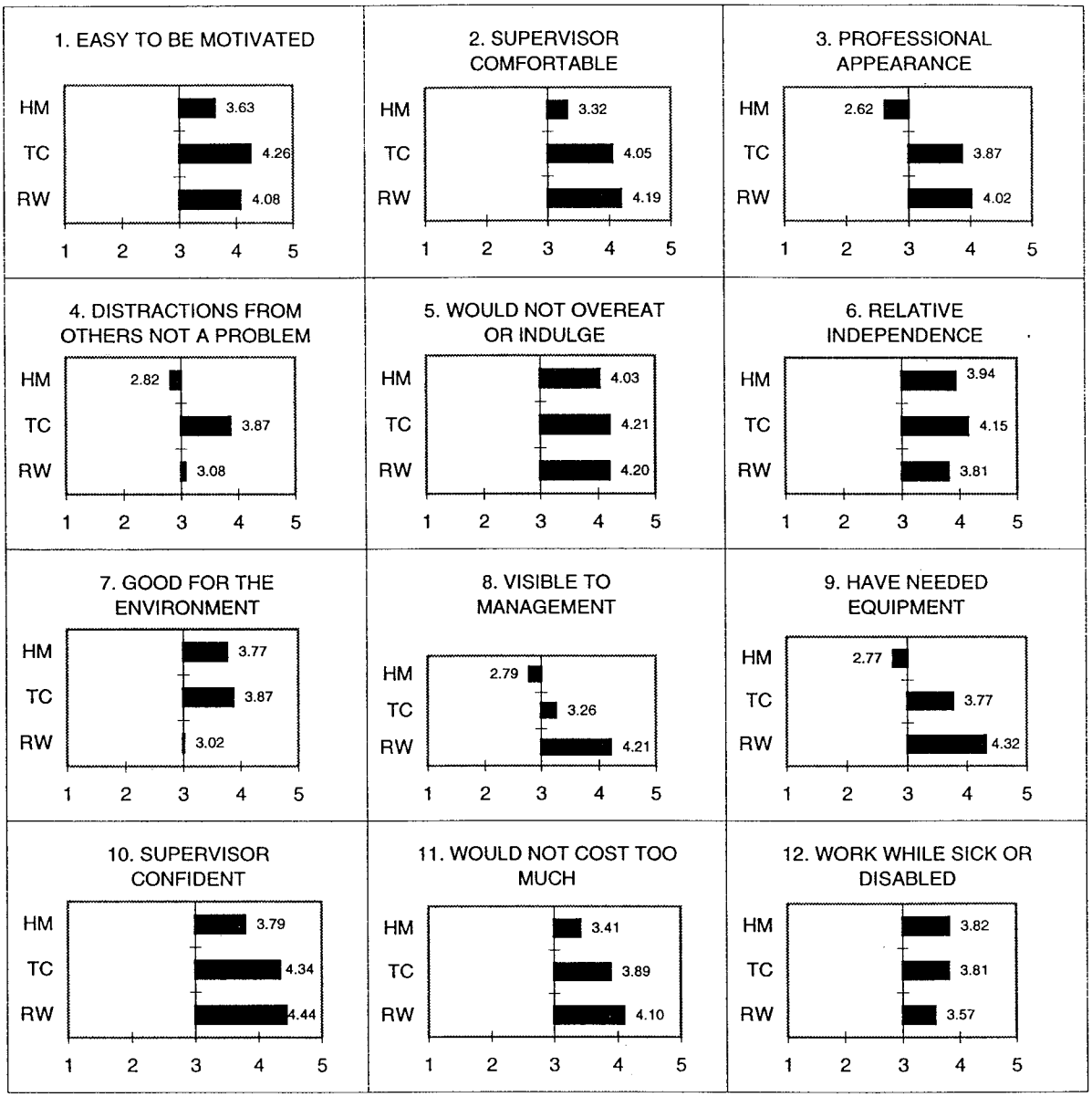


Figure I-1: Supervisor Work Environment Characteristics Charts (Continued)

