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Non-Work Activity Scheduling Effects in the Timing of Work Trips

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by

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ABSTRACT

Non-Work Activity Scheduling Effects in the Timing of Work Trips

by

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This dissertation examines the effect of work and non-work scheduling flexibility on the timing of work trips. It explores whether increasing activity scheduling flexibility, whether due to work or non-work factors, results in non-peak travel and hence shorter travel times. It examines in detail work scheduling flexibility, non-work scheduling flexibility, and travel time characteristics.

An examination of trip timing choices using data from the 1990 Bay Area Travel Survey showed that the likelihood of traveling during peak hours increases with work scheduling flexibility, and is only weakly related to non-work flexibility indicators. We conclude that activity flexbility indicators do not capture well workers' flexibility, and also that network travel time estimates do not represent accurately travel time differentials.

Data on work and non-work scheduling practices were gathered from a sample of full-time employees, using detailed personal interviews, self-administered questionnaires, and

activity diaries. The survey collected factual information about work and non-work schedules, and attitudinal information about the discretion available to reschedule work and non-work activities. Data from an independent survey were used to estimate travel time as a function of time-of-day on each corridor used by the survey subjects.

It was found that work scheduling flexibility has three components: strategic or medium term flexibility, quotidian or short term flexibility, and the gradient or loss of schedule flexibility as the desired schedule diverts from the nominal work schedule. Only strategic flexibility plays a major role in work trip timing. It was found that many flexible workers travel during congested times of day because they must engage in mandatory, time-of-day dependent non-work activities. Flexible workers also choose to participate in discretionary activities which require them to travel in congestion. These flexible workers exhibit travel time penalties as large as the penalties of commuters who have rigid work schedules. The implication is that congestion pricing and other congestion alleviation policies will succeed in shifting trips from peak to non-peak hours only to the extent that workers are able and willing to reorganize their personal and family activities.

12/14/99

Chair Date

A los trece que ya somos,

y a los que aun están por llegar.

TABLE OF CONTENTS

	Page No.
Index of Tables	viii
Index of Figures	xi
Acknowledgments	xiii
Chapter 1 **Introduction**	1
1.1 Research Questions	1
1.2 Motivation	2
1.3 The State of Practice	4
1.4 Study Organization	5
Chapter 2 **Literature Review**	8
2.1 Work Trip Scheduling	8
2.2 Non-Work Activities and Work Schedules	19
2.2.1 Impact of Personal and Family Activities on Work Schedules	19
2.2.2 Work Scheduling Motivations of Workers on Flexitime	21
2.3 Other Studies of Work Trip Timing Choice	25
2.4 Summary	27
Chapter 3 **Conceptual Basis and Study Methodology**	28
3.1 Conceptual Basis	29
3.1.1 Human Activities	29
3.1.2 Activity Scheduling Flexibility	34
3.1.3 Work Trip Timing Hypothesis	37
3.2 Study Methodology	40
3.2.1 Measurement of Activity Scheduling Flexibility in the Demand for Work Trip Timing Choice.	40
3.2.2 Activity Scheduling Flexibility Effects in the 1990 Bay Area Travel Survey	42
3.2.3 Transportation and Activity Scheduling Flexibility Survey	43

Chapter 4
Activity Scheduling Flexibility Effects on Work Trip Timing: The 1990 Bay Area Travel Survey 48

4.1 Introduction 48
4.2 Data Description 49
4.2.1 Travel Behavior Survey 49
4.2.2 Network Travel Times 50
4.2.3 Work Scheduling Flexibility Survey 50
4.3 Methodology 51
4.3.1 Hypotheses 51
4.3.2 Measurement of Work and Non-Work Scheduling Flexibility 53
4.3.3 Methods of Analysis 55
4.3.4 Sample Selection 58
4.4 Findings 60
4.4.1 Effect of Activity Scheduling Flexibility on Work Arrival Time Choice 60
4.4.2 Effect of Activity Scheduling Flexibility on Work Arrival Time Variability 63
4.5 Summary 67

Chapter 5
Personal Interviews 71

5.1 Introduction 71
5.2 Methodology 72
5.3 Subject Sample Description 73
5.4 Findings 77
5.4.1 Availability and Extent of Work Scheduling Flexibility 77
5.4.2 Non-Work Activity Scheduling Preferences and Constraints 84
5.4.3 Time-of-Day Characteristics of the Transportation Supply 89
5.4.4 Behavioral Mechanisms for Choosing Time-of-Day for Work Travel 94
5.5 Summary 99

Chapter 6
Estimation of Travel Time by Time-of-Day 103

6.1 Background 103
6.2 Data Description 107

6.3 Travel Time Function Estimation 111
6.3.1 Travel Time Model 111
6.3.2 Estimation of the Time-of-Day Parameters 114
6.3.3 Estimation of the Travel Time and Speed Parameters 121
6.3.4 Implications for Work Trip Timing Choice 132
6.4 Travel Time Differential Metric 135
6.5 Summary 138

Chapter 7
Descriptive Analysis of the Activity Scheduling Survey 141

7.1 Survey Design 142
7.1.1 Subject Selection Criteria 142
7.1.2 Survey Instruments 142
7.1.3 Sample Design 144
7.1.4 Sampling Procedure 145
7.2 Sample Description 147
7.2.1 Demographic Characteristics 147
7.2.2 Occupational Characteristics 149
7.3 Work Scheduling Characteristics 151
7.4 Characterization of Work Scheduling Flexibility 161
7.5 Non-Work Activity Scheduling Characteristics 172
7.5.1 Discretion to Shift Work Schedules Due to Non-Work Scheduling Flexibility 172
7.5.2 Non-Work Activity Preferences and Constraints 178
7.6 Summary 187

Chapter 8
Analysis of Travel Time Savings and Activity Scheduling Flexibility 192

8.1 Introduction 192
8.2 Effect of Work Scheduling Flexibility on Work Trip Timing Choice 193
8.3 Effect of Non-Work Scheduling Flexibility on Work Trip Timing Choice 204
8.3.1 Non-Work Activity Effects by Work Scheduling Motivation 206
8.3.2 Non-Work Activity Effects by Non-Work Flexibility 212
8.3.3 Non-Work Activity Effects by Activity Discretion Levels 220
8.4 Non-Work Activity Scheduling of Non-Flexible Workers 221

Chapter 9
Conclusions and Recommendations 224

References 232

Appendix 1
Personal Interview Materials 237

Appendix 2
Activity Scheduling Survey Instruments 251

Appendix 3
Faculty and Staff Housing and Transportation Survey 265

TABLES

Page No.

Chapter 2

2.1 Empirical Estimation of Activity Scheduling Effects on Work Trip Timing Choices. 17

Chapter 4

4.1 Availability of a Flexible Work Schedule on Principal Job of Wage and Salary Workers, by Occupation. 54
4.2 Effect of Work Scheduling Flexibility on Work Arrival Time. 61
4.3 Congestion Penalties by Likelihood of Flexible Work Schedule. 61
4.4 Congestion Penalty Estimates by Sex and Age of Children. 62
4.5 Proportion of Workers by Low Arrival Time Variability, by Occupation. 64
4.6 Effect of Work Scheduling Flexibility on Work Arrival Time Variability. 64
4.7 Effect of Non-Work Scheduling Flexibility on Work Arrival Time Variability. 67

Chapter 5

5.1 Demographic Characteristics of Subject Sample. 75
5.2 Occupational Characteristics of Subject Sample. 76
5.3 Time-of-Day Parking Availability on UCB Lots and Structures. 91
5.4 Drivers of Work Schedule Choice. 95

Chapter 6

6.1 Time-of-Day Parameter Estimates. 121
6.2 Travel Time Function Parameter Estimates. OLS Estimation. 122
6.3 White's Test of Homoscedasticity. 123
6.4 Travel Time Function Parameter Estimates. WLS Estimation. 131
6.5 Travel Time Savings for a 10-Mile Commute. 138

Chapter 7

7.1 Survey Completion Rates. 146
7.2 Survey Sample Demographic Characteristics. 148
7.3 Occupational Characteristics of Survey Sample Subjects. 150

7.4 Work Schedule Flexibility Questions. 153
7.5 Work Schedule Characteristics of Subject Sample. 154
7.6 Discretion to Shift the Work Schedule, by Shift Interval. Effect of Work Constraints. 156
7.7 Shift Discretion Gradient. Effect of Work Constraints. 156
7.8 Average Level of Discretion to Shift the Work Schedule. 159
7.9 Work Scheduling Flexibility Variables. 163
7.10 Work Scheduling Flexibility Factor Pattern, Varimax Rotation. 165
7.11 Discretion to Shift the Work Schedule, by Shift Interval. Effect of Non-Work Constraints. 173
7.12 Schedule Flexibility Gradient. Effect of Non-Work Constraints. 173
7.13 Average Discretion to Shift Work Schedules Early, by Work and Non-Work Factors. 175
7.14 Average Discretion to Shift Work Schedules Late, by Work and Non-Work Factors. 175
7.15 Scheduling Discretion Gradient, by Work and Non-Work Factors. Early Shifts. 177
7.16 Scheduling Discretion Gradient, by Work and Non-Work Factors. Late Shifts. 177
7.17 Work Scheduling Motivations of Flexible Work Schedule Commuters. 182
7.18 Cross-Tabulation of Morning and Evening Non-Work Scheduling Motivations. 184
7.19 Level of Discretion/Willingness to Reschedule or Cancel Non-Work Activities, Flexible Work Schedule Commuters. 186

Chapter 8

8.1 Schedule Delay and Time-of-Day Deviations of Non-Flexible Workers. 197
8.2 Travel Time Savings by Work Schedule Flexibility. 200
8.3 Effect of Work Scheduling Flexibility on Travel Time Savings. 202
8.4 Effect of Work Scheduling Flexibility on Time-of-Day Deviations. 203
8.5 Travel Time Savings of Flexible Work Schedule Commuters (Morning Commute), by Work Trip Scheduling Motivation. 207
8.6 Travel Time Savings of Flexible Work Schedule Commuters (Evening Commute), by Work Trip Scheduling Motivation. 208
8.7 Daily Travel Time Savings. 209
8.8 Average Length of the Work Day, by Work Scheduling Motivation. 211
8.9 Crosstabulation of Work Scheduling Motivations and Non-Work Flexibility 215

8.10 Work and Non-Work Scheduling Flexibility Effects on Travel Time Savings. 217
8.11 Work and Non-Work Flexibility Effects on Time-of-Day Deviations. 219
8.12 Travel Time Savings by Non-Work Activity Scheduling Discretion or Willingness. 221
8.13 Non-Work Activities of Non-Flexible Workers. 223

FIGURES

Page No.

Chapter 3

3.1 Factors Involved in Work Trip Timing Decisions. 30
3.2 Activity Scheduling Flexibility and Work Trip Timing Choice. 39
3.3 Location of the Survey Site. 47

Chapter 4

4.1 Box-Whiskers Plot of Arrival Time Variability, by Work Scheduling Flexibility 65

Chapter 5

5.1 Usual and Official Work Arrival Times. 79
5.2 Usual and Official Work Departure Times. 80
5.3 Attendant and Capacity Parking Limits for the Sample Subjects. 92

Chapter 6

6.1 Corridor Travel Time Model. 113
6.2 Pure Time-of-Day Effect on Travel Times. Highway 24, AM Commute. 115
6.3 Pure Time-of-Day Effect on Travel Times. Highway 24, PM Commute. 116
6.4 Pure Time-of-Day Effect on Travel Times. Interstate 80, AM Commute. 117
6.5 Pure Time-of-Day Effect on Travel Times. Interstate 80, PM Commute. 118
6.6 Pure Time-of-Day Effect on Travel Times. Surface Streets, AM Commute. 119
6.7 Pure Time-of-Day Effect on Travel Times. Surface Streets, AM Commute. 120
6.8 OLS Residuals by Time of Day, Morning Commute. 124
6.9 OLS Residuals by Time of Day, Evening Commute. 125
6.10 OLS Residuals by Distance Traveled, Highway 24. 126
6.11 OLS Residuals by Distance Traveled, Interstate 80. 127
6.12 OLS Residuals by Distance Traveled, Surface Streets (I-80). 128
6.13 Travel Time Confidence Bands. Highway 24, AM Commute. 133
6.14 Travel Time Savings Metric. 136

Chapter 7

7.1 Medium Term vs. Short Term Scheduling Flexibility. 167
7.2 Medium Term Scheduling Flexibility vs. Loss of Discretion. 168
7.3 Work Schedule Flexibility Clusters. 170

Chapter 8

8.1 Travel Time Savings by Time-of-Day Deviations. Morning. 194
8.2 Travel Time Savings by Time-of-Day Deviations. Evening. 195
8.3 Time-of-Day Deviations by Work Flexibility Cluster. Morning. 198
8.4 Time-of-Day Deviations by Work Flexibility Cluster. Evening. 199
8.5 Travel Time Savings by Strategic Work Scheduling Flexibility. 205

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1.
INTRODUCTION

1.1 RESEARCH QUESTIONS

The purpose of this dissertation is to study the scheduling of urban work trips. The main hypothesis of the study is that the availability of flexible schedules at work gives employees a greater opportunity to consider personal preferences and household constraints in planning their work and non-work activity schedules. Thus the timing of the work trip is likely to be the result of interactions between work, non-work activities, and transportation options. In particular, the following two questions are addressed:

- How do non-work activity scheduling preferences and constraints affect the choice of work schedule?
- How do commuters make tradeoffs, in choosing their work schedule, between travel time, and work and non-work activity scheduling preferences and constraints?

An empirical approach is used to explore these questions. Available data on urban travel demand proved insufficient to comprehensively identify and characterize commuters' work and non-work activity scheduling preferences and constraints. Hence a travel behavior survey was designed and conducted, to obtain data that would allow the

examination of the role of these preferences and constraints on work trip timing. Together with a study of travel times for trips starting and ending at the survey site, these data constitute the backbone of the present study.

1.2 MOTIVATION

The alleviation of traffic congestion is a primary objective of transportation planners and engineers. Congestion occurs primarily because the demand for work and school trips is concentrated in a few hours of the day. This is largely blamed on the rigidities associated with the scheduling of these trips. Consequently, strategies aimed at shifting trips from peak hours to non-peak hours often feature alternative work scheduling practices: flexible work schedules, compressed work weeks, staggered work hours, and telecommuting, among others. Other policies are intended to create incentives for rescheduling trips. Time-of-day varying tolls or CBD access restrictions have been used to increase the relative attractiveness of non peak-hour travel.

In spite of several decades dedicated to the promotion and implementation of these policies, little is actually known about the motivations that drive the temporal demand for urban travel. In effect, the focus on work trips and work scheduling rigidities has obscured the fact that many commuters can choose the times at which they start and end their work day. Estimates vary from 29% to 35% of full time workers in urban areas such as the Los Angeles Metropolitan Area and the San Francisco Bay Area (Commuter

Transportation Services 1994, York 1995), to 15% of the wage and salary worker population of the United States (Bureau of Labor Statistics 1991)[1]. Our knowledge of how these people consider the scheduling of non-work activities or the characteristics of transportation supply when they plan their work trips remains incomplete.

Better understanding of the time-of-day choice for work travel is hardly just an academic issue. Consider for example the case of congestion pricing. It is claimed that congestion pricing would result in a less equitable distribution of the travel burden than the current, unpriced, condition (Newell 1987). Low-income workers would be less likely to have options to reschedule their work than high-income workers, since they are typically employed in jobs that offer little scheduling discretion. Yet little is known about why some people commute during peak hours while others avoid doing so. These differences could be due to constraints and preferences related to the scheduling of non-work activities, and not due to income or work rigidities, as is more conventionally assumed. In fact, a review of the literature on the synergies between work and family life indicates that non-work activities play an active role in the scheduling of work hours (see Chapter 2).

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[1] Estimates of the population of workers who have flexible working hours exhibit a wide range due not only to the higher availability of flexible schedule occupations in urban regions over rural areas, but also due to differences in the definition of flexible schedule used in the various surveys.

1.3 THE STATE OF PRACTICE

An additional motivation to study work trip scheduling decisions is to further the development of urban travel demand forecasting models. The decision as to when to travel to work has been treated perfunctorily in the models used by regional planning agencies: typically, the proportion of trips in the peak hour (the peaking factor) is estimated from travel surveys and assumed to remain stable over time for travel forecasting purposes, for example to split projected trip tables into peak and off-peak trips (Johnston and Rodier 1993). This is problematic because this type of modeling does not support the analysis of policy options such as congestion pricing, flexitime, or even changes in highway capacity.

Models of the work trip timing decision are primarily based on work related factors, such as occupation or industry, and on work trip characteristics such as peak to off-peak travel times, travel distance, and travel route (see for example Purvis 1997, Levinson and Kumar 1993). Work trip timing is represented as a binary choice: to travel during the peak period or to travel during off peak hours.

Demographic or activity-related variables are largely absent from these models. Harvey and Deakin (1996) use age, sex, and household size to model the likelihood of starting work on each hour between 6:00 A.M. and 10:00 A.M., in addition to occupation and travel time variables. To date, this is the only model that recognizes that the work trip

timing decision may be represented as a two-step process: first a decision on the timing of the work schedule, and given that, a choice of time to travel. This model could be improved by explicitly incorporating the effect of non-work activity scheduling motivations, instead of implicitly accounting for them through the use of demographic variables.

Typically the work-related factors used in these models are workers' occupation and industry of employment. Both of these variables have been found to explain differences in work trip timing. These differences may result from the availability of flexible work schedules, which varies by type of occupation and industry (Bureau of Labor Statistics 1992). But they may also reflect the fact that work start times across industries are not uniform; for example construction workers tend to arrive at work earlier than retail sales workers. Hence models that use occupation and industry to characterize commuters' employment do not allow us to distinguish between the worker who must start work during peak commute times, and the worker who chooses to start work at those times. Yet distinguishing between these two cases is important, since these workers' responses to congestion alleviation policies are likely to be quite different.

1.4 STUDY ORGANIZATION

The dissertation starts with a review of the standard theory and supporting empirical evidence on work trip timing (Chapter 2). This theory encompasses the behavior of some

workers with non-flexible schedules only. While no comprehensive theory has been advanced to describe the behavior of flexible schedule workers, elements of a plausible framework can be found in the literature of work and family interactions.

Chapter 3 contains a description of the conceptual framework used to conduct the study. Conceptually, the study is largely based on human activity analysis. This allowed us to explicitly incorporates non-work activity scheduling motivations as factors in the work schedule and work trip timing decisions. The study also expands on the conventional theory by considering a richer set of work scheduling rules.

In Chapter 4 we examine available urban travel demand data for clues about the validity of the conventional wisdom on the synergies between flexible work schedules and time-of-day travel choices. The study is organized around hypotheses that describe the travel behavior of workers expected to exhibit different work and non-work scheduling flexibility.

In order to overcome the limitations imposed by existing data, we conducted a survey of trip timing choices and activity scheduling flexibility. As a first step, we conducted an exploratory study of the nature of work and non-work scheduling flexibility. Personal interviews with workers on various occupations, and of different lifecycle stages, allowed us to explore in-depth the determinants of activity scheduling flexibility, and its effect on work schedule and work trip decisions. This exploratory study is described in

Chapter 5.

A study complementary to the activity scheduling survey, namely a characterization of travel times by time of day in the area where the survey was conducted, is discussed in Chapter 6. This chapter includes a description of the travel time metric which will be used later to examine trip timing choices as a function of scheduling flexibility, as well as the estimation of these travel time functions.

The survey design and sampling methods are documented in Chapter 7. The analysis of the survey data is organized in two chapters. In Chapter 7, we provide a detailed description of the subject sample, including a comparison of its demographic and occupational characteristics with those of the sample population. This chapter also includes our characterization of work and non-work scheduling flexibility. This characterization provides the foundation for Chapter 8. Here, we analyze differences in commuters' choice of time-of-day for work travel due to work and non-work scheduling flexibility. Finally, conclusions and recommendations are discussed in Chapter 9.

2.
LITERATURE REVIEW

We review the literature on work trip scheduling with the purpose of establishing the starting point for this work. The standard theory and associated empirical evidence on work trip timing are described, paying particular attention to their limitations. This theory assumes that commuters have little or no decision to choose their work schedules, in effect ignoring the social and institutional context in which work and work trip scheduling decisions are made. While the behavioral motivations for scheduling work trips are poorly understood, sufficient evidence about the impacts of family life on work schedules is available to warrant in-depth investigation of their role in work and work trip scheduling.

2.1 WORK TRIP SCHEDULING

The scheduling of work trips has been studied primarily within the context of recurring traffic congestion, which creates tradeoffs between travel at convenient times and travel in uncongested conditions. The basic premise is that every traveler would like to be at work by some work start time S_W. But when demand exceeds capacity during commute periods, not everyone can arrive at their destination on time. In choosing a work arrival time S, commuters incur two different costs in their home to work trip: a travel time cost, and a scheduling delay cost (Vickrey, 1969):

$$C(S) = \alpha * t(S) + \begin{cases} \beta_E * (S_W - S) & if \ S \le S_W \\ \beta_L * (S - S_W) & if \ S > S_W \end{cases} \quad (2.1)$$

Current wisdom postulates that each driver chooses a time of work arrival by minimizing his/her total work trip scheduling cost (Equation 2.1), explicitly trading off the cost of being early or late with the cost of traveling during the peak.

This result has been used to explain the formation of congestion at transportation facilities. Given the decision function described by Equation 2.1, the evolution of arrivals at the facility is obtained by postulating a user equilibrium solution, where each driver minimizes his/her travel cost subject to a fixed arrival curve. At the user equilibrium, some commuters will arrive well before or well after their work start time, incurring a high schedule delay cost, while others will arrive at or near their work start time, incurring a high travel time cost. Since S_W, α, β_E and β_L are assumed to be the same for everyone, commuters are indifferent between incurring schedule delay and spending additional time traveling.

This solution describes well changes in peak spreading and peak shifting due, for example, to changes in road capacity or in work start times. But because the theory does not differentiate between commuters with a high schedule delay unit cost and commuters with a high travel time unit cost, it cannot explain how the different commuters respond to traffic congestion.

Vickrey's basic postulate has been extended to allow for differences in work start times and in schedule delay costs. If the cummulative distribution of desired arrivel times is strictly increasing and differentiable, commuters arrive in the order of their S_{W_i} (Smith 1984, Daganzo 1985). But if in addition, travelers differ in the relative cost of schedule delay to travel time, then the order of arrival changes (Newell 1987): commuters with the highest cost of schedule delay will always arrive at their desired arrival time, incurring no schedule delay; commuters whose desired arrival time occurs near the tails of the peak period (but still within it) will choose to arrive at their desired arrival time too. And there will be a group of commuters with low cost of schedule delay relative to travel time, who will find it advantageous to arrive earlier than their desired arrival time. Arnott et al. (1988) also examine various cases of commuter heterogeneity, arriving at qualitatively similar conclusions.

If commuters indeed arrive at work in order of their desired arrival times, then only policies that directly affect these times can be used as demand management tools to effect changes in congestion patterns. But by recognizing commuter heterogeneity in schedule delay costs, Newell has shown that congestion alleviation policies need influence only the fraction of travelers most willing to shift, that is, those with the lowest schedule delay cost relative to their travel time cost. Where congestion is severe, there should be interest in identifying these travelers and understanding their work trip timing preferences.

Besides commuter homogeneity, other assumptions in Vickrey's model have been

relaxed, with the purpose of making it more realistic:

- The transportation facility is represented as a highway of finite length, instead of a point bottleneck as originally proposed by Vickrey (Henderson 1977, Mahmassani and Herman 1984, Newell 1988): qualitatively, the trip timing behavior derived from these models is similar to that of point bottleneck models.

- Travel times are assumed to be stochastic (Hendrickson et al. 1981, Noland and Small 1995); route capacity is also represented as a stochastic variable (Arnott et al. 1988): this recognizes that commuters are likely to hedge against the possibility of late arrivals by arriving earlier than they would if travel conditions were deterministic.

- The home departure time decision is modeled as a stochastic choice, as opposed to the deterministic one typically assumed (De Palma 1983): this approach recognizes that unobserved factors may influence trip timing decisions.

- The home departure time decision is treated as a two-step process: first whether to change the departure time, and conditional on this, what new departure time to choose (Chang and Mahmassani, 1988 and 1989).

- Day to day variability in departure time decisions is incorporated by modeling

the rate at which individuals change their departure time over a period of several days (Ben Akiva et al. 1984): this may be used to examine how commuters adjust their schedules when travel conditions change, but it does not explain the motivations behind regular day-to-day variability.

However the basic premise, namely the travel time / schedule delay (TT/SD) tradeoff, and hence the main behavioral predictions described above, have remained the same.

Some scheduling effects in work trip timing have been examined empirically, using stochastic multinomial discrete choice models to represent the choice of time-of-day for work travel. The basic formulation for the utility function is:

$$U(S|S_W) = \alpha * t(S) + \beta_E * (S_W - S) * \delta + \beta_L * (S - S_W) * (1 - \delta) \qquad (2.2)$$

that is, the utility of choosing a work arrival time S is a function of the travel time associated with arriving at that time, $t(S)$, and the schedule delay incurred by arriving at S, S-S_W; α, β_E, and β_L are parameters to be estimated, and δ is a dummy variable that indicates if, given the choice interval, arrival would occur later than S_W. Though S is a continuous variable, it has been discretized through the use of time choices as the arrival time intervals, each usually no longer than 5 or 10 minutes. Travel times and schedule delay are assumed constant within each interval.

Other terms included in the utility function are quadratic schedule delay terms that model non-linear increasing disutility when delays are large, and the use of dummy variables to estimate differences in schedule delay costs among commuters, or to signal preferences for an arrival time interval. An estimated probability of arriving late at work has also been used to represent the inconvenience of late arrivals (McFadden et al. 1978).

One major difficulty in estimating trip timing choice models is to obtain reliable data on travel times for each work arrival time interval. Three of the six studies listed in Table 2.1 calculated travel times using a network-based program, and supplemented these estimates with floating car observations during peak periods (McFadden et al. 1978, Small 1981, and Abkowitz 1981). Hendrickson and Plank (1984) relied on floating car data to estimate travel time as a function of time-of-day, while Wilson (1989) used data from a commuter survey conducted in Singapore to estimate average speed as function of time-of-day, distance, and the spatial location of the trip destination.

McFadden et al. (1978) report that in their sample, peak travel time was within 5 minutes of off-peak travel time for most routes, so it is not surprising that they were not able to estimate the TT/SD tradeoff. Similarly, the commute routes chosen by Hendrickson and Plank do not experience significant congestion (see Hendrickson et al. 1981), hence their travel time coefficient estimate is also not significant. Wilson (1989) and Chin (1990), who use data from Singapore, where congestion is quite severe, obtain significant coefficients both for travel time and schedule delay.

Late schedule delay was found to be more onerous than early schedule delay, as predicted. And the cost of late schedule delay is non-linear: Small (1981) found threshold effects, which depend on having some allowance to arrive late at work, while Hendrickson and Plank (1984) found that the marginal cost of late schedule delay increases linearly with delay.

Table 2.1 includes the effects of several behavioral and demographic variables on the TT/SD tradeoff, or on work trip timing choice. The influence of formal and informal work scheduling rules may be reflected by the results obtained for white-collar workers: they appear to value late schedule delay less, or to be less likely to arrive early, relative to other workers (see in Table 2.1 the models estimated by Small (No.5) and Abkowitz). The availability of a flexible work schedule increases the likelihood of arriving at work right on time or late (Abkowitz 1981). Chin (1990) estimated schedule delay coefficients by type of occupation, but found no significant differences among the different occupational groups (this result is not reported in Table 2.1).

Small's (1981) estimates indicate that carpoolers value early schedule delay less than drive-alone commuters: the former exhibit a marginal rate of substitution (MRS) of 0.9 minutes of early schedule delay for each minute of travel time, while the latter exhibit a MRS of 1.9 minutes of early schedule delay for each minute of travel time. Presumably the convenience and cost savings due to carpooling, in addition to the need to make sure all carpoolers arrive on time, outweight the inconvenience of arriving too early at work.

Demographic variables have been used to explore whether, due to a high flexibility to schedule non-work activities, certain groups of workers are more likely to avoid congested hours, i.e., value schedule delay less than travel time relative to other workers. Workers who live in one-person households have been found to exhibit a lower MRS of early schedule delay for travel time than all other workers (Small 1981). Men have also been found to value schedule delay (early or late) less than travel time, relative to women (Wilson 1989). These two results have been justified under the hypothesis that men and single workers have fewer household responsibilities than women or workers with children, and hence they have more flexibility to avoid peak commute hours. Yet Wilson (1989) also finds that workers who have young children exhibit a lower value of schedule delay relative to travel time than workers who have older or no children, which contradicts the previous hypothesis. It has also been hypothesized that older workers would be more willing than young workers to avoid the stress associated with driving during peak commute times; the coefficients estimated by Abkowitz (1981) and Wilson (1989) suggest that this may be the case.

All of the models reported in Table 2.1 were estimated using a logit formulation. Given that the arrival time intervals fall into a sequential ordering, the choices may be correlated, that is, the model may violate the property of independence from irrelevant alternatives (IIA). Small (1981) performs two different tests for departures from the IIA assumption, and concludes that this kind of correlation is not present in his models. The other studies reviewed here do not address this issue.

Again, the main thrust of this body of work has been two-fold: to explain the occurrance of traffic congestion, and to understand how users respond to congestion when scheduling work trips. The assumption that work schedules are fixed and exogenous, and that consequently users operate according to the travel time / schedule delay tradeoff, has proven so far both fruitful and convenient. But this assumption renders the conventional theory largely irrelevant as far as explaining the behavior of about a third of all workers in an urban area. The reason is quite simple: for someone with a flexible work schedule, the work start time itself is a decision variable. Basically, there is no fixed work start time against which to measure the disutility of scheduling work trips at different times of day.

The standard theory portrays work scheduling as a very simple tradeoff. But a closer examination of the context in which travel decisions are made suggests that the behavioral motivations behind work trip scheduling decisions are far richer that what has been assumed so far. It should be obvious that people with flexible schedules are likely to take account of family and personal activities when scheduling their work hours. In fact, activities such as child care may even place more restrictions on the timing of the work trip than work itself. The empirical findings discussed above indeed suggest that non-work factors play a role in work trip timing decisions. Additional evidence is available from studies that examine the influence of family and personal life on work scheduling, as described next.

TABLE 2.1
Empirical Estimation of Activity Scheduling Effects on Work Trip Timing Choices

Variables [f]	Estimated Coefficients (absolute value of t statistics in parenthesis)							
	McFadden [a] (1977)	McFadden [b] (1977)	Small [c] (1981)	Small [d] (1981)	Abkowitz (1981)	H & P [e] (1984)	Wilson (1989)	Chin (1990)
Travel Time	-0.127 (1.7)	0.005 (0.1)	-0.147 (2.4)	-0.056 (0.8)	-0.041 (1.3)	-0.008 (0.3) [g]	-0.016 (4.2)	-0.062 (5.6)
Disutility from Arriving Early:								
Early Schedule Delay	-0.078 (8.4)	-0.055 (6.2)	-0.076 (10.8)	-0.067 (8.4)			-0.026 (5.5)	-0.255 (8.8) [k]
Early Schedule Delay Squared						-0.0004 (5.3)		
Early Arrival Loss [f]					-3.17 (1.4)			
Disutility from Arriving Late:								
Probability of Arriving Late	-2.720 (8.1)	-2.610 (6.7)						
Late Schedule Delay			-0.156 (5.4)	-0.443 (2.4)		-0.148 (6.4)	-0.035 (6.4)	-0.255 (8.8) [k]
Late Schedule Delay Squared						0.0014 (2.3)		
Tardiness Penalty [h]			-1.14 (0.2)	-1.29 (6.8)				
Tardiness Penalty (per min.) [i]			-0.206 (2.6)	-0.171 (2.1)				
Late Arrival Loss [f]					-25.73 (1.1)			
Behavioral/Demographic Effects:								
Carpooling								
Interacted with Travel Time			0.096 (1.2)	0.052 (0.6)				
Interacted with Early S.D			0.022 (2.4)	0.022 (2.4)				

[a] Drive alone modes only.
[b] Shared-ride modes only.
[c] Model No.4.
[d] Model No.5.
[e] Hendrickson and Plank.
[f] Arrival loss includes schedule delay and arrival time uncertainty due to travel time variance.
[g] Includes congested time only.
[h] Penalty for arriving later than the permitted tardiness.
[i] Additional penalty per minute of late delay when arriving later than the permitted tardiness.
[j] All travel time and schedule delay variables expressed in minutes.
[k] Early and Late Schedule Delay coefficients constrained to be equal.

TABLE 2.1 (cont).
Empirical Estimation of Activity Scheduling Effects on Work Trip Timing Choice

Variables	Estimated Coefficients (absolute value of t statistics in parenthesis)							
	McFadden [a] (1977)	McFadden [b] (1977)	Small [c] (1981)	Small [d] (1981)	Abkowitz (1981)	H & P [e] (1984)	Wilson (1989)	Chin (1990)
White-Collar Occupation								
Interacted with Late S.D				0.270 (1.5)				
Interacted with Tradiness Pen.				0.620 (3.3)				
Very Early Arrival Choices [f]					-0.49 (-1.8)			
Early Arrival Choice [f]					-0.58 (-2.3)			
Work Arrival Flexibility (1 if worker has a flex. schedule)								
On-Time Arrival Choice [f]					1.08 (4.8)			
Late Arrival Choices [f]					3.16 (4.2)			
Household Size (1 if One)								
Interacted with Travel Time				-0.201 (1.7)				
Interacted with Early S.D.				-0.013 (1.1)				
Sex (1 if Male)								
Interacted with Sched. Delay							0.006 (2.1)	
No. of Children younger than 5								
Interacted with Sched. Delay							0.006 (4.0)	
Age								
Interacted with S. D. (in years)							1.7E-4 (1.5)	
Very Early Arrival Choice [f,m]					1.10 (3.6)			
Income (1 if $5,000 or less)								
On-Time Arrival Choice [f]					2.04 (2.0)			

[f] Variable interacted with the constant for this choice(s)

[m] Age expressed as a dummy variable, 1 if older than 50 yrs. old.