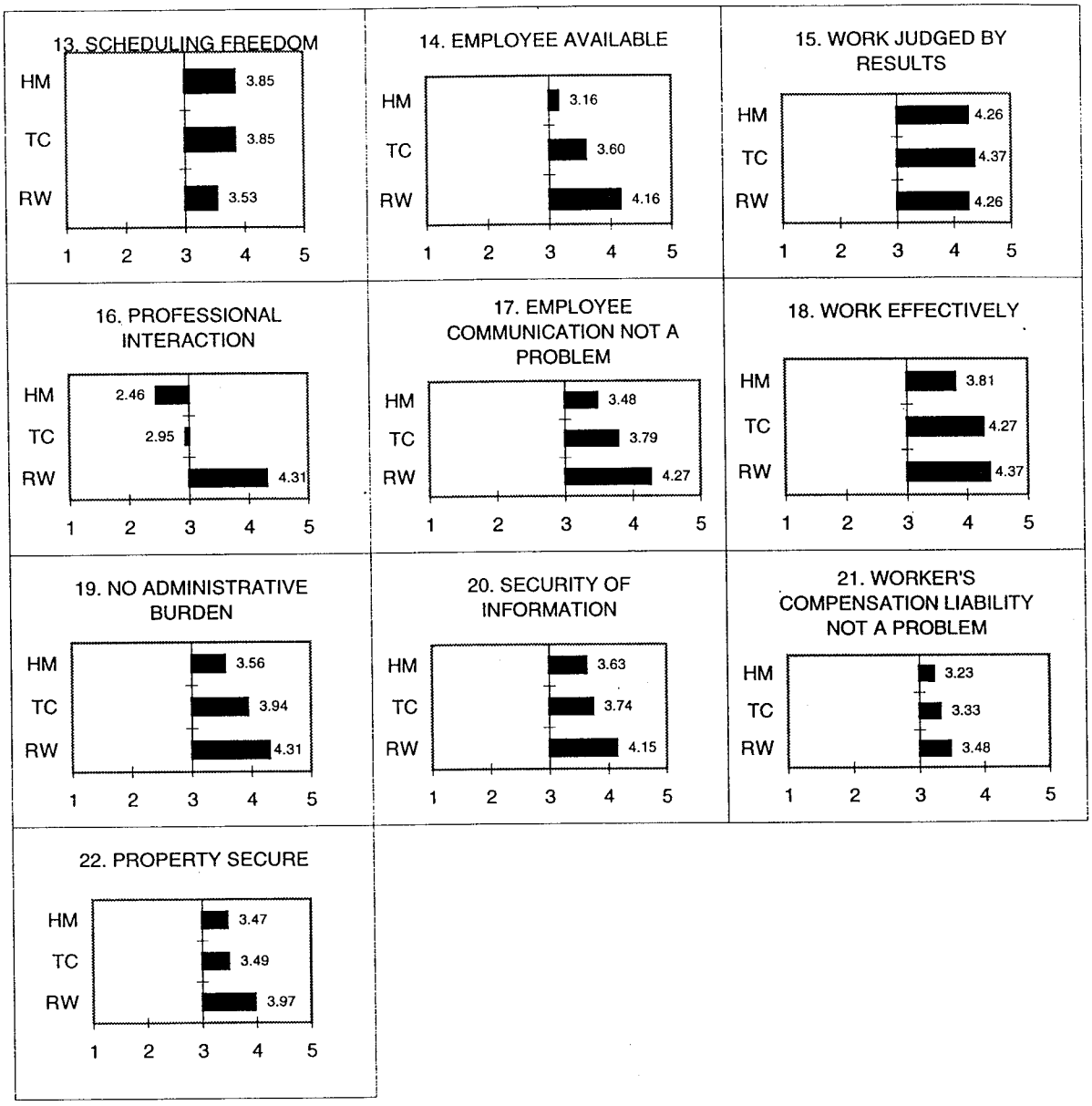
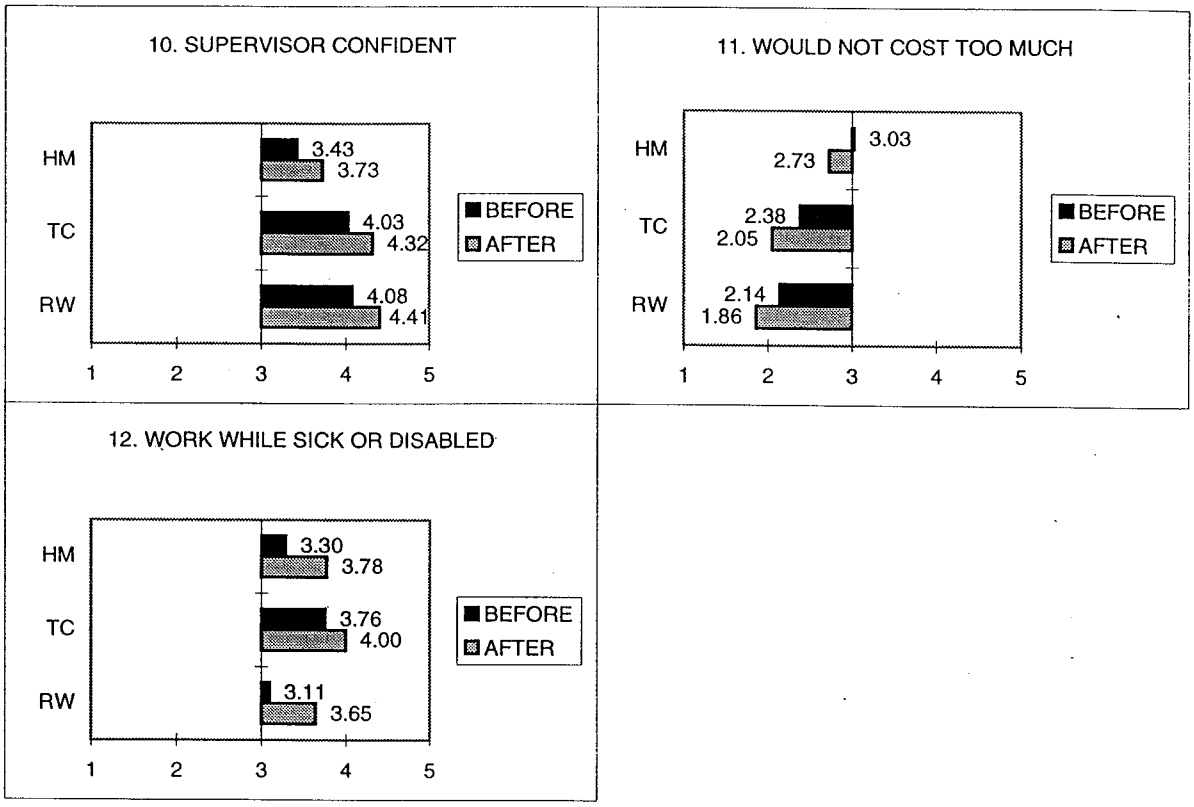