2.2 NON-WORK ACTIVITIES AND WORK SCHEDULES

Though ignored by the conventional work trip timing theory, ample evidence exists to indicate that workers take account of personal and family activities when scheduling their work and work trips. This evidence is presented in two sections: first a general assessment of the synergies between work and non-work activities, and second a specific look at the findings of flexitime studies.

2.2.1 Impact of Personal and Family Activities on Work Schedules

Most research on work trip scheduling implicitly assumes that the scheduling of work takes precedence over the scheduling of non-work activities. This presumes that non-work activities can be successfully scheduled around work hours. Instead, it appears that many workers have difficulty reconciling work and family obligations. These workers are more likely to be female than male, which is not surprising considering that women still bear the largest share of family responsibilities (McRae 1989 and Hochschild 1997). But men are not free from such problems: the same studies found that one third to one half of male workers also report work/family conflicts. It would not be surprising if these workers took advantage of any available work scheduling flexibility to resolve their work/family conflicts.

The presence of young children in the household often creates or exacerbates scheduling

conflicts between work and home activities. This is because the limited availability of child care services dictates the days and times at which women (primarily) are able to engage in salaried out-of-home work (OECD 1995). Some women have been found to take advantage of flexible working hours primarily because it facilitates getting children to school or nurseries (McRae, 1989). It has also been found that when both parents work, a common strategy when formal child care is not available is for the husband and wife to work different shifts (Staines and Pleck 1983). In all these cases, the choice of work schedule, and consequently the choice of work trip timing, is largely dictated by a non-work activity, namely child care.

Increasing work schedule control, which is associated with the availability of flexible working hours, has been found to result in decreasing work/family conflicts (Staines and Pleck, 1983). But even when workers have control over their work schedules, work/family conflicts are still frequent when the work schedule is non-standard or falls outside normal work hours. Because of the predominance of the normal work schedule, non-work activities are likely to have schedules that accommodate it better than other, less common work schedules.

Workers who experience a high degree of work/family conflicts are unlikely to have much choice to schedule their work hours, either because they have rigid work schedules, or because non-work institutions such as child care effectively determine the times (and sometimes days) at which they can be at work. Not only are these workers likely to end

up traveling during peak hours, the longer travel times and higher travel time variability encountered during the peak periods compound the scheduling conflicts as well. Yet this body of literature has not addressed the travel decisions of these workers, nor whether and how these decisions change when flexible working hours are available.

2.2.2 Work Scheduling Motivations of Workers on Flexitime

Flexitime is a work scheduling policy that allows workers some freedom to self-schedule their work hours. Though variations exist, the basic policy defines a core work period and two flexitime bands:

- During the core period, all workers must be at the work place; but,
- Within the flexitime bands, workers are free to choose the times at which they would like to start and end their work day, provided they work the minimum required number of hours.

There was considerable interest in the 1970s and 1980s in promoting flexitime as a traffic congestion alleviation tool. A few demonstration projects were carried out, which looked specifically at the work trip timing choices people made after being offered a flexitime schedule (see for example Ott et al. 1980; Jones et al. 1983). Since flexitime is only one of many ways in which a worker may have a flexible schedule, the findings from these studies have limited application to understand the decisions of the general population.

Yet they are reviewed here because the studies provide key insights about the kinds of motivations that influence work schedule choices.

Aversion to traffic and transit congestion certainly motivates individuals on flexitime to choose work schedules that let them travel during off or non peak hours. The proportion of workers ranking congestion aversion as their primary consideration for scheduling work hours varied, according to flexitime studies, from about one-fifth to one-third of workers on flexitime (Ott et al. 1980, Jones et al. 1983, Jovanis 1979). And the proportion of workers who report reductions in their post-flexitime travel time are usually much higher, on the order of two-thirds of workers surveyed (in addition to the above references, see also Port Authority of New York and New Jersey 1975, and McGuire 1986).

All of these studies report that workers also list the need or desire to participate in non-work activities as an important motivation for scheduling work hours. Among the motivations cited are:

- Carpool arrangements
- Childcare and school schedules
- Preferences over sleeping hours
- Preferences for home evening arrival time
- Desire to spend time with family or friends
- Participation in out-of-home activities

In fact, it has been found that workers on flexitime participate more often in several non-work activities, including outdoor recreational activities, and in-home activities such as working around the house, resting, reading, and spending time with the family (Stevens and Elsworth 1979). Flexible working hours, or the perception of control over the work schedule, has been associated in several surveys with increased levels of satisfaction over leisure and recreational time (Pierce et al. 1989).

Another example of the effects of non-work activitiees on work schedules was observed druing the Hawaii Staggered Hours Demonstration Project (Giuliano and Golob, 1990). All public workers in the downtown area were required to participate, unless they could claim undue hardship. It was found that 50% of all public workers did not participate, primarily due to conflicts with child-related activities, before and after work obligations, carpooling, and transit schedules. Moreover, among private sector workers, for whom participation was not compulsory, less than 20% changed their work schedule, citing similar reasons as the public sector employees.

Workers' preferences for early or late work arrivals (measured as deviations from the average arrival time) have been found to vary with their socio-economic characteristics, for example income and household structure (Ott et al. 1980, Jovanis 1979, Moore et al. 1984). Moreover, Abkowitz (1981) found that socioeconomic factors were better predictors of work trip timing choice than either travel time or schedule delay. One

possible reason for this is that the socioecomic factors are correlated with characteristics of the non-work activity schedule that influence work trip timing. It would be desirable to represent these effects more directly, so as to avoid unnecessary generalizations.

Ott et al. (1980), Jovanis (1979), and Moore et al. (1984) model the work arrival time decision, given flexible work hours, as a linear function of workers' characteristics, including age, sex, presence of children, travel mode, occupation, and income, among others. Differences in work schedule choice are thus obtained with respect to the estimating sample's average arrival time. While useful to show differences between workers due to their socioeconomic characteristics, these models overlook the role of travel time differentials. For example, it is implicitly assumed that workers who arrive close to the average arrival time are likely to be the ones who experience the most congestion, but that need not be the case. Moreover, in some cases people switching late may have been switching into the peak hour rather than away from it (Jones 1983).

A second shortcoming of these models is that they consider only the work start decision, isolating it from the work end choice, and in effect ignoring the latter. Conceptually, the most serious consequence is that this ignores that the need to leave work (or arrive at home) in the evening at a given time is oftentimes the driving motivation for the choice of work arrival time. Another concern is that commuters may or may not experience congestion during both the morning and the evening work trips, depending on the peaking characteristics of their travel route and the length of their work day. The travel time

savings that flexible work hours are expected to afford may actually be obtained in the evening, not in the morning.

Schedule shifts may occur either to a time earlier than the one before flexitime was adopted, or to a time later. When taken together, flexitime findings do not support the notion that earlier schedules are typically preferred to later schedules, or viceversa. The average shift in the distribution of arrivals of any given sample is probably more a reflection of the socioeconomic composition of the sample, as well as their transportation options, than any inherent or universal preferences for earlier or later schedules.

2.3 OTHER STUDIES OF WORK TRIP TIMING CHOICE

Supernak (1992) proposed a utility maximizing approach that considers all daily activities, and not just work or congestion, as factors in the choice of work trip timing. He postulated that the utlility from participating in any given activity is a function of the time of day at which the activity is executed. In particular, the utility of starting work at a given time is the sum of the utility from all activities in which the worker chooses to participate, including travel, given that work start time. The optimal work start time would be the one that maximizes the total daily activity participation utility.

An empirical formulation of this idea was carried out by Wang (1996). The utility profile

of an activity is taken to be proportional to the time-of-day frequency distribution of aggregate participation in that activity, as obtained from a time use study. These profiles are then used to estimate Weibull-distributed functions of activity participation, where the parameters of each distribution are functions of sociodemographic and behavioral variables. To find the optimal work start time, Wang assumes that a person's activity set does not change with the work start time; that is, someone who starts work at 7:00 A.M. and engages in a given set of activities would perfom the same activities if her work were to start at 10:00 A.M. Hence, for each person's activity set (obtained from a time-use survey), he calculates from the activity participation functions the utility of this activity set at each work start time (varying the start time and duration of all other activities as necesary to achieve an optimum given the work start time). This utility is then compared to the disutility of traveling to work at that time of day, also estimated from time-use data. The optimal work start time is the one that maximizes the sum of activity and travel utilities.

Wang implicitly assumes separability of activities in the total utility function. Yet the time-use data he uses to estimate each activity participation function already incorporates time-of-day preferences and constraints from participating in other activities. For example, that most people can be found at home in the evenings is not independent of the fact that they are likely to be at work during the day. Even more troubling, the utility profile for the work activity already incorporates the disutility of traveling to work at a given time, since that must have been accounted for in the choice of work schedule or

work trip timing in the first place.

While Supernak's idea is certainly attractive, there appear to be serious difficulties in trying to assess the utility from participating in any given activity as a function of time of day, independent of other activities. This is even further complicated by the likelihood that such utility profiles are likely to vary across persons, and also by the fact that, in estimating an optimal schedule, one should consider that the set of chosen activities may change depending on the timing of the work schedule.

2.4 SUMMARY

The conventional approach to modeling the timing of work trips is limited in that it does not account for the decisions of workers with flexible schedules. Several studies have shown that workers are likely to incorporate non-work factors in their choice of work schedule, when given the opportunity to do so. And in turn, these non-work factors appear to result in systematic differences in work schedule choice. However, a comprehensive assessment of the choice mechanism has not been advanced.

3.
CONCEPTUAL BASIS AND STUDY METHODOLOGY

We study the demand for trip-making as derived from the need to participate in activities: work, recreation, household maintenance, etc. This is known in the literature as the human activity theory of travel demand (Fox 1995). According to this theory, travel decisions are affected not only by trip-related variables such as trip time and trip cost, but also by the characteristics of the activities to be pursued and of the person pursuing them. In Section 3.1 below we describe the social and institutional context in which work trip timing decisions are made, and discuss several characteristics of work and non-work activities which we hypothesize are key to understanding these decisions.

The second section of this chapter describes the methods employed to address our research questions, identified in Chapter 1. We made use of both existing and new data on travel behavior to examine hypotheses that describe the effect of selected traveler and activity characteristics on work trip timing behavior. The dissertation consists of three related studies, each corresponding to a different data set. This section explains the overall methodology as well as the relationship between the three studies.

3.1 CONCEPTUAL BASIS

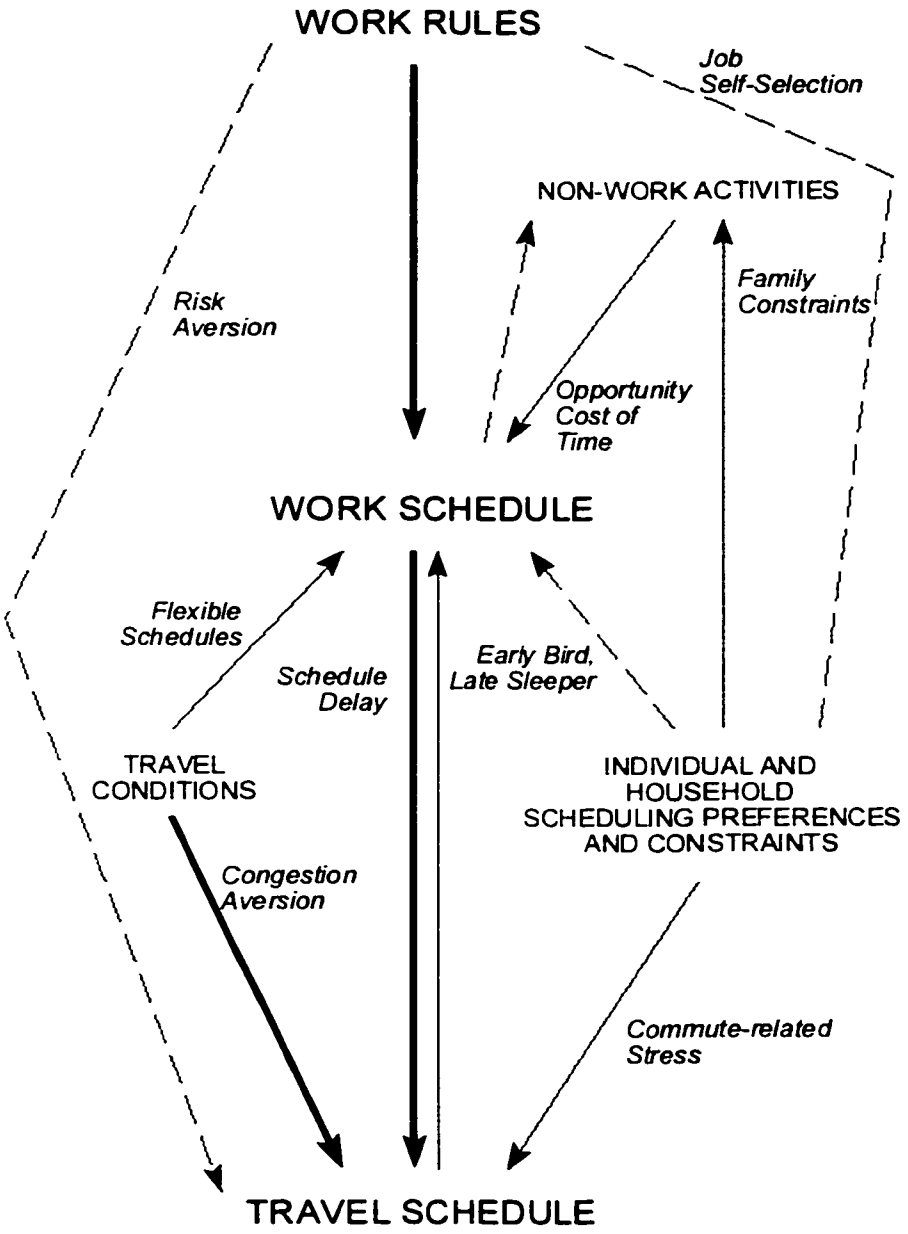
3.1.1 Human Activities

Two factors have traditionally been considered in the study of work trip timing, as shown in Figure 3.1: travel condition characteristics and work schedule characteristics. In particular, the characteristics studied so far have been those expected to affect the travel time / schedule delay tradeoff. These characteristics include peak and off-peak travel times, work start times, commuters' occupation, and different measures of tardiness discretion.

Non-work factors have also been considered in work trip timing studies, but only when these factors have been hypothesized to influence the travel time / schedule delay tradeoff, as was discussed in Chapter 2. In effect, non-work activities have been assumed to be subordinate to work activities. However, work trip timing decisions are likely to involve more complex interactions between work and non-work activities than has been assumed so far. The remainder of this section discusses these interactions as well as their expected effect on work scheduling and work trip timing.

We have already established that for many workers, the work schedule is itself a decision variable. Hence, in the study of work trip timing decisions, work start times should not be assumed constant; they are instead the outcome of an activity scheduling process

FIGURE 3.1
Factors Involved in Work Trip Timing Decisions



where both work and non-work activities are likely to be considered. In choosing a work schedule, workers may tradeoff against travel time not just the inconvenience of arriving early or late at work, but also the inconvenience of sub-optimal non-work activity scheduling. Hence a first step in the study of work trip timing decisions is the study of work scheduling choices. In doing so, we must consider characteristics of both work and non-work activities.

Job-related characteristics relevant to the work scheduling decision are not just those that signal willingness to incur schedule delay. In addition to a person's occupation and industry of employment, the ability to choose working hours is likely to be related to factors such as a person's job tasks, their company's work scheduling policies (for example, how much tardiness and how often it is tolerated, or whether flexitime schedules are allowed and encouraged), their rank within the organization, etc.

In turn the fact that jobs allow varying degrees of discretion to choose working hours means that workers have opportunities to consider their non-work activities when deciding their work schedules. They may use this discretion in a variety of ways, for example:

- to engage in non-work activities that are typically scheduled within normal work hours;
- to distribute household responsibilities according to each person's work scheduling discretion;

- to schedule working hours at the times at which they feel most productive;
- and of course, to avoid commuting during peak hours.

Three characteristics of non-work activities may be relevant for work scheduling decisions: whether the activity is discretionary or mandatory, the schedules available for performing the activity, and whether the scheduling of the non-work activity is at the discretion of the commuter. Another factor that affects work scheduling decisions are commuters' preferences for scheduling work, non-work activities and travel.

Mandatory fixed-schedule activities clearly constrain the times at which people can be at work. For example, having to drop off children at school in the morning usually defines the earliest time at which one can arrive at work. Activities of this type may force commuters to incur travel at peak hours, since they offer few, if any, scheduling options.

But there are also mandatory activities which are unlikely to affect working hours, because they can be successfully completed at almost any time of day. Consider for example grocery shopping: though a frequent and necessary activity, workers' shopping schedules are likely to be limited only by store business hours. Mandatory yet infrequent activities, such as medical visits, are also unlikely to be a principal determinant of the schedule of an activity as regular as working.

Contrary to common wisdom, discretionary activities too may constrain the work

schedule. This is because many discretionary activities have time-of-day dependent schedules, so that in fact there is little choice of schedules. In choosing to participate, a person commits herself to traveling at a given time-of-day, perhaps electing to commute during peak hours. The additional time spent traveling may be viewed as another cost incurred to access the activity. For example, to attend a class after work, one may need to leave work at a time such that peak hour travel is unavoidable.

Commuters' preferences for activity scheduling also play a role in the travel time / activity scheduling tradeoff. For example, some people feel more productive early in the day, so they prefer to take time off in the afternoon; other people like to exercise in the mornings, so they may end up working well into the evening. These preferences may also be related to the availability of opportunities to engage in non-work activities at different times-of-day, instead of being inherently personal. For example, people who enjoy the theater and concerts on a regular basis might prefer to end the work day earlier than people who prefer to watch television.

Due to the time-of-day dependence associated with the scheduling of some non-work activities, these activities are not necessarily subordinated to the scheduling of work. Moreover, some activities reflect long-term lifestyle commitments, and it is likely that in these cases people would accommodate their work schedules to facilitate their non-work activity engagement. Some of these activities are volunteering at a school or animal shelter, attending religious services, and exercising, for example. It is likely though that

the tradeoffs between travel time and activity scheduling implicit in the choice of discretionary non-work activities may be different from the tradeoffs incurred to fulfill mandatory non-work activities, hence it may be important to distinguish between these two types of activities.

Similarly, whether or not there is a choice of schedule may also result in travel time vs. activity scheduling tradeoffs of different magnitude, since the larger the choice set the more opportunities there are to avoid peak commutes while still finding a feasible schedule.

3.1.2 Activity Scheduling Flexibility

Collectively, the activity scheduling preferences and characteristics described so far define various types of non-work activity scheduling discretion. And of course, there are also varying levels of discretion associated with the scheduling of working hours. We will refer to the discretion to choose and schedule work and non-work activities as activity scheduling flexibility. Activity scheduling flexibility is a key factor to understanding work schedule and work trip timing decisions.

Activity scheduling flexibility is multidimensional, its dimensions stemming from the activity scheduling characteristics previously discussed:

(a) Discretion to choose the activities to perform:

As this study is limited to people who already work, the discretion to choose whether to work or not will not be considered here. Instead, this dimension is related to the level of "obligatoriness" of the non-work activity, as well as to personal preferences about non-work time uses. Lack of activity scheduling flexibility along this dimension implies a commitment to perform regularly one or more non-work activities, resulting either from lack of choice or from a strong willingness to perform them.

(b) Discretion to schedule work and non-work activities:

This discretion derives from the personal and institutional factors which jointly determine the availability of work and non-work activity schedules, as well as from commuters' discretion to choose activity schedules. It is also affected by the personal preferences people may have about activity scheduling. Lack of activity scheduling flexibility along this dimension implies a requirement to perform one or more activities at given times-of-day, again resulting either from lack of choice or from a strong preference for particular schedules.

That is, through an investigation of activity scheduling flexibility, one can identify the discretion associated with the choice of activities and their schedules, whether work or non-work, as well as how difficult, or how unwilling, people are to change these schedules.

As depicted in Figure 3.2, workers would consider their work scheduling flexibility, non-work scheduling flexibility, and travel conditions to choose a work schedule. Given the work schedule, the home departure time would be determined by subtracting the expected home to work travel time.

There remains the possibility that commuters with little work scheduling flexibility would consider incurring a work schedule delay to reduce their travel time. This is shown in Figure 3.2 as an alternative decision path, which takes the work schedule and travel conditions as given, and results in a choice of work trip timing. This dissertation does not study this choice behavior.

Activity scheduling flexibility may vary depending on the time frame considered for the study of work schedule and work trip timing decisions. This dissertation examines these decisions in the medium and short-term only. Medium-term flexibility allows workers to schedule their working hours to account for, among other factors, the schedules of non-work activities, schedule coordination with family members, travel time differences by time of day, and changes in the road network, transit schedules, or time-of-day travel tolls. Short-term flexibility allows commuters to vary their work arrival and departure times on a daily basis. This type of flexibility may decrease the penalties associated with late work arrivals, therefore encouraging workers to choose later home departure times.

But, since it appears that workers tend not to make use of this flexibility, [2] its effect on trip timing choice is not expected to be as important as the effect of medium-term flexibility.

Instead, in the long run (for example several years), work and non-work flexibility is affected by labor participation decisions and life-stage changes. For example, the discretion to choose whether to work or not would affect work scheduling flexibility. Workers would be able to increase their scheduling flexibility by choosing jobs that allow more scheduling discretion, or simply by accumulating seniority at their present job. Life-stage changes such as getting married or having children may drastically change workers' non-work scheduling flexibility. These types of long term changes and/or decisions are not addressed in this dissertation; therefore we do not examine changes in trip timing decisions over time.

3.1.3 Work Trip Timing Hypothesis

A primary goal of this dissertation is to understand the motivations underlying commuters' decision to travel in traffic congestion. In particular, we wish to explore the

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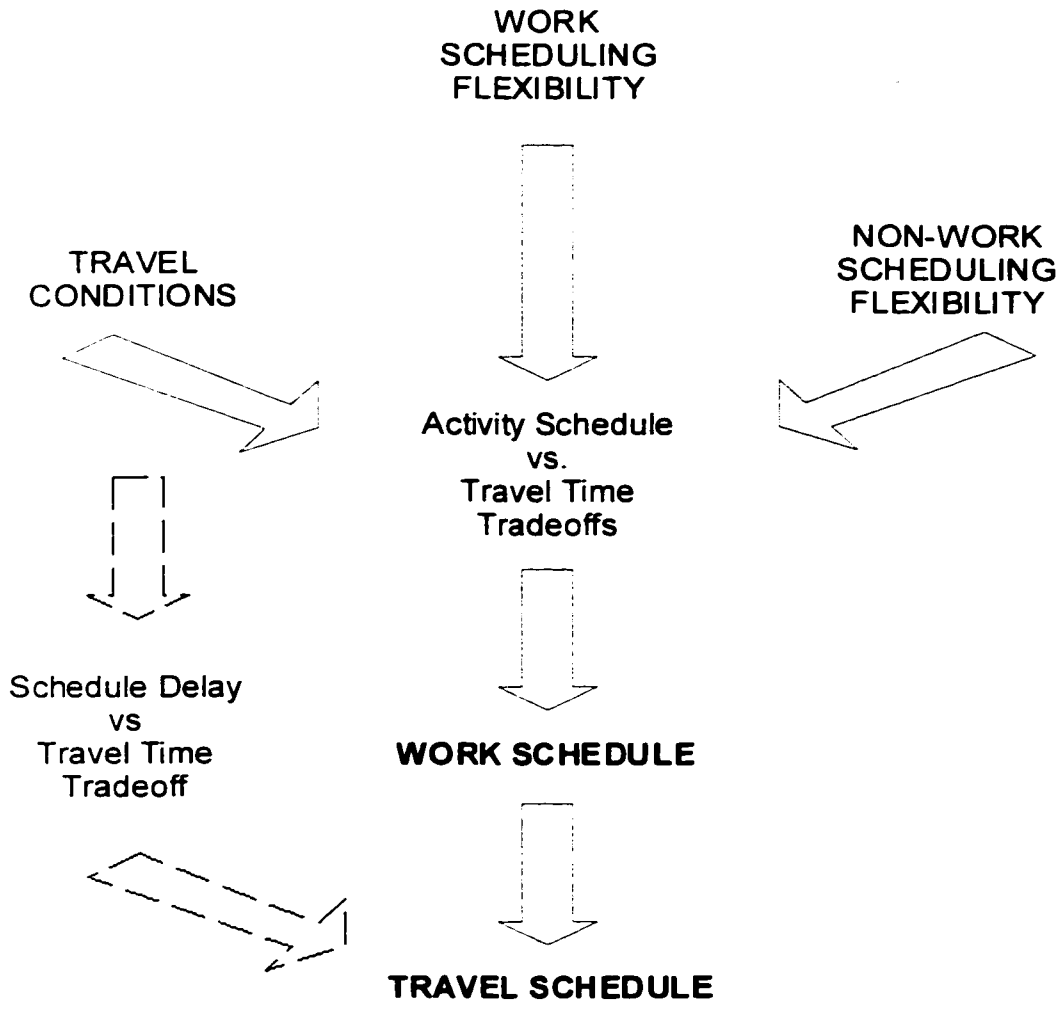
[2] For example, Mehndiratta (1996) found evidence that people with flexible work schedules (i.e. not required to be at work at any particular time in the morning, nor required to work a minimum number of hours per day),"take limited advantage of this flexibility in terms of varying their schedules on a day to day basis". Also, BATS data show that, of all workers who report a work trip on each of five weekdays, 35% arrived at work at the same time every day, and an additional 32% arrived at work at the same time at least three days out of five. Finally, it is common for workers on flexitime to be required to keep the same schedule for a minimum time period, usually a week or two.

conventional view that says that commuters with work scheduling flexibility are likely to travel during non-peak hours. In this context workers' activity scheduling flexibility is relevant because it provides a way to measure how constrained commuters' are in their activity scheduling, and consequently how much discretion they really have in choosing between alternative times of day for activity participation. And because the work and non-work sources of scheduling flexibility are well-identified, it allows us to examine the effect of each of these environments on the trip timing choice.

Increasing work and non-work scheduling flexibility give workers more opportunities to schedule their work trips. We assume moreover that commuters view travel time as undesirable: all things equal, they would rather have a short commute than a long one. These two premises lead into our research hypothesis:

> In the presence of recurrent congestion, workers with high activity scheduling flexibility are likely to exhibit shorter travel times than workers with little activity scheduling flexibility. Furthermore, we hypothesize that lack of non-work scheduling flexibility is as constraining as lack of work scheduling flexibility. As a consequence, workers who lack either work or non-work flexibility will exhibit longer travel times than workers who have both work and non-work flexibility.

FIGURE 3.2
Activity Scheduling Flexibility and Work Trip Trip Timing Choice



3.2 STUDY METHODOLOGY

The dissertation consists of two studies about the effects of work and non-work scheduling flexibility on work scheduling and work trip timing decisions. Both studies examine the research hypothesis, but they differ in two ways: the characterization of activity scheduling flexibility, and the measurement of traffic congestion. The next sections explain the methods used to measure activity scheduling flexibility, and then describe the two studies undertaken for this dissertation.

3.2.1 Measurement of Activity Scheduling Flexibility in the Demand for Work Trip Timing Choice.

There are two main approaches to incorporating activity scheduling flexibility effects into the study of work trip timing choice. One way, the most common in the literature, is to use likely indicators of activity scheduling flexibility as explanatory variables. Typical indicators include occupation, industry of employment, and workers' sex, age, marital status, number of children, and age of their youngest child. Here one must rely on assumptions about the likely relation between these characteristics and work scheduling flexibility. Since scheduling flexibility itself is never observed, these assumptions cannot be tested. In turn, the observed differences in trip timing behavior must be examined in light of possible confounding effects associated with workers' characteristics.

The second way is to directly measure work and non-work scheduling flexibility. This can be done using both factual and attitudinal indicators, for example:

- earliest and latest activity start and end times,
- work tardiness allowances,
- level of discretion available to choose non-work activities,
- willingness to participate in non-work activities, or
- level of discretion to schedule non-work activities.

Both of these approaches are used in this dissertation. In the first case, we use workers' occupation as an indicator of work scheduling flexibility, and workers' sex and the presence of young children as indicators of non-work flexibility. The rationale for these choices is described in Chapter 4, together with the findings about the effect of these characteristics on work trip timing choice.

To implement the second approach, we created various indicators of work and non-work scheduling flexibility, and used them to survey people's work schedules, non-work schedules, and work trip timing choices.

To measure work scheduling flexibility, questions were designed to elicit the following information:

- nominal work start and end times, if required by the employer,
- whether job allows to vary work start and end times,

- discretion to choose the current work schedule,
- discretion to shift the current schedule early or late, by shift interval,
- participation in any official alternative work schedule program,
- ability to substitute lunch time or work at home for regular working hours.

All this information resulted in four main indicators of work scheduling flexibility, as explained in Chapter 7.

To measure non-work scheduling flexibility, we examine whether there are any non-work activities, or time-of-day scheduling preferences, which affect commuters' choice of work schedule. Workers were asked to examine a diary of their daily activities, and to state which activities would be difficult to shift or cancel, using Likert scales to indicate the level of difficulty. Hence non-work scheduling flexibility is identified by the presence of an influential non-work activity, its purpose and its scheduling/cancellation index. The method used is explained in detail in Chapter 7.

3.2.2 Activity Scheduling Flexibility Effects in the 1990 Bay Area Travel Survey

In the first study, we examine work trip timing behavior using a multi-purpose, household-based travel survey (see Chapter 4). We chose the 1990 Bay Area Travel Survey (BATS), which was the most recent travel survey conducted in the San Francisco Bay Area. The sample drawn from BATS consisted of 600 full-time workers, of various occupations and household compositions. BATS allowed us to examine differences in

work trip timing choices among subgroups of the population presumed to have different levels of work and non-work scheduling flexibility. BATS also includes a panel study: a subset of households kept travel diaries for five working days, instead of only one. This allowed us to observe day-to-day work trip timing variability, and in turn to relate this variability to work and non-work scheduling flexibility indicators.

Peak and off-peak travel times were obtained from the regional urban travel forecasting model developed by the Metropolitan Transportation Commission. For each commute period, the network travel time is estimated as the sum of link travel times, for all links in the minimum travel time path between each trip's origin and destination zones.

3.2.3 Transportation and Activity Scheduling Flexibility Survey

We designed and conducted an activity scheduling and work trip timing survey. This allowed us to directly measure activity scheduling flexibility, and use it to examine work trip timing choices.

As a first step towards the design of this survey, we conducted a series of in-depth personal interviews with full-time workers. The interviews allowed us to examine people's understanding of their own work and non-work scheduling flexibility, their work and work trip scheduling practices, and their strategies for reconciling work and non-work schedules. The findings from these interviews are described in Chapter 5.

The interviews and survey were conducted at the Berkeley campus of the University of California. The selection of this site was driven by the following considerations:

(a) Availability of Flexible Work Schedules:

It was necessary that the selected site included many workers who enjoyed flexible work schedules, but also some who did not. Full-time employees at UCB are for the most part faculty or administrative staff. Among the former, high work scheduling flexibility is a characteristic of their jobs. And while the incidence of high work scheduling flexibility among the administrative staff was not known a priori, it was expected that many of these workers would enjoy some degree of flexibility. Some administrative staff are classified as "exempt" employees, meaning that they are not compensated per hour worked; they may or may not be tied to a schedule. "Non-exempt" employees must keep a record of the hours labored, are typically expected to arrive and leave on a schedule, and are typically not allowed to work overtime without prior approval. Both exempt and non-exempt employees may request to participate in the university's flexitime program. The guidelines of this program are published by the Staff Ombuds Office (Wesley, unknown year). It essentially gives workers the right to negotiate an alternative work schedule with their supervisor, but it also clearly states that the supervisor has the right to turn down the request.[3]

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[3] Exempt and Non-exempt status indicates whether a job is covered by the regulations of the Fair Labor Standards Act.

(b) Ease of Travel Time Measurement:

For each subject, we required the peaking characteristics of his/her usual commute route, both in the morning and in the evening. This information is rarely collected routinely by local or regional transportation authorities. Fortunately, travel time data for commute trips originating and terminating at the Berkeley campus are available from the university's Parking and Transportation Office.

(c) Peak/Off-Peak Travel Time Differentials:

In order to study the influence of congestion aversion vis a vis work and non-work activity scheduling preferences, it is necessary that all study subjects face some amount of congestion on their work commutes. Two corridors, shown in Figure 3.3, were selected among all possible commute routes: the Highway 24 corridor, which links East Contra Costa County to Alameda County, and the Interstate 80 corridor, which links North Contra Costa County to Alameda County. Congestion occurs regularly during morning and evening commute times in both corridors.