Figure I-2: Selected Supervisor Work Characteristic Attitudes
from the Before and After Surveys (N = 37)



APPENDIX J

STATISTICAL TEST RESULTS FOR COMPARISONS OF AFTER EMPLOYEE AND MANAGER DATA

APPENDIX J: STATISTICAL TEST RESULTS FOR COMPARISONS OF AFTER EMPLOYEE AND MANAGER DATA

This appendix tabulates the results of statistical tests between the 47 telecenter user employee-manager pairs, which are described in Chapter 3. Tables J-1 and J-2 report the means from a 5-point scale that runs from strongly disagree (1) to strongly agree (5). The comparison of telecommuting frequency given in Table J-3 is described in Table 3-30. Significantly differing means at a level of significance of 0.05 are marked in boldface type. Figure J-1 plots the mean ratings on 15 work environment characteristics, for which two-way ANOVA results are presented in Table 3-28.

Table J-1: Comparison of Job Performance Means between Employee Assessment and Manager Assessment

Attribute	Employee Assessment	Manager Assessment	T-statistic	P-value
a. Amount of work	4.35	4.28	0.573	0.569
b. Quality of work	4.50	4.43	0.651	0.519
c. Ability to meet deadlines	4.33	4.39	-0.465	0.644
d. Overall productivity	4.39	4.33	0.703	0.485

Table J-2: Comparison of Job Performance Means between Perceived and Actual Manager Assessment

Attribute	Perceived (by Employee) Supervisor's Assessment	Supervisor's Actual Assessment	T-statistic	P-value
a. Amount of work	4.30	4.28	0.465	0.644
b. Quality of work	4.41	4.43	0.843	0.404
c. Ability to meet deadlines	4.35	4.39	0.903	0.371
d. Overall productivity	4.33	4.33	0.489	0.627

Table J-3: Comparison of Employees' and Supervisors' Assessments of Telecommuting Frequency

Question	Proportion of Work Week			
	From a Center		From Home	
	T-test	P-value	T-test	P-value
Job	1.716	0.093	**2.086**	**0.043**
Supervisor/permit	-0.384	0.703	**2.007**	**0.051**
Choice	-0.372	0.712	0.307	0.761
Expect	-0.356	0.723	0.880	0.384

Figure J-1: Attitudes toward Different Work Environments across Status Groups and Work Locations (N = 47)

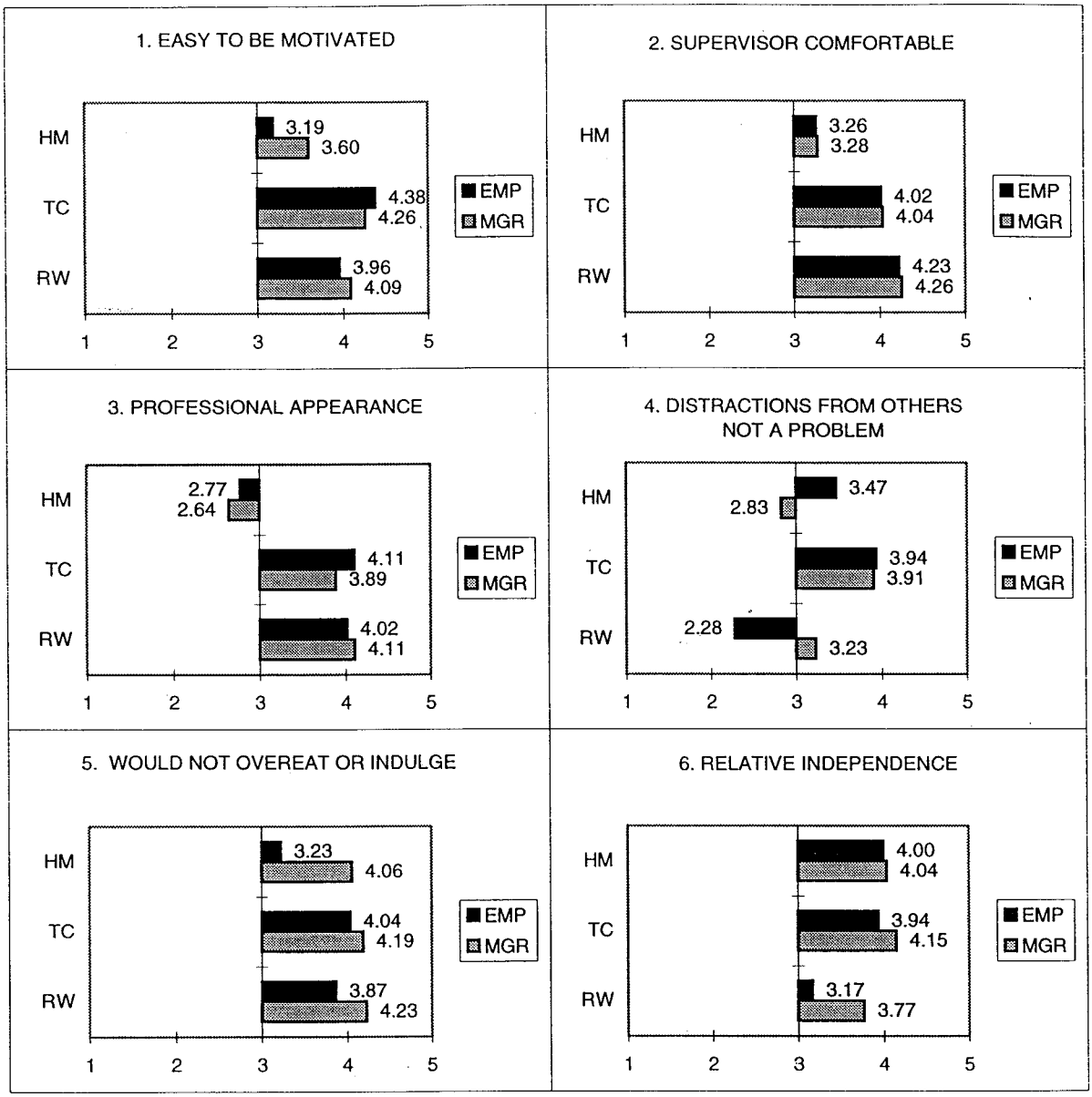


Figure J-1: Attitudes toward Different Work Environments across Status Groups and Work Locations (Continued)