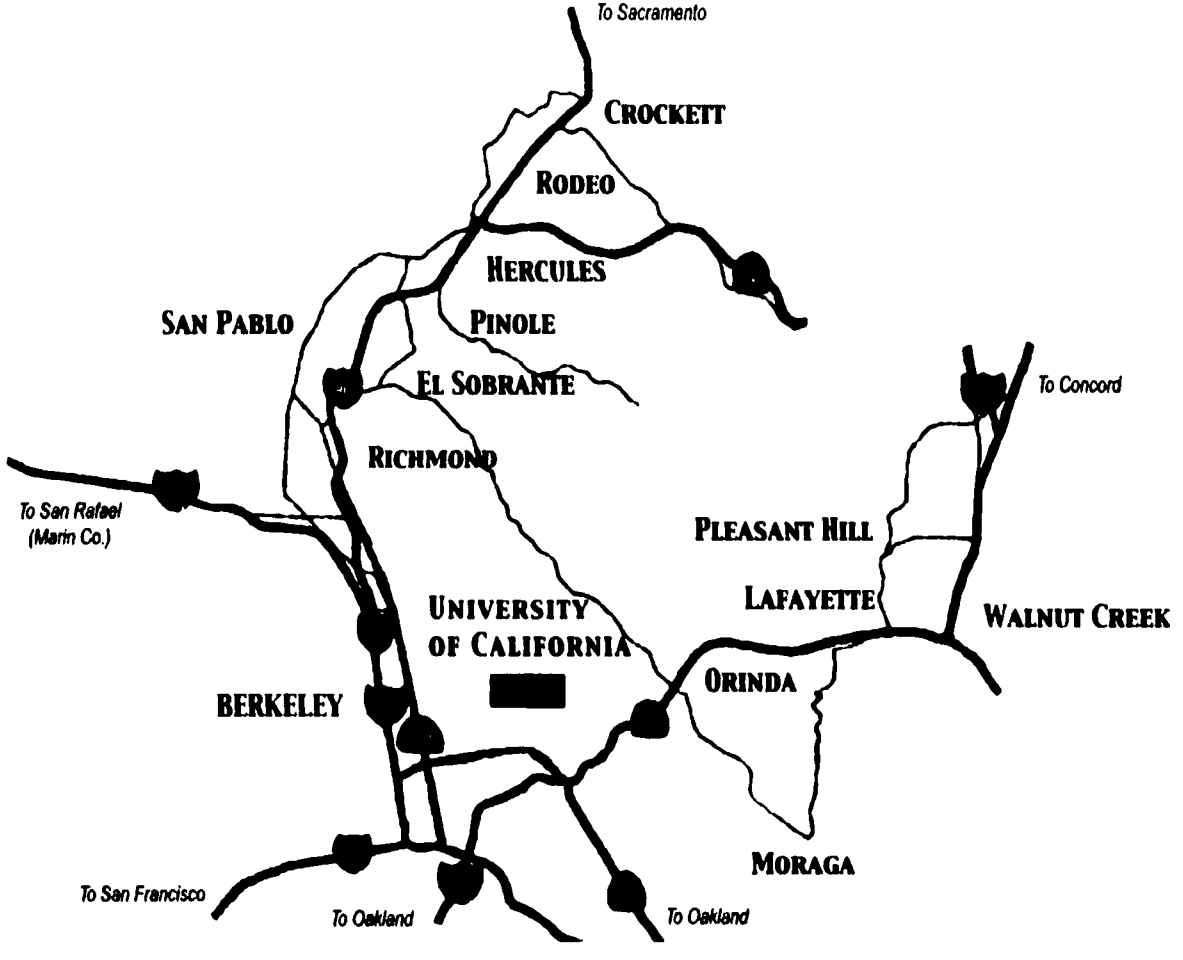
The selection of these corridors in turn determined the location of workers' residences. The sample for the initial exploratory interviews and for the survey was drawn from the population of UCB employees who live in East Contra Costa County (cities of Orinda, Moraga, Lafayette, Walnut Creek, and Pleasanton) and commute on Highway 24, or who live in North Contra Costa County (cities of Richmond, San Pablo, El Sobrante, Hercules, Crocket, and Rodeo) and commute on Interstate 80 or a parallel arterial corridor.

Due to differences in the distribution of campus employees between the two chosen residential regions, we used a stratified sampling strategy. Faculty and managerial staff are more likely to live in East Contra Costa County than in North Contra Costa County, while the majority of the clerical staff lives in North Contra Costa County. This is most likely due to differences in the price of housing between the two regions: the median price of a house in East Contra Costa ranges between $225,000 and $410,000, while the median price of a house in North Contra Costa varies between $115,000 and $225,000 (Bureau of the Census, 1990). The sampling strategy and sampling method are described in Chapter 7.

We made use of three distinct but complementary instruments to survey each selected employee: a self-administered questionnaire, an activity diary, and a personal interview. A detailed description of the survey methods and instruments as well as our findings are presented in Chapters 7 and 8.

To measure transportation supply, we used estimates of the difference in travel times between alternative times-of-day for work travel. These estimates were constructed from employee work arrival, work departure and travel time data collected by the UCB Office of Parking and Transportation. The travel time estimation procedures and results are described in Chapter 6.

FIGURE 3.3
Location of the Study Site and Travel Corridors



4.
ACTIVITY SCHEDULING FLEXIBILITY EFFECTS ON WORK TRIP TIMING: THE 1990 BAY AREA TRAVEL SURVEY

4.1 INTRODUCTION

The most comprehensive and readily available source of urban travel behavior data are the home-based travel surveys conducted in metropolitan regions. These surveys typically include several thousand households, chosen so as to ensure a representative sample of the urban population. These data allow us to seek and explain differences in work trip timing choices between population cohorts expected to exhibit different levels of activity scheduling flexibility.

These surveys do not explicitly ask for information about subjects' work or non-work activity scheduling flexibility. However, commuters' scheduling flexibility may be inferred from other available data: evidence from previous research, as well as data from the Bureau of Labor Statistics, indicate that work scheduling flexibility is related to workers' occupation and/or industry of employment, and that non-work activity scheduling flexibility is related to household composition and family roles. By using the appropriate occupational and demographic cohorts, hypotheses about expected differences in work trip timing behavior due to the availability of scheduling flexibility can be examined.

Since work and non-work flexibility are not directly available, the study cannot examine how well the selected job and demographic characteristics represent workers' scheduling flexibility. The surveys typically lack information which would help characterize commuters' work environment, for example their official or nominal work start and end times. Similarly, non-work activity characteristics such as their time-of-day dependence have to be inferred from the activity's purpose. Yet, although scheduling flexibility cannot be precisely identified or characterized, the available information does warrant an initial exploration of activity scheduling flexibility effects on work trip timing.

4.2 DATA DESCRIPTION

This analysis is based on information from three sources: a travel behavior survey, network-wide travel times, and a survey of the availability of flexible schedules.

4.2.1 Travel Behavior Survey

For urban travel behavior data, the study relies on the 1990 Bay Area Travel Survey (BATS). The BATS sample is drawn from the population of the nine-county San Francisco Bay Area. It consists of trip diaries, one for each member of every sampled household. Diaries were reported for one day (10,000 households), three days (1,000 households), or five days (480 households). Information was collected about the personal and household characteristics of all members of each household, and about characteristics

of all trips made during the sampled period.

4.2.2 Network-Wide Travel Times

Peak and off-peak travel times on the San Francisco Bay Area highway network at the time of the survey were obtained from the Metropolitan Transportation Commission. These travel times are estimated by a regional travel forecasting model calibrated using BATS data. The travel times are estimated on a zonal basis, and so they were assigned to each trip in the survey in accordance to the trip's origin and destination zones. These travel time estimates are available for the morning commute only, hence the trip's origin corresponds to the location of home, while the trip's destination corresponds to the location of work.

4.2.3 Work Scheduling Flexibility Survey

Data on the availability of flexible work schedules is available from the May 1991 Current Population Survey (CPS), Bureau of Labor Statistics. The May 1991 CPS included a special supplement on work schedules (in this case, flexible hours and shift work). A flexible work schedule was defined as a schedule that *"allows the worker to vary the times at which he/she begins or ends his/her work day"*. The data are available only at aggregate levels, in tables that show the proportion of workers with flexible schedules by occupation, industry, sex, age group, marital status, presence of children,

age of youngest child, race, and Hispanic origin.

The CPS uses a sample of approximately 50,000 housing units, drawn from all 50 states (including rural and urban areas). Data is collected for all household members 16 years old or older who were employed at the time the survey was taken, resulting in approximately 100,000 wage and salary workers. Workers are contacted at their place of residence, either personally or by telephone.

4.3 METHODOLOGY

4.3.1 Hypotheses

We restate the principal research hypothesis so we can test it using the available data. As mentioned before, the main limitation of these data is that they contain no information on work schedule choice, only on work trip timing choice. The data provide only a few indicators by which we may infer activity scheduling flexibility, as explained in Section 4.3.2. And they only allow us to examine the morning commute, since there are no evening network travel time estimates.

The effect of activity scheduling flexibility on work trip timing will be examined through two indicators: the proportion of the morning commute's travel time that corresponds to congested travel conditions, referred here as the congestion penalty, and the day-to-day

variability of work arrival times. The two hypotheses below address how work and non-work scheduling flexibility are expected to be reflected in these indicators.

(a) Hypothesis 1: Effect of Activity Scheduling Flexibility on Congestion Penalties

It is hypothesized that commuters with little work or non-work scheduling flexibility are more likely to travel in congestion than commuters with high scheduling flexibility. This results because commuters are averse to congestion and will try to avoid it whenever they reasonably can. Flexible schedule commuters have more opportunities to do so, and as a result will travel less during peak hours. Hence, flexible schedule commuters will exhibit lower congestion penalties than non-flexible schedule commuters.

(b) Hypothesis 2: Effect of Activity Scheduling Flexibility on Work Arrival Time Variability

Commuters with little work or non-work scheduling flexibility are likely to exhibit less variability of work arrival times (over a period of several days) than commuters with high work or non-work scheduling flexibility. Workers with little work scheduling flexibility are expected to arrive at work at about the same time every day, while the more work-flexible employees may have the option of varying their work arrival time on a day-to-day basis, or by day of the week.

4.3.2 Measurement of Work and Non-Work Scheduling Flexibility

The following measures are used to identify work and non-work scheduling flexibility in the BATS sample:

(a) Work Scheduling Flexibility

The only employment-related data in BATS are workers' occupation and industry of employment, coded at the two-digit level of the Standard Industrial Classification code. Occupation was chosen as the indicator of work scheduling flexibility: it is hypothesized that occupational differences, for example the scheduling characteristics of assembly line jobs vs. "desk" jobs, are more likely to be related to the availability of a flexible schedule than differences by type of industry. The likelihood that a worker would have a flexible work schedule is a function of her occupation, and is assumed equal to the proportion of workers with a flexible work schedule in that occupation (see Table 4.1).

(b) Non-Work Scheduling Flexibility

Workers' sex and household composition (presence and age of the youngest child) are used as indicators of the likelihood of having non-work scheduling flexibility. These characteristics define the following groups, ranked in order of increasing non-work flexibility: women in households with children, men in households with children, women in households without children, men in households without children.

TABLE 4.1
Availability of a Flexible Work Schedule on Principal Job of Wage and Salary Workers, by Occupation.

Likelihood of a Flexible Work Schedule	Occupation	Proportion of Workers with Flexible Work Schedule
High	Executive, Administrative, and Managerial.	23%
	Technicians and Related Support.	23%
	Sales.	22%
	Professional Specialty.	21%
Medium	Administrative Support.	14%
	Private Household Services.	13%
	Services Other Than Private Household or Protective.	11%
	Farming, Forestry, and Fishing.	11%
	Transportation and Material Moving Occupations.	11%
Low	Protective Services.	9%
	Precision Production, Craft and Repair.	8%
	Handlers, Equipment Cleaners, Helpers and Laborers.	7%
	Machine Operators, Assemblers, and Inspectors.	5%

Source: May 1991 Current Population Survey, Bureau of Labor Statistics.

In principle, one could also identify non-work scheduling flexibility from the purpose of activities conducted before or after work: education, child care, and serve passenger trips are likely to result from activities with constrained schedules, such as classes, children's school or day care attendance, and the spouse's work schedule. Commuters whose work trip chain includes any of these trips would be expected to have less non-work scheduling flexibility than all other commuters. Unfortunately, there were not enough cases to support the analysis of non-work activity purpose as an indicator of non-work scheduling flexibility.

4.3.3 Methods of Analysis

(a) Activity Scheduling Effects on Congestion Penalties

A person's home-to-work travel time may be expressed as a function of the travel time conditions on her route as follows:

$$TravelTime_{ijk} = Off\ PeakTravelTime_{jk} + \delta_i * (Peak - Off\ PeakTravelTime)_{jk} \qquad (4.1)$$

namely, the sum of free-flow or non-peak travel time on the route between j and k, and additional travel time due to congestion on this route, or congestion penalty. The coefficient δ is interpreted as a congestion penalty, that is, an indicator of the fraction of congestion experienced by traveler i in going from trip origin j to trip destination k, relative to the maximum congestion on her route. If person i traveled at the peak time-of-

day, then δ would be 1; if she traveled at a time-of-day when peak and off-peak traffic volumes are the same, then δ would be 0.

Under the null hypothesis, of two people traveling between j and k, the person with the highest activity scheduling flexibility will exhibit the lowest congestion penalty δ. Hence, we make use of (4.1) to estimate δ as a function of commuters' work and non-work scheduling flexibility characteristics.

In the case of work scheduling flexibility, we assume that δ is proportional to the likelihood that a commuter has a flexible work schedule:

$$\delta_i = \delta_0 * Likelihood of a Flexible Schedule_i$$

where the likelihood of having a flexible schedule, for a commuter of a given occupation, is equal to the proportion of workers with flexible schedules in that occupation (see Table 4.1). Hence the function to be estimated is:

$$TT_{ijk} = \alpha + \beta * OPTT_{jk} + \delta * LFlex_i * (PTT_{jk} - OPTT_{jk}) + \varepsilon_{ijk} \qquad (4.2)$$

where α represents the sum of origin and destination intrazonal or network access travel time, β is expected to be equal to 1, PTT_{jk} and $OPTT_{jk}$ are the peak and off-peak travel times respectively, and $LFlex$ is the likelihood of a flexible work schedule. The error in

the estimation arises from errors between commuters' reported and actual travel times, as well as errors in the estimation of network travel times, and is assumed to be random and normally distributed.

In the case of non-work scheduling flexibility, the congestion penalty δ is expressed as a function of qualitative characteristics: workers' sex and the presence and age of children in their household. If these characteristics divide the sample into *n* groups, the model is estimated with *n-1* dummy variables as follows:

$$TT_{ijk} = \alpha + \beta * OPTT_{jk} + (\delta_0 + \delta_1 * DV1_i + ... + \delta_{n-1} * DVn-1_i) * (PTT_{jk} - OPTT_{jk}) + \varepsilon_{ijk} \quad (4.3)$$

The coefficient estimates of (4.2) and (4.3) are shown and discussed in Section 4.4.1.

(b) Effects on Work Trip Timing Variability

To test this hypothesis, we base the analysis on the five-day BATS panel. We use the standard deviation of the work arrival time, computed for each worker over the five reported days, as the measure of trip timing variability, and seek to explain this variability in terms of the activity scheduling flexibility variables.

In the case of work scheduling flexibility, the model to estimate is:

$$Std.Dev.TT = \sigma + \gamma * LFlex + \varepsilon \quad (4.4)$$

while in the case of non-work scheduling flexibility, since all explanatory variables are qualitative, the model to estimate is:

$$Std.Dev.TT = \sigma + (\gamma_1 * DV1 + ... + \gamma_{n-1} * DVn - 1) + \varepsilon \quad (4.5)$$

If the scheduling flexibility dummy variables are numbered in increasing order of activity scheduling flexibility, then we expect the gamma coefficients to increase in the same order.

The estimation results and related findings are discussed in Section 4.4.2.

4.3.4 Sample Selection

Only trips that fulfill all of the following characteristics were drawn from the BATS sample:

- home-to-work trips,
- trips by full-time workers,
- auto (driver or passenger), taxi, or motorcycle trips,
- time of arrival at work between 6:00 A.M. and 10:00 A.M.
- trips taken on routes where the difference between peak and off-peak travel times is more than 5 minutes.
- trips that started and ended at the same place on all five days.

These limits were required either due to the focus of the study (work trip timing by full-time workers in the presence of congestion), or due to the characteristics of available network travel time data. The requirement of a 5 minute travel time differential applies only to the trips drawn from the single-day survey; the five-day sample would have been too small had it been restricted in this way. The work arrival time interval was restricted partly to minimize the effect of highly non-regular work schedules (for example people who start work very early in the morning). Also because it is unlikely that people who voluntarily shift out of peak hours would choose very early or very late work start times.

In the few cases in which a worker had more than one home-to-work trip per day, we chose the earliest trip. The one-day sample yielded 600 work trips, which represent about 10% of all auto work trips by full-time workers in BATS. The requirement of a five-minute minimum travel time differential alone reduced the sample by about one-tenth. The five-day sample yielded 119 workers with five trips each, representing approximately 7% of all full-time workers in the panel survey. Many workers did not report a work trip on one or more of the five days. Also, some workers do not travel to the same work destination on all five days.

4.4 FINDINGS

4.4.1 Effect of Activity Scheduling Flexibility on Work Arrival Time

Contrary to expectation, BATS data show that commuters' incurred congested travel time increases with increasing scheduling flexibility (see Table 4.2). That is, commuters with high work scheduling flexibility exhibit higher travel times, due to congestion, than commuters with low work scheduling flexibility. This finding does not support the notion of commuters using their work scheduling flexibility primarily to shift out of peak commute times. Instead, it appears that other drivers of work trip timing choices, for example non-work obligations or participation in discretionary non-work activities, may result in peak hour travel and hence higher travel times.

The average congestion penalty, not controlling for work scheduling flexibility, is 0.41 (Table 4.3). That is, on average commuters experience 40% of the maximum travel time premium due to traveling in congested traffic. After controlling for work scheduling flexibility, it is clear that workers with higher work scheduling flexibility incur higher congestion penalties, which would indicate that they are more likely to travel during peak hours. For example, as the likelihood of a flexible work schedule increases from 10% to 20%, the proportion of congestion-induced travel time differential increases from 0.24 to 0.48.

TABLE 4.2
Effect of Work Scheduling Flexibility on Work Arrival Time

Variable (Coefficient)	Coefficient Estimate	t Statistic
Intrazonal Travel Time (α)	17.5	7.9
Off-Peak Travel Time (β)	0.8	18.2
LFlex [a] * (Peak - Off Peak Travel Time) (δ)	2.4	2.1

[a] LFlex: Likelihood of having a flexible work schedule.

TABLE 4.3
Congestion Penalties by Likelihood of a Flexible Work Schedule.

Likelihood of a Flexible Work Schedule	Congestion Penalty
5%	0.12
10%	0.24
20%	0.48
Average Congestion Penalty:	0.41

BATS data provide weak evidence that sex and the presence of children in the household affect work trip timing choice. As shown in Table 4.4, women who have young children exhibit higher congestion penalties than all other workers. However the differences in congestion penalties are not highly statistically significant, especially once the youngest child in the household is older than 12 years old. By the time the youngest child is older than 12 years old, there are no differences between workers due to the presence of children in the household. This suggests that, as children become more independently mobile, they demand less transportation services from the adults in the household. Similarly, we observe that the congestion penalty of women with children diminishes as the age of the youngest child increases from less than 5 years old to less than 12 years old, which would indicate that women's scheduling flexibility increases as their children age.

TABLE 4.4
Congestion Penalty Estimates, by Sex and Age of Children

	Coefficient Estimates (t statistic)		
	Age of Youngest Child:		
Variable (Coefficient)	0-5 Yrs. Old	5-12 Yrs. Old	12-16 Yrs. Old
Intrazonal Travel Time (α)	18.0 (5.6)	18.7 (6.0)	17.8 (6.2)
Off Peak Travel Time Factor (β)	0.79 (16.4)	0.79 (17.0)	0.79 (17.6)
Peak - Off Peak Travel Time (δ_n):			
Women with Children [a]	0.92 (1.7)	0.67 (1.1)	-0.17 (0.2)
Men with Children [a]	-0.21 (0.8)	-0.56 (1.0)	0.20 (0.2)
Women without Children	-0.48 (1.2)	-0.46 (0.9)	0.59 (0.8)
Men without Children	-0.46 (1.2)	-0.50 (1.0)	0.56 (0.8)

[a] Includes those in households where the youngest child is of the age indicated in the banner.

4.4.2 Effect of Activity Scheduling Flexibility on Work Arrival Time Variability.

As shown in Table 4.5, about one-half of the workers in this sample report a five day standard deviation of work arrival time of 5 minutes or less. For reference, a person who arrives at work always within five minutes of his planned arrival time would exhibit a standard deviation of work arrival time of about 5 minutes or less. Thus it appears that overall, this sample exhibits little day-to-day variability of work arrival times. Nevertheless, as work scheduling flexibility decreases, the proportion of workers who exhibit a standard deviation of work arrival time of 5 minutes or less increases. This suggests that day-to-day arrival time variability increases with increasing work scheduling flexibility. However the regression analysis did not bear out this hypothesis. As shown in Table 4.6, the coefficient associated with the likelihood of a flexible schedule, while positive, is not statistically significant.

It appears that this is due to the large positive tail exhibited by some occupations in the distribution of arrival time variability (see Figure 4.1). As there are between 10 and 20 observations per occupation, a few observations with high values may exert a disproportionate influence on the least squares estimation. Table 4.6 shows that, by restricting the sample to those observations with a standard deviation of arrival time equal to or less than 75 min, the statistical significance of the coefficient of LFlex increases. There is however, no compelling reason to exclude these observations, and hence we can only conclude that there appears to be a weak, positive relation between work scheduling

flexibility and work arrival time variability. Work arrival time variability appears to increase by 3 minutes for each 10 percent increase in the likelihood of a flexible schedule.

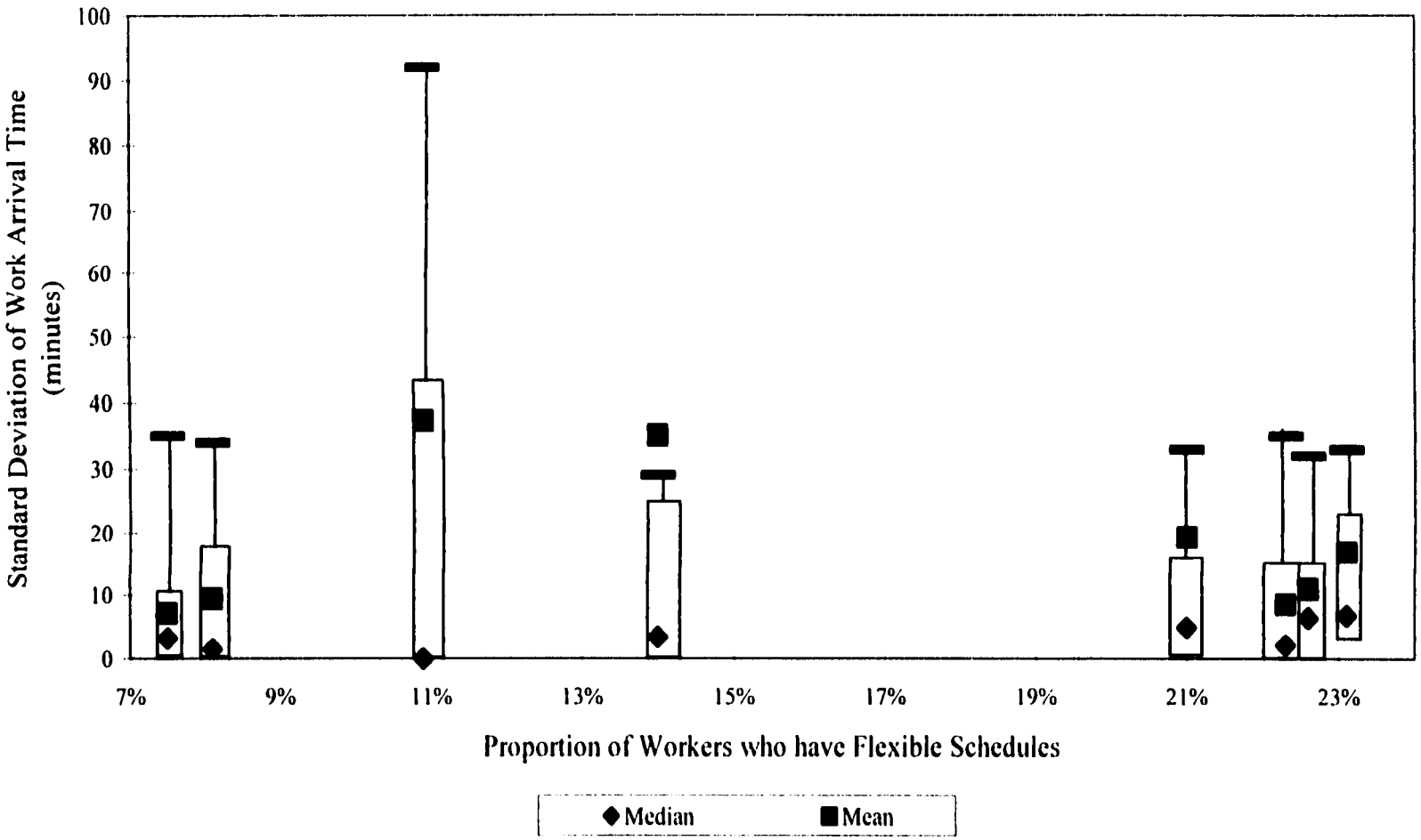
TABLE 4.5
Proportion of Workers with Low Arrival Time Variability, by Occupation

Occupation	Sample Size	Likelihood of Flex. Schedule	Proportion of Workers Exhibiting Std. Dev. of Work Arrival Time Equal to: 0 min.	5 min. or less
Executives, Managers	23	23%	22%	39%
Technicians	20	23%	20%	40%
Sales	11	22%	45%	54%
Professionals	38	21%	18%	50%
Administrative Support	12	14%	50%	50%
Services	14	11%	57%	64%
Precision Production, Craft	8	8%	50%	62%
Handlers, Laborers	9	7%	33%	66%
Total:	135		42	67

TABLE 4.6
Effect of Work Scheduling Flexibility on Work Arrival Time Variability

Variable	Coefficient Estimates (t Stat) All Observations	Observations with Std.Dev (TT) < 75 min.
Constant	6.7 (1.6)	3.0 (0.8)
Likelihood of Flexible Schedule (LFlex)	14.0 (0.6)	30.6 (1.6)

FIGURE 4.1
Box-Whiskers Plot of Arrival Time Variability, by Work Scheduling Flexibility



The coefficient estimates shown in Table 4.7 for the groups Men with Children and Men and Women without Children indicate the additional trip timing variability exhibited by these workers with respect to Women with Children. As shown in Table 4.7, women whose youngest child is five years old or younger exhibit lower standard deviation of work arrival times than the other groups. And these women's work arrival time variability increases (with respect to the variability exhibited by the other groups) as their children age, which is expected since the children should become more mobile as they get older. Surprisingly, when the youngest child is older than 12 years old, women exhibit higher absolute trip timing variability than the other commuter groups. One possible explanation is that the effect of children's activities on their parents' schedules varies as they age: for example when they are very young, they may attend kindergarten at about the same times every day; instead when they are older, they may attend after-school activities on some, but not all, days of the week. A person whose work trip is highly influenced by serve child passenger trips would exhibit low trip timing variability in the first case, but high trip timing variability in the second case.

Among workers with children, the differences in work arrival time variability between men and women are not significant in any of the three cases examined in Table 4.7. Instead, there appear to be differences in trip timing variability between workers with and without children. This suggests that the presence of young children in the household is by itself an indicator of lack of scheduling flexibility, while workers' sex is not.

TABLE 4.7
Effect of Non-Work Scheduling Flexibility on Work Arrival Time Variability

Variable	Estimate of Std. Dev. of Arrival Times [a] (t stat) Age of Youngest Child: 0-5 Yrs. Old	5-12 Yrs. Old	12-16 Yrs. Old
Women with Children [b]	0.1 (0.0)	4.2 (0.4)	18.1 (2.3)
Men with Children [b]	5.0 (1.2)	7.6 (0.7)	-5.3 (0.4)
Women without Children	9.8 (1.9)	5.6 (0.6)	-8.3 (1.0)
Men without Children	7.3 (1.5)	4.3 (0.4)	-9.6 (1.2)

[a] All coefficients are estimated with respect to the Women with Children group. For example, the average standard deviation for Men with Children (5 yr. old) would be 2.5-1.4=1.1 min.

[b] Includes those in households where the youngest child is of the age indicated in the banner.

4.5 SUMMARY

We find that work and non-work scheduling flexibility affect workers' choice of work trip timing, in ways that both confirm some previously held beliefs, but that challenge others. The most significant finding is that the proportion of work travel time corresponding to congested travel increases with increasing work scheduling flexibility. This runs contrary to conventional wisdom, which states that work scheduling flexibility would typically be used to opt out of congested traffic. It appears that flexible work schedule commuters are more likely to travel during peak, congested hours than non-flexible commuters.

Day-to-day work arrival time variability was also found to increase with increasing work scheduling flexibility, although the relation is not strong. There is some evidence from the literature that workers tend to settle into a routine, even when they have great

discretion to choose their work schedules. Hence the absence of a strong correlation should not be surprising. For example, inasmuch as flexitime programs require employees to adhere to their chosen schedule, little day-to-day variability would be observed among these workers.

The data allowed few avenues to explore the effect of non-work scheduling flexibility on work trip timing. The characteristics chosen as indicators of non-work scheduling flexibility exhibit weak relationships with work arrival time choice and work arrival time variability. However, the relationships are as expected: women who have young children are more likely to travel during peak hours than all other workers, and commuters with children exhibit different day-to-day work trip timing variability than commuters without children. Workers with young children, and especially women, are possibly among the commuters with the lowest non-work scheduling flexibility. Children's activities are time-of-day dependent, but their schedule may vary from day to day. Yet it is not clear whether the effect of young children on workers' time-of-day choices is to increase or decrease their trip timing variability. This in turn suggests that trip timing variability by itself says little about a workers' non-work scheduling flexibility.

Several caveats limit the analysis and conclusions that can be derived from BATS data. For example, the variability of the availability of flexible schedules within each of the occupational groups used by BATS may be as large as the variability across two-digit SIC code occupational groups, as shown in the CPS data (BLS 1991). For example, among

the professional occupations, teachers (not college or university) exhibit only a 4% proportion of workers with flexible schedules, while among scientists this proportion is 44%. Similarly, within the service occupations, this proportion varies from 8% to 23% depending on the type of service. That is, at the two-digit level, occupation does not adequately discriminate workers by their work scheduling flexibility. It is also possible that nominal work schedules are related to workers' occupation and industry of employment, so that the observed differences in work arrival times may be due to differences in nominal work schedules, and not to work scheduling flexibility effects.

Inferences between day-to-day variability in trip timing and non-work scheduling flexibility hold only to the extent that the observed variability is not due to day-to-day systematic differences in nominal work schedules. Moreover, the combined effect of errors in network travel time estimates with people's tendency to round-off reported travel times, may drown any existing relation between scheduling flexibility and trip timing variability. In this sample, of people whose home-to-work routes exhibit more than 5 minutes of additional travel time during the peak hours, only about 20% use routes in which the travel time increases by 10 or more minutes during peak hours. At the same time, arrival and departure times are typically rounded-off by at least that much, if not more.

The weakness of the relationship between work trip timing and workers' sex and presence of children suggests either that these characteristics do not adequately capture workers'

non-work scheduling flexibility, or that trip timing variability has little relation to activity scheduling flexibility. It remains to be examined whether non-work activity purposes, or other characteristics of non-work activities, better discriminate workers by their non-work flexibility.

Hence, the analysis is stymied by the lack of information on activity scheduling flexibility and on activities' nominal schedules. The effects of work and non-work scheduling flexibility on trip timing could best be observed by knowing the scheduling norms at each person's workplace. And in order to understand the effect of non-work activities on work schedules and work trip timing, it would be necessary to first understand the options and motivations considered when planning both work and non-work activities. The research reported in the next chapters overcomes the limitations of BATS, primarily by designing, conducting and analyzing a survey of work travel and work and non-work scheduling flexibility.

5.
EXPLORATORY STUDY: IN-DEPTH PERSONAL INTERVIEWS

5.1 INTRODUCTION

It is clear that available data are insufficient to comprehensively study activity scheduling flexibility and its effect on work schedules and work trips. As a first step towards the design of an activity scheduling flexibility survey, an exploratory study on this topic was undertaken. The purpose of the study is to examine people's understanding of their own work and non-work scheduling flexibility, their work and work trip scheduling practices, and their strategies for reconciling work and non-work schedules. The present study is exploratory because it explores in-depth the decisions and motivations of a few individuals, rather than seeking a general assessment of a segment of the working population, or even looking for statistical differences between population subgroups.

The study also explores concepts which have become current wisdom in urban transportation planning, such as whether the traditional classification of activities as discretionary or mandatory is relevant for time-of-day choice. And it also explores some of the findings discussed in Chapter 4. These include the relation between occupation and work scheduling flexibility, examining whether the usual demographic variables (sex, marital status, age, etc.) are indicators of differences in non-work activity scheduling flexibility, as well as the extent to which day-to-day variability in work trip timing results

from flexibility in work scheduling.

5.2 METHODOLOGY

The exploratory study consists of a series of in-depth personal interviews. The interview method was chosen because, unlike written questionnaires or activity diaries, it gives the interviewer greater freedom to choose questions and the order in which they are posed. The method is likely to elicit detailed descriptive accounts of subjects' actions and motivations, and it does not force subjects to fit their responses to pre-established categories. Focus groups were also considered, but this method was rejected partly because the population available for conducting the study was not large enough to support groups differentiated by key workers' characteristics (occupation, sex, and household composition).