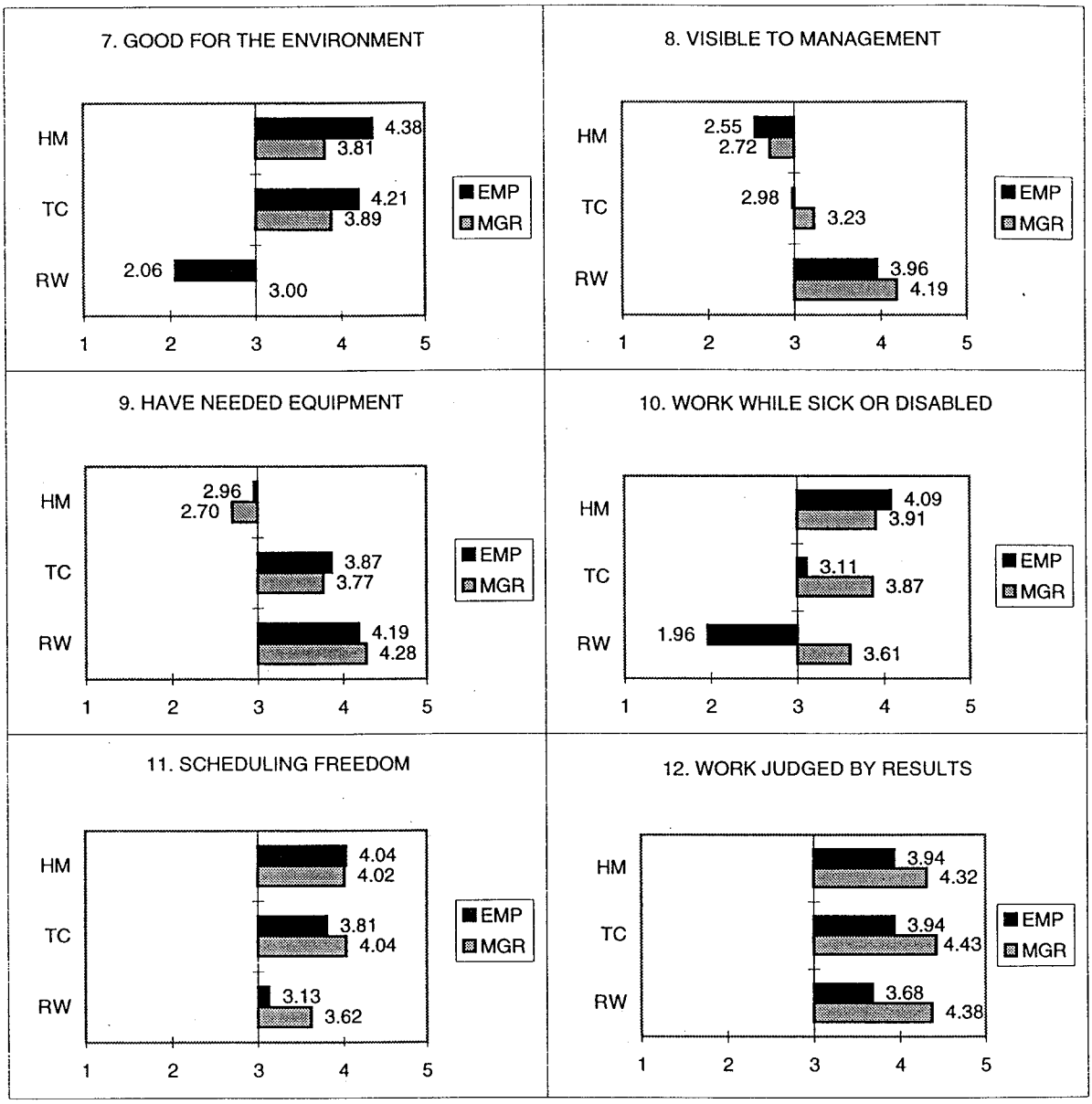
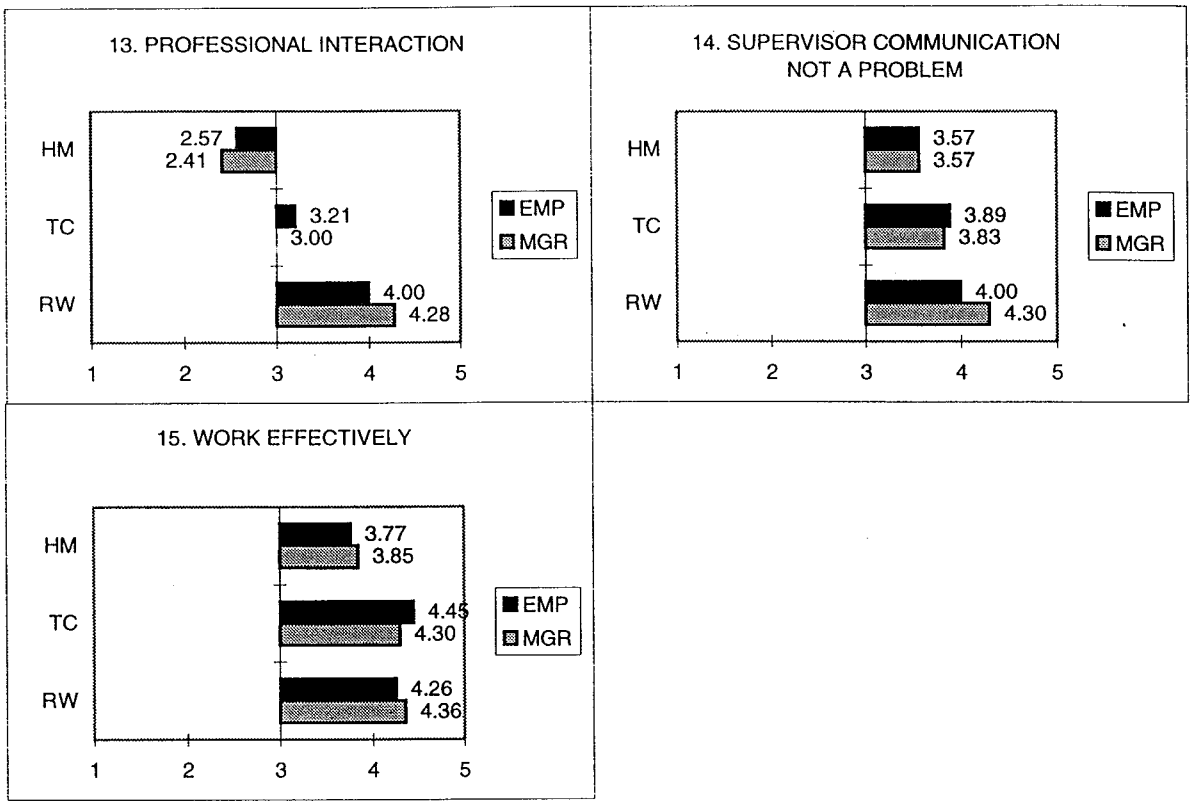