Subjects were asked open-ended questions about their household characteristics, their typical work schedule and deviations from it, their work commute (both in the morning and in the evening), and their participation in and scheduling of non-work activities before and after work, both in-home and out-of-home. Concerns over biasing the interview with pre-conceived notions about work trip and activity scheduling motivations resulted in a fairly open-ended, and only somewhat structured interview questionnaire (see Appendix 1).

5.3 SUBJECT SAMPLE DESCRIPTION

As indicated in Chapter 3, this exploratory study was conducted at the University of California at Berkeley (UCB). Subjects for this study were selected from the employees that live in one of the two previously identified target residential areas, East Contra Costa County. All subjects were required to work a nominal full-time schedule (35 hours per week or more) and to commute to campus by car, either driving or carpooling. Part-time workers were excluded because they may face work and trip scheduling options different from the options available to full-time workers. For example, they may have a job schedule such that they already travel during non-peak hours. Transit commuters were also excluded, because the difference in travel times between peak and off-peak travel was anticipated to be very small relative to the one-way travel time.

A stratified random sample design was used to ensure adequate representation among the interviewees of workers with the following characteristics:

- Administrative and teaching occupations,
- Male and female,
- Single and married (including living with a partner),
- With and without children under 5 years old living in the household.

Workers were selected at random from a list prepared by the University's Personnel Office. They were contacted by telephone at their place of work, and screened on the

basis of the factors listed above. Initially a response rate of approximately 90% was obtained. After approximately 10 people had been scheduled for interviews, four out of every five people further contacted were rejected because their households did not include young children. A total of thirteen interviews were completed over the course of three weeks.

Some demographic and occupational characteristics of the interview subjects are shown in Tables 5.1 and 5.2, respectively. While the study sought to recruit subjects of various occupational, gender, and household groups, the sample nevertheless reflects the occupational and demographic characteristics of university personnel. In particular, among the interviewees the four low to mid-level administrative staff members are women, while all the faculty and executive administrators (five subjects in total) are men. As both occupation and gender are factors that may affect a person's activity scheduling flexibility, care was taken when attributing flexibility (or lack thereof) to one or the other factor.

TABLE 5.1
Demographic Characteristics of Subject Sample

Subject ID	Sex	Age Group	Marital Status[a]	Working Spouse/Partner	Children in the Family	
					Total	Age of Youngest
A	F	36 - 45	P	Yes	0	-
B	F	36 - 45	S	-[c]	0	-
C	F	46 - 55	S	-	0	-
D	F	46 - 55	S	-	1	14
E	F	36 - 45	M	Yes	2	11
F	M	Over 55	M	Yes	1	18
G	M	46 - 55	M	Yes	0	-
H	F	26 - 35	M	Yes	1	1
I	M	26 - 35	P	Yes	0	-
J	M	36 - 45	M	Yes[b]	1	2
K	M	36 - 45	M	No	3	7
L	M	36 - 45	M	Yes[b]	2	9
M	M	36 - 45	M	Yes	3	3

[a] S = single, M = married, P = living with partner.

[b] Employed part-time.

[c] Data not applicable.

TABLE 5.2
Occupational Characteristics of Subject Sample

			Work Schedule			
		Flexible	Official		Usual	
ID	Occupation	Schedule	Start	End	Arrive	Depart
A	Truck Driver	Yes	8:00	4:30	9:00	5:30
B	Administrative Assistant	No	8:30	5:30	8:30	5:30
C	Administrative Assistant	Yes	8:00	5:00	7:30	3:00/4:00
D	Student Services Supervisor	Yes	8:00	5:00	8:15	5:00-6:00
E	Student Adviser	Yes	8:00	5:00	8:30	4:30-5:30
F	Administrative Executive	No	8:00	5:00	7:40	5:00-5:30
G	Administrative Executive	Yes	-[b]	-	7:30	5:00-6:00
H	Staff Research Associate	Yes	-	-	8:30	5:00
I	Computer Analyst	No	7:30	4:30	7:30	3:30-7:00
J	Computer Analyst	Yes	8:00	5:00	8:30-10:00[a]	5:00-7:30[a]
K	Professor	Yes	-	-	6:30	7:00
L	Professor	Yes	-	-	9:30	6:30-7:00[a]
M	Professor	Yes	-	-	8:00-12:00[a]	5:30-7:30[a]

[a] Schedule varies by day of the week.

[b] No official time.

5.4 FINDINGS

The findings from the exploratory interviews are presented in two sections. The first section describes the work scheduling flexibility of the interview subjects, the influence of non-work activity scheduling on their work schedule, and the characteristics of the transportation environment which affect work and non-work scheduling. The second section proposes three mechanisms to explain subjects' time-of-day choice for work travel.

5.4.1 Availability and Extent of Work Scheduling Flexibility.

The official business hours of the University of California at Berkeley vary between 8:00 A.M to 8:30 A.M. and 4:30 P.M. to 5:00 P.M. This does not include some of the janitorial, security and physical maintenance staff, who do not work a daytime shift. Employees who are not exempt from the regulations of the Fair Labor Standards Act typically work eight hours per day, and are entitled to up to 60 minutes of rest time, including lunch. Exempt employees instead have variable work day lengths, determined mostly by the requirements of the position. UCB has an official policy on the availability of alternative work schedules, which covers work at home, flexitime, and compressed work hours (Wesley, unknown year).

Figures 5.1 and 5.2 show the typical range of arrival and departure times for each interview subject, and their official work start and end times, if any. In the next section we elaborate on subjects' work scheduling flexibility and its effect on work schedule choices. For this purpose, we classify the sample by occupation into three groups: faculty, professional and managerial staff, and administrative and clerical staff.

5.4.1.1 Faculty (Subjects K, L, and M).

Of all workers, the ones with the highest flexibility to schedule work hours are the professors. For example, professors have the discretion to work at home: Professors L and M go to campus only on the days in which they have classes, usually two or three days in a week. Professors' discretion to schedule their campus hours is constrained primarily by class schedules and to a lesser extent by administrative duties. Class schedules are decided at the department level, and once set, cannot be easily changed. Administrative duties oftentimes require that the faculty meet with colleagues and other staff members, so that the schedules of these meetings depend also on other people's availability. Classes and meetings may play a role in the times at which professors travel to and from campus whenever they occur at the beginning or at the end of the work day.

In spite of their high degree of work scheduling flexibility, two of the three professors in this sample reported little random day-to-day variability in work trip timing. In the case of M, the arrival or departure time ranges (shown respectively in Figures 5.1 and 5.2)

FIGURE 5.1
Usual and Official Work Arrival Times

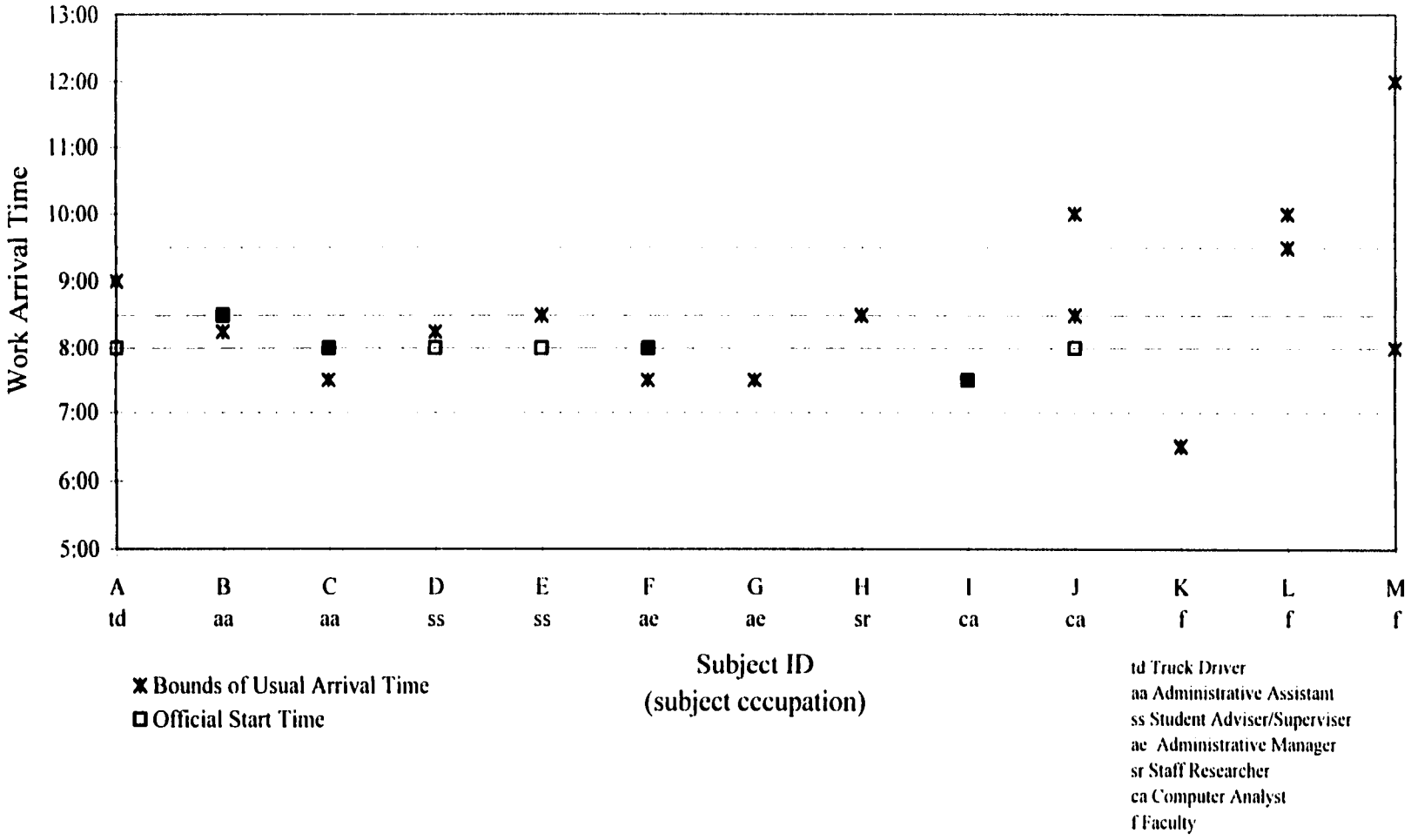
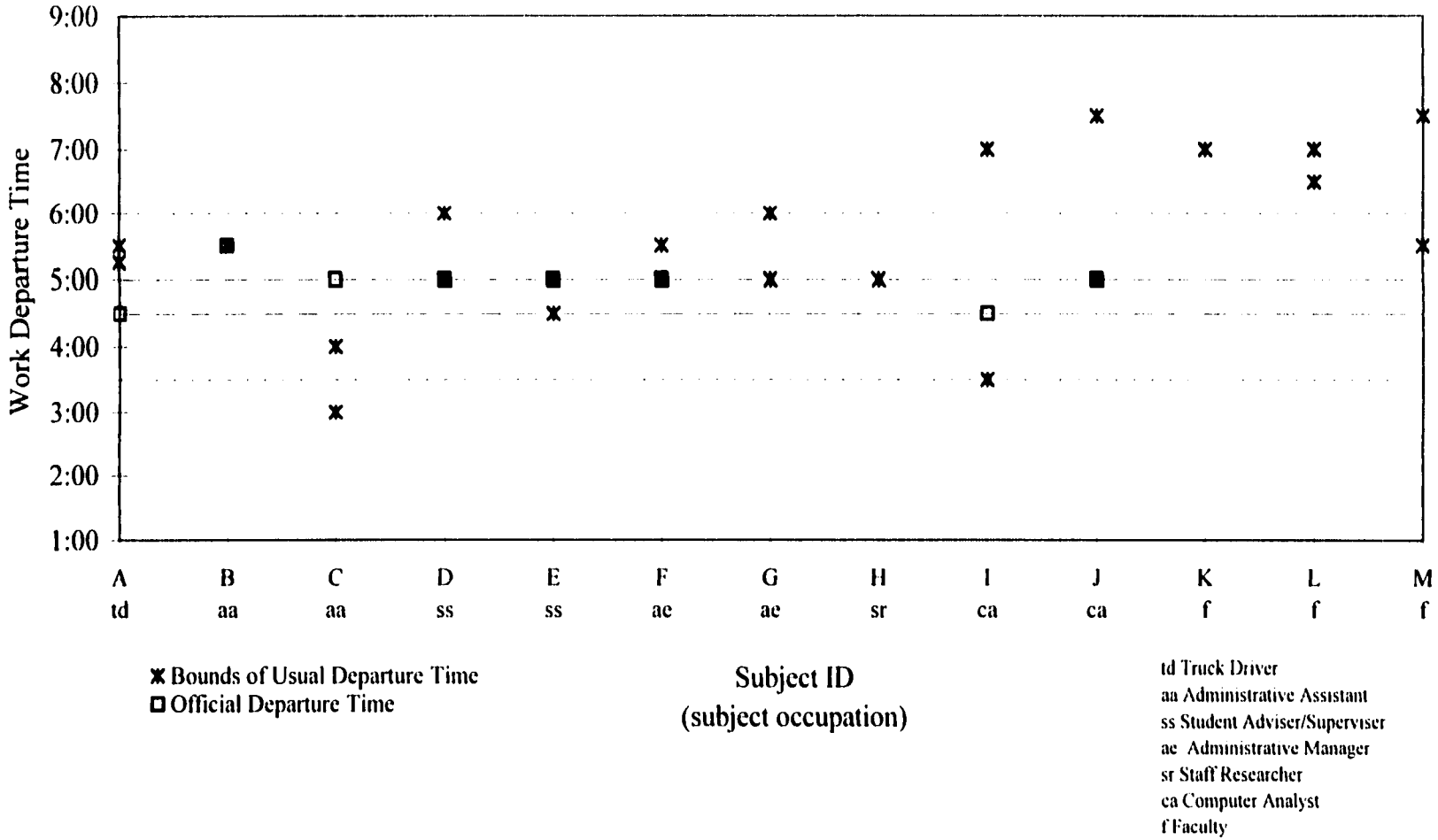


FIGURE 5.2
Usual and Official Work Departure Times



incorporate both a systematic, day to day component, and a random component. Day-to-day systematic differences are due to class days vs. non-class days.

5.4.1.2 Professional Staff (Subjects F, G, H, I, and J).

As is the case with the faculty, almost unlimited work scheduling flexibility accrues to the "professional" staff. This term is used here to distinguish occupations such as managers, analysts and staff researchers, from the clerical and administrative assistant jobs. Different work rules apply to these groups, not just related to work scheduling and timeliness, but also in terms of pay and promotion. In particular, the professional staff is not expected to start the day at any pre-determined time, and so it was surprising to find that only one person, subject J, among those interviewed deviated from the official start time by more than 30 minutes.

The reasons for this behavior varied, and were related both to work and non-work factors. One of the administrative managers feels compelled to work the same schedule that his staff is expected to follow. Subject I, a computer analyst, is required to arrive punctually because his work unit must provide on-call computer support throughout the day, and he is the one with the earliest schedule. The staff research associate, subject H, works a schedule similar to the campus official hours because it fits her non-work activities well. And the hours of J vary systematically by day of the week due primarily to household responsibilities, in such a way that he works hours close to UCB's official schedule on

three days of the week, and a later schedule on the other two days. The official start and end time indicated for this person in Figures 5.1 and 5.2 are the business hours of his work unit.

5.4.1.3 Administrative Staff (Subjects A, B, C, D, and E).

Unlike the professional staff, the administrative staff typically must follow a work schedule. Yet four out of five workers interviewed had agreed with their supervisors to work on schedules different from their original nominal schedule. Schedule flexing was usually explained in terms of changes to the work start time (as opposed to the work quit time). The work schedule changes sought varied from 15 minute to 60 minute shifts in work arrival times. And these shifts were accommodated either by shifting the work end time and/or by shortening the lunch break. Even when the start time is not flexed, working through the lunch break is still used as a strategy to leave early. Figures 5.1 and 5.2 show the official schedules of these workers, before they were flexed.

Of five administrative workers, four have flexed their work schedules, but only one, subject A, did so by making use of the university's official flexitime policy and procedures. The other administrative staff member, subject B, had also formally requested a 30 minute change in her schedule, but her request was not approved. Moreover, she is the only person in this sample who would get docked whenever she arrives late. Not surprisingly, compared to the other workers she adheres more closely to

her official work schedule (see Figures 5.1 and 5.2).

As expected, all of these subjects exhibit little day-to-day variability in work arrival and departure times. Although they have succeeded in flexing their work hours, they are still expected to arrive punctually and to stay at work until the nominal end of their day.

In summary, most people in the sample enjoy some degree of work scheduling flexibility, varying from a 15 minute shift in work hours to the discretion to work at home. Even so, the schedules of 9 of the 13 subjects do not deviate from the "official" 8:00 to 8:30 A.M. start time by more than 30 minutes. Conversely, there is more variability in evening departure times: only 5 of the 13 subjects depart regularly within 30 minutes of the "official" 4:30 to 5:00 P.M. end time. One subject departs consistently earlier than this. The other subjects either depart regularly at a later time, or have a range of departure times larger than 60 minutes. It was found that flexible hours result from occupational privilege or necessity (e.g. faculty), from informal arrangements between staff members and their supervisors, or least commonly from formally taking advantage of the university's official policy on flexible work arrangements. Many workers have schedules that vary systematically by day-of-the-week. Around these schedules, most workers typically arrive within 10 minutes of their planned arrival time, and depart within 30 minutes of their planned departure time.