Figure J-1: Attitudes toward Different Work Environments across Status Groups and Work Locations (Continued)



APPENDIX K

STAYERS AND QUITTERS TABULATIONS AND STATISTICAL TEST RESULTS

APPENDIX K: STAYERS AND QUITTERS TABULATIONS AND STATISTICAL TEST RESULTS

The tables in this appendix present the results of statistical tests of differences between stayers and quitters, which are described in Chapter 5. Except where noted, the sample sizes are 44 and 106 for the stayers and quitters, respectively. Means which differ at a level of significance less than or equal to 0.05 are marked in boldface type. The calculation for telecommuting frequency (in terms of percent of work days) given in Table K-1 is described in Table 3-10. Tables K-2 and K-3 report the mean response on a 5-point scale that runs from strongly disagree (1) to strongly agree (5). Table K-4 reports the mean response on a 4-point scale that runs from not at all important (1) to extremely important (4).

Table K-1: Relative Telecommuting Frequency Means (Before Survey)

Question	Stayers	Quitters	T-statistic	P-value
Job suitability from a center	44.53	43.77[2]	0.14	0.885
Job suitability from home	27.35	29.30[3]	-0.35	0.726
Manager support from a center	41.22[1]	44.16[4]	-0.52	0.604
Manager support from home	20.84[1]	27.12[5]	-1.12	0.263
Choice from a center	20.66	17.03[6]	0.79	0.431
Choice from home	11.53[1]	13.83[7]	-0.48	0.630
Preference from a center	51.14	53.15[6]	-0.36	0.719
Preference from home	20.90[1]	27.96[8]	-1.26	0.211
Expected from a center	43.01	35.21[3]	1.55	0.124
Expected from home	13.16[9]	16.74[8]	-.077	0.444

[1] N = 43 [2] N = 104 [3] N = 103 [4] N = 101 [5] N = 98 [6] N = 102
[7] N = 99 [8] N = 100 [9] N = 42

Table K-2: Job Performance and Satisfaction Means (Before Survey)

1. Respondent's Opinion	Stayers	Quitters	T-statistic	P-value
a. Amount of work	4.12[1]	3.96[2]	1.14	0.258
b. Quality of work	4.36[1]	4.37[2]	0.01	0.995
c. Ability to meet deadlines	4.30[1]	4.10[2]	1.34	0.183
d. Overall productivity	4.19[1]	4.10[2]	0.66	0.508
2. Supervisor's Opinion				
a. Amount of work	4.12[3]	4.08[4]	0.39	0.696
b. Quality of work	4.37[3]	4.34[4]	0.24	0.814
c. Ability to meet deadlines	4.27[3]	4.16[4]	0.78	0.438
d. Overall productivity	4.27[3]	4.11[4]	1.30	0.196
3. Satisfaction Components				
a. Supervisor communication[9]	4.20	4.07[2]	0.77	0.442
b. Promotion opportunity	3.75	3.96	-1.23	0.219
c. No lack of resources[9]	3.36	3.51[2]	-0.73	0.469
d. Work team is effective	3.84[1]	3.80[2]	0.24	0.812
e. Work well with supervisor	4.12[1]	4.10[2]	0.15	0.881
f. Clients are not unreasonable[9]	3.10[5]	3.40[6]	-1.43	0.157
g. Overall satisfaction	3.95[1]	4.17[2]	-1.77	0.079
h. Get a sense of accomplishment	4.02	4.14	-0.78	0.439
i. Supervisor appreciation[9]	3.81[1]	4.04[2]	-1.29	0.199
j. Get along well with co-workers[9]	4.36	4.49[2]	-1.01	0.314
k. Confident in abilities	4.41	4.49	-0.79	0.432
l. Unlikely to look for a new job[9]	3.36	3.36[2]	0.01	0.994
m. Work well with those supervised	4.00[7]	4.12[8]	-0.71	0.481
n. Job is tedious and boring[9]	4.09	4.17	-0.57	0.570

[1] N = 43 [2] N = 105 [3] N = 41 [4] N = 104 [5] N = 31 [6] N = 92
[7] N = 20 [8] N = 51
[9] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table K-3: Work Environment Means (Before Survey)

Question	Location	Stayers	Quitters	T-statistic	P-value
1. Easy to be motivated	Reg. Workplace	3.66	3.84[2]	-1.05	0.294
	Telecenter	4.27	4.16[3]	0.93	0.356
	Home	3.25	3.49[4]	-1.22	0.225
2. Not stressful to work[9]	Reg. Workplace	3.11	3.21	-0.42	0.677
	Telecenter	4.02	4.12[5]	-0.69	0.489
	Home	3.25	3.52[5]	-0.01	0.994
3. Supervisor comfortable[9]	Reg. Workplace	4.23[1]	4.25[3]	-0.12	0.906
	Telecenter	3.60[1]	3.75[5]	-0.78	0.435
	Home	3.14 [1]	3.25[6]	-0.49	0.623
4. Professional appearance	Reg. Workplace	4.02	4.11[3]	-0.77	0.444
	Telecenter	4.11	4.02[5]	0.69	0.489
	Home	2.57	2.89[5]	-1.69	0.092
5. Distractions from others not a problem[9]	Reg. Workplace	2.36	2.36	0.02	0.980
	Telecenter	3.84	3.91[4]	-.050	0.621
	Home	3.05	3.11[4]	-0.33	0.743
6. Free time[9]	Reg. Workplace	2.34	2.32	0.10	0.918
	Telecenter	3.68	3.54[3]	0.87	0.388
	Home	3.82	3.69[5]	0.86	0.390
7. Would not overeat or indulge[9]	Reg. Workplace	3.91	3.91	0.02	0.983
	Telecenter	4.07	4.10[3]	-0.23	0.817
	Home	3.18	3.24[3]	-0.26	0.792
8. Social interaction	Reg. Workplace	3.91	4.08	-1.34	0.183
	Telecenter	3.36	3.18[3]	1.07	0.288
	Home	2.86	2.59[3]	1.42	0.158

Table K-3: Work Environment Means (Continued)

Question	Location	Stayers	Quitters	T-statistic	P-value
9. Relative independence	Reg. Workplace	3.59	3.64[3]	-0.28	0.776
	Telecenter	4.25	4.20[5]	0.42	0.676
	Home	4.09	4.02	0.47	0.641
10. Convenient to run errands	Reg. Workplace	2.77	2.77[3]	0.02	0.987
	Telecenter	3.66	3.69[3]	-0.20	0.840
	Home	3.80	3.67[4]	0.83	0.406
11. Enough space[9]	Reg. Workplace	3.61	3.44[4]	0.84	0.210
	Telecenter	3.61	3.87[5]	-1.68	0.096
	Home	**2.66**	**3.39[3]**	**-3.36**	**0.001**
12. Good for the environment	Reg. Workplace	2.07	2.02[2]	0.30	0.765
	Telecenter	4.25	4.25	-0.04	0.969
	Home	4.43	4.35[4]	0.64	0.525
13. Visible to management[9]	Reg. Workplace	3.88[1]	4.14[3]	-1.83	0.069
	Telecenter	2.91[1]	3.24[5]	-1.71	0.090
	Home	2.63[1]	2.86[3]	-1.13	0.259
14. Have needed equipment[9]	Reg. Workplace	4.23	4.23	0.01	0.995
	Telecenter	3.91[1]	3.02[4]	-0.77	0.441
	Home	2.73	2.73	-0.00	0.997
15. Easy to keep home and work separate[9]	Reg. Workplace	4.07	4.22[4]	-1.19	0.234
	Telecenter	4.16	4.21[4]	-0.47	0.642
	Home	2.91	2.91	0.01	0.988
16. Control over environment	Reg. Workplace	2.55	2.24[4]	1.57	0.118
	Telecenter	3.02[1]	3.22	-1.02	0.308
	Home	3.93	3.97	-0.22	0.829

Table K-3: Work Environment Means (Continued)

Question	Location	Stayers	Quitters	T-statistic	P-value
17. Would not cost too much[9]	Reg. Workplace	2.86	3.08	-0.98	0.330
	Telecenter	3.93	4.08[4]	-1.09	0.278
	Home	3.75	3.94[4]	-1.09	0.280
18. Commute is not a hassle[9]	Reg. Workplace	1.86	2.01	-0.75	0.452
	Telecenter	4.34	4.10	1.68	0.095
	Home	4.48	4.42	0.38	0.705
19. Work while sick or disabled	Reg. Workplace	1.89	2.15[4]	-1.47	0.145
	Telecenter	2.86[1]	2.97[4]	-0.52	0.601
	Home	3.95	4.05	-0.54	0.592
20. Scheduling freedom	Reg. Workplace	3.02	3.15[4]	-0.58	0.560
	Telecenter	3.77	3.85[4]	-0.44	0.657
	Home	4.02	4.03	-0.04	0.971
21. Can handle dependent care	Reg. Workplace	3.61	3.95[5]	-0.89	0.377
	Telecenter	4.39	4.79[3]	-1.39	0.170
	Home	4.80	5.02[5]	-1.02	0.311
22. Work judged by results	Reg. Workplace	4.00	3.86[4]	0.90	0.371
	Telecenter	3.98	3.90[4]	0.46	0.648
	Home	3.91	3.90[3]	0.03	0.977
23. Household conflicts not a problem[9]	Reg. Workplace	2.84	3.06[4]	-0.67	0.507
	Telecenter	2.98	3.23[3]	-0.77	0.440
	Home	2.36	2.65[3]	-0.92	0.360
24. Save me money	Reg. Workplace	1.98	1.84[5]	0.95	0.346
	Telecenter	4.11	3.97[3]	0.76	0.447
	Home	4.26[1]	4.08[4]	1.00	0.319

Table K-3: Work Environment Means (Continued)

Question	Location	Stayers	Quitters	T-statistic	P-value
25. Wouldn't require self-discipline[9]	Reg. Workplace	3.43	3.69	-1.29	0.200
	Telecenter	3.36	2.64[4]	-1.30	0.197
	Home	2.43	2.63[4]	-0.81	0.420
26. Professional interaction not a problem[9]	Reg. Workplace	3.86	4.12[3]	-1.64	0.102
	Telecenter	3.30[1]	3.30[4]	-0.01	0.989
	Home	2.79[1]	2.70[4]	0.42	0.679
27. Dress the way I like	Reg. Workplace	**3.20**	**2.70**	**2.47**	**0.015**
	Telecenter	**4.00**	**3.57[4]**	**3.09**	**0.002**
	Home	4.39	4.18[4]	1.73	0.085
28. Balance responsibilities	Reg. Workplace	3.32	3.06[4]	1.25	0.211
	Telecenter	3.82	3.89[3]	-0.53	0.600
	Home	3.43	3.51[4]	-0.44	0.633
29. Supervisor communication not a problem[9]	Reg. Workplace	4.12[1]	4.02[4]	0.65	0.514
	Telecenter	3.93[1]	3.83[3]	0.65	0.517
	Home	3.81[1]	3.65[3]	0.87	0.387
30. Work effectively	Reg. Workplace	**4.23**	**3.98[4]**	**2.06**	**0.041**
	Telecenter	4.30	4.27	0.21	0.831
	Home	3.52	3.67[4]	-0.71	0.480

[1] N = 43 [2] N = 101 [3] N = 104 [4] N = 105 [5] N = 103 [6] N = 102

[9] Statements were negatively worded on the survey, but ratings were reversed so that a high rating is always favorable.

Table K-4: Work Characteristic Importance Rating Means (Before Survey)

Characteristic	Stayers	Quitters	T-statistic	P-value
1. Being motivated to work	3.45	3.62	-1.26	0.209
2. Working with little stress	2.93	3.03	-0.62	0.537
3. Supervisor being comfortable	3.66	3.58	0.67	0.501
4. Professional environment	2.82	2.67	0.83	0.409
5. Working with no distractions	3.09	3.02	0.52	0.606
6. Spending time with family/friends	3.23	3.06	1.11	0.268
7. Not overeating or indulging	2.86	2.80	0.34	0.737
8. Interacting socially at work	2.59	2.55	0.32	0.748
9. Having work independence	3.55	3.51	0.32	0.752
10. Running errands while commuting	2.36	2.23	0.84	0.402
11. Having enough work space	3.39	3.27	0.93	0.353
12. Benefitting the environment	3.14	2.99	0.91	0.364
13. Being visible to management	2.41	2.25	0.98	0.329
14. Having needed equipment	3.73	3.85	-1.28	0.204
15. Separating home and work	2.93	2.95	-0.12	0.907
16. Having control over work area	3.18	3.78	-1.51	0.134
17. Not spending own money on work	3.14	3.08	0.28	0.780
18. Commuting without a hassle	3.41	3.42	-0.11	0.913
19. Working while sick or disabled	2.32	2.56	-1.32	0.176
20. Able to change work schedule	3.36	3.34	0.18	0.857
21. Able to care for dependent(s)	2.45	2.42	0.13	0.894
22. Work judged by results	3.73	3.75	-0.19	0.849
23. Minimizing household conflicts	3.07	2.94	0.77	0.440
24. Saving money on work expenses	3.27	3.23	0.30	0.768
25. Having strong self-discipline	3.48	3.59	-1.12	0.266

Table K-4: Work Characteristic Importance Rating Means (Continued)

Characteristic	Stayers	Quitters	T-statistic	P-value
26. Interacting professionally	3.18	2.99	1.40	0.163
27. Dressing the way I like	**2.80**	**2.45**	**2.34**	**0.021**
28. Balancing home and work	2.77	2.97	-1.26	0.209
29. Communicating with supervisor	3.27	3.51	-1.81	0.072
30. Working effectively	3.84	3.92	-1.36	0.178