5.4.2 Non-Work Activity Scheduling Preferences and Constraints

The section above described the university's work scheduling rules, and the particular work schedules chosen by the interview subjects. This section examines the effects that non-work activities have on work schedule choice.

5.4.2.1 Relevant Non-Work Activity Characteristics

In the travel demand literature, activities are typically identified as mandatory or discretionary. One expects that mandatory activities would be more likely to affect work schedule and work trip timing choice than discretionary activities. For example, parents may have no option but to give up the possibility of a short, non-peak commute to be able to drop a child at school on time. Instead, they may consider a fitness class after work only if they can find a schedule that does not require peak travel. Yet we found that a discretionary activity is no more or less important than a mandatory activity in terms of work schedule choice. Instead, two other characteristics of non-work activities were more relevant: the time period over which the activity takes place (occasional vs regular activities), and whether the activity is time-of-day dependent.

Activities which reflect medium term, lifestyle preferences tend to be taken into account when choosing the work schedule. Many of these non-work activities are performed periodically over a long period of time (at least several months). Some, such as driving

children to and from day care or school, can be hardly considered optional. But many of these activities would traditionally be considered discretionary: in this sample they included recreational or extra-curricular classes, volunteer work, aerobics or dancing practice, and religious meetings, among others. On a day-to-day basis, these activities may constrain the work and work travel schedule in ways similar to concerns over work tardiness.

The constraint that participation in these activities impose on work schedule choice stems from their being time-of-day dependent. Several of the non-work activities mentioned above have fixed schedules, either because they are only available at certain times-of-day (like classes), or because an a priori agreement has been made with an instructor or activity partners. Conversely, activities such as shopping and going to the cleaners rarely affect the choice between peak and non-peak travel, even though they are often chained to the work trip, and take place at least once a week. These activities can be completed at almost any time of day, within the constraints of business hours: for example, local supermarkets close no earlier than 10:00 P.M, while dry-cleaning establishments may open as early as 7:00 AM. and close as late as 7:00 P.M. Moreover, these activities could be completed with equal degrees of satisfaction during the weekend.

5.4.2.2 Non-Work Activity Scheduling Flexibility

Just as the usual classification of activities as mandatory or discretionary says little about

whether they impact the work schedule, it also sheds little light on the extent of scheduling flexibility that the activity affords. Some activities must be performed at particular times-of-day, if they are going to be performed at all. For example, in the case of C, even though her work at the animal shelter is voluntary, she must accommodate to the shelter's regular work shifts, which in turn required her to rearrange her campus work hours. Conversely, while in general there is little slack in scheduling when it comes to taking children to school, parents of older children may consider dropping them off well before classes start, thus regaining some scheduling flexibility. This was the strategy used by D: her daughter arrives 30 minutes early at school, while she arrives 15 minutes "late" at work.

Neither is the ability to cancel a regular activity a function of its being mandatory or discretionary. In two-parent households, even when the responsibility to drive the children to school falls primarily on one of the parents, the other parent occasionally may take care of this activity. So although the primary driver has one less time-dependent activity in his/her schedule, the activity itself need not be cancelled. However, household members cannot substitute when it comes to personal activities such as exercise, hobbies or religious practice. Thus, under some circumstances, it might be easier to "cancel" a mandatory activity than a discretionary one.

5.4.2.3 Non-Work Activity Scheduling and Workers' Demographic Profile

Oftentimes characteristics such as age, education, marital status, family size, family role, and children's ages, instead of activity characteristics, are used to explain people's travel behavior. In some cases the relationship between travel behavior and demographics is strong. But in other cases people's demographic profiles are insufficient to make inferences about the types of non-work activities they are likely to engage in, or about their scheduling preferences and constraints.

In this sample, the most clear interactions between work and non-work activity schedules occur among workers with young children at home. This is especially the case with working mothers (subjects D, E, and H): two of the three working mothers bear the primary responsibility of driving the children to and/or from school and after-school activities. The other used do it, but now she does it only on occasion, because her oldest child is old enough to drive and takes care of driving the younger one. Conversely, only one of the four working fathers, subject J, is routinely responsible for shuttling his children back and forth, and only on the days in which his wife works.

Hence three workers, D, H, and J, have fit their work schedules around school and daycare hours, to the extent that the available job flexibility allows it. In one case the availability of a very flexible schedule has allowed a research associate to schedule her work around her baby's day care needs, and she recently changed it to take advantage of

changes in her husband's working hours. In the other case, while a flexible schedule was not a job prerogative, D was able to negotiate a 15 min. late start every day, and a one hour early departure twice a week, in exchange for working through lunch and at home, which allows her to meet most of her daughter's transportation needs.

On the other hand, all fathers except J were relatively free to schedule their work without taking into account their children's activities: those with small children have spouses who are either homemakers or work part time. And though subject M's wife worked full time, she was able to base her business at home. In addition the couple hired someone to provide day care at home. Obviously income also plays a role here, in addition to gender differences in the distribution of household labor, since three of the four male parents are faculty members, while the working mothers are administrative assistants or research staff.

While for these men the children's activities or needs are rarely a constraint on their schedules, most of them expressed a desire to end the day at a time early enough to participate in dinner and/or bed time. They would drive children to and from school to the extent that school start and end times coincided with their usual commute times, however the main responsibility for this chore rested with the spouse, and in fact several cited this (together with being at home while the kids are not in school) as a reason for their wife's working part time, working at home, or not working at all for a salary.

Another case of a relationship between demographic characteristics and non-work scheduling preferences is the case of older, empty-nest workers. Two of the three empty-nesters in this sample tend to lead relatively quiet lives: they are senior enough that they need not take employment-enhancing classes, neither of them dedicates serious time to hobbies (other than reading or watching T.V.) or other activities outside home. The only scheduled non-work activity appears to be dinnertime. Consequently, the hours they work seem to be primarily determined by job needs, even if they have some work flexibility.

One type of non-work scheduling preference that is difficult to predict with traditional demographic variables is the choice of sleeping hours. Some workers stated that they like to rise early, and as a result arrive on campus before 8:00 A.M., or work at home for a couple of hours before the rest of the family rises. Others have tried, and sometimes succeeded, in re-scheduling their work start time towards later in the morning, since they find it taxing to get up early.

5.4.3 Time-of-Day Characteristics of the Transportation Supply

In addition to work rules and non-work activity effects, the study also considered the characteristics of transportation supply as a factor in work schedule and trip timing choice. There were two characteristics of the travel environment that affected people's

work and work travel scheduling behavior. One was the scarcity of parking at and around the UCB campus; the other was the traffic peaking pattern on the roads leading from the study area to campus.

5.4.3.1 Parking

Parking at and near the UCB campus is at a premium. By 8:30 A.M. some of the parking lots are already full, and by 9:30 A.M. not even attendant parking is available in a few of them (see Table 5.3). All workers are aware of the latest time at which they can arrive in the morning and still park at their regular lot. A few subjects mentioned parking, and not concern for being late, as the reason for rushing in the morning or for not choosing a later arrival time.

Even so, most subjects arrive on campus well before their usual parking lot reaches capacity (see Figure 5.3), which indicates that concern over parking availability, while limiting their latest feasible arrival time, is not their primary work scheduling motivation. Most people dislike leaving their car keys at the garage, which is required if arrival occurs after attendant parking has begun. But even these workers mentioned other work or non-work related motivations as the primary driver of their work schedule choice.

There are alternatives to campus parking, and two people take advantage of them. Subject J would rather park on street than arrive earlier, not just because he would have to

drive during peak hours, but also because he would have to cut short the time he spends in the morning with his two-year old child. On-street parking entails checking or moving the car every two hours. Subject H rents a private garage a few blocks from her office, which allows her to schedule her work completely around her son's child care schedule.

TABLE 5.3
Time-of-Day Parking Availability on UCB Lots and Structures
1998

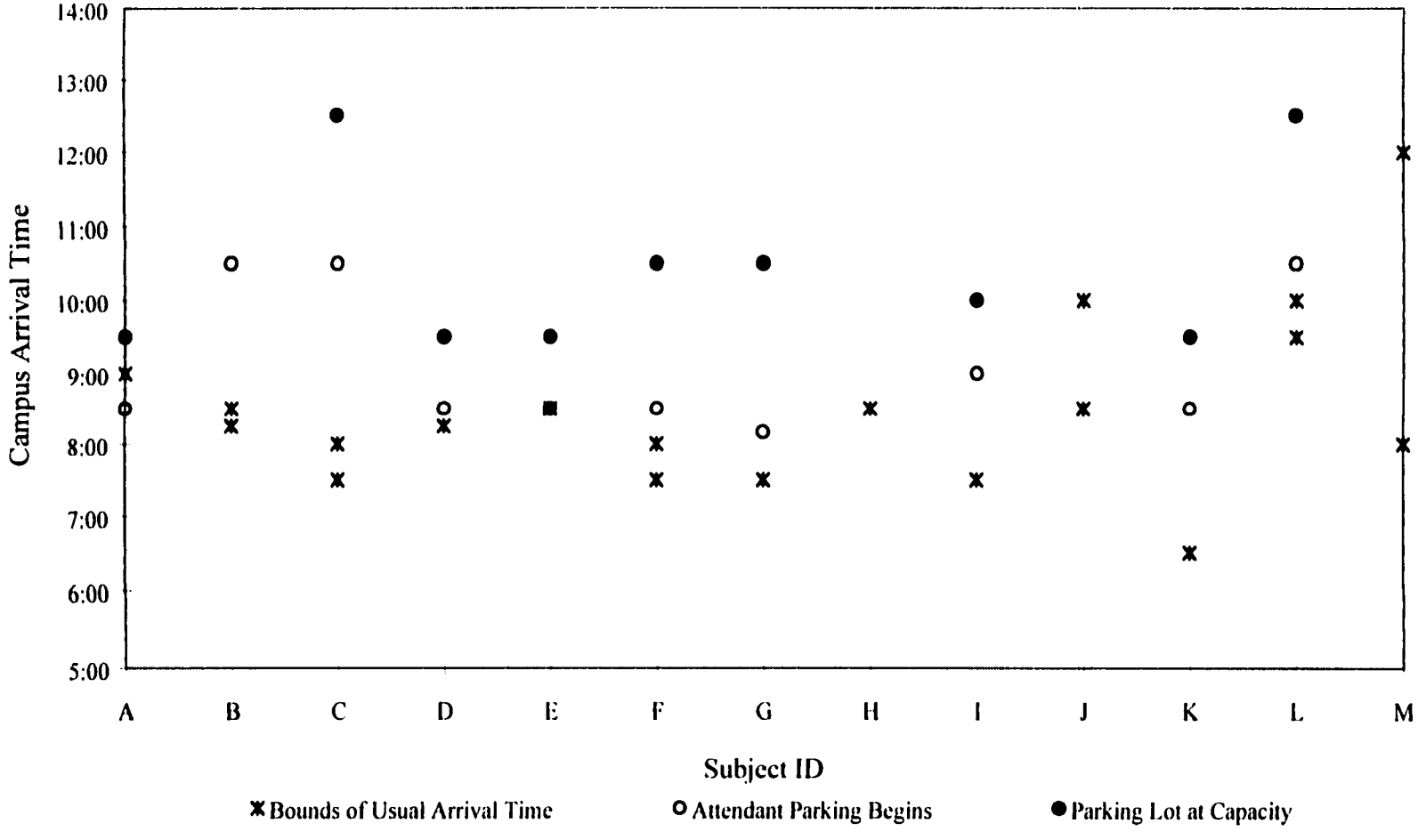
Lot Name	Hours of Service (AM - PM)	No. of Spaces Stacked	Avg. Time Stacking Begins	Avg. Time at Capacity
Bancroft Structure	9:30 - 5:00	30	10:30	2:30 PM
Bancroft/Fulton	8:00 - 6:00	45	9:00	10:00
Dana/Durant	7:30- 6:00	30	8:00	9:00
Dwinelle Lot	9:30 - 7:00	34	10:30	12:30 [b]
Foothill Lot	8:00 - 6:00	90	9:00	
Lower Hearst (level 1)	8:00 - 6:00	65	8:30	9:30
Lower Hearst (level 2)	8:00 - 6:00	65	8:30	9:30
Lower Hearst (level 3)	8:00 - 6:00	65	8:30	9:30
Recreational Sports Facility	8:00 - 6:00	65	8:30	9:30
Upper Hearst (level 4)	10:00 - 7:00	25	10:30 [a]	12:30 [a]
Upper Hearst (level 1)	10:00 - 7:00	30		
University Hall (level 1)	7:30 - 6:00	30	8:00	10:00
University Hall (level 3)	7:30 - 6:00	40	8:00	10:00
Kleeberger Lot	8:00 - 6:00	40	8:30	11:00
Ellsworth Structure	8:00 - 6:00	120	8:30	10:30
Underhill Lot	8:00 - 6:00	130	8:30	10:30
West Anna Head Lot	9:00 - 6:00	40	9:00	10:00

Source: Office of Parking and Transportation, University of California at Berkeley.

[a] Information not available.

[b] Lot seldom fills up.

FIGURE 5.3
Attendant and Capacity Parking Limits for the Sample Subjects.



5.4.3.2 Traffic Peaking Pattern

The characteristics of travel time were evaluated independently of the interviews. Floating car runs were performed both in the morning and in the evening, from campus to all freeway exits used by subjects in the sample. Three characteristics of the peaking pattern were found to affect time-of-day work travel choice:

(a) The length of the peak period:

Both in the morning and in the evening, the peak lasts for approximately two hours. Subject A, who is on flexitime, needed to flex her arrival by 60 minutes to avoid the peak. Professors L and M report waiting sometimes 30 minutes or more beyond their preferred departure time, to make sure traffic is free-flow.

(b) The difference between average peak and non-peak travel times:

Depending on distance traveled, this difference varied from one-third to one-half of the one-way travel time. For the three professors, this difference was sufficient to keep them from traveling during peak hours on a regular basis. Among the rest of the subjects, only A appears to have taken action to avoid the peak, and that only for the morning commute.

(c) Within time-of-day travel time variability:

Peak period travel times exhibit a larger standard deviation than non-peak travel times. Subject B accounts for this variability when choosing her home departure time. On days

on which her journey is longer than usual. she forgoes her stop for coffee in order to make sure she is at work on time. H leaves from campus no less than 60 minutes before she has to arrive at the daycare center. even though the usual travel time is about 45 minutes. because occasionally it will take longer and she gets charged $5 for each minute she arrives past the latest pick up time. Professors cited arrival time uncertainty due to travel time variability as another reason to avoid peak hours.

5.4.4. Behavioral Mechanisms for Choosing Time-of-Day for Work Travel

Table 5.4 lists the main drivers of work scheduling choice for each subject in the sample. There are three main behavioral mechanisms that explain the choice of time-of-day for work travel among these workers. These mechanisms appear to be adopted depending both on the amount of work scheduling flexibility available to the worker. and the extent to which they use this flexibility to attend to non-work demands, as explained next.

5.4.4.1 Compliance with Official Work Schedules

Workers with non-flexible work schedules have little choice to decide when to start or end their day. Their discretion is limited to arriving earlier than their official start time, or leaving later than their official end time. Two of these three workers rarely stay in the office past their official work end time. The other person works overtime often, so his departure time varies a lot.

TABLE 5.4
Drivers of Work Schedule Choice

Work Schedule Choice Mechanism	Subject ID	Work Schedule Determining Motivation (s)
Official Work Schedule	B	Official start and end times.
	F	Official start and end times. Arrives 20 minutes early. Could flex, but thinks in his case it would be unprofessional.
	I	Official start time. Often works past his official end time.
Work Schedule vs. Travel Time Tradeoff	A	Avoid morning peak hour. Requested flexitime to be able to arrive one hour later than official schedule.
	K	Avoid morning and evening hour. Works about 12 hours per day on campus.
	L	Combination of class schedule (mid-morning arrival), and evening peak hour avoidance. Prefers to work at home in the morning.
	M	Class schedule. Prefers to work at home otherwise.
Work Schedule vs. Non-Work Schedule	C	Flexed end time to be able to do volunteer work off campus. Used her vacation time so she does not need to flex her arrival time.
	D	Take child to school in the morning.
	E	Aerobics classes, religious activities in and out of home.
	G	Preference for early working hours.
	H	Drop off and pick up child from day care.
	J	Varies by day of the week: drop off and pick up wife from work and child from day care, dance group.

In the morning, three of these workers regularly leave home early, in effect keeping a buffer interval between their usual arrival time and their official start time. Subject F plans to arrive at his office up to 20 minutes ahead of his official start time, and uses the buffer interval to perform various work activities, such as going over the weekly calendar or the mail. Congestion avoidance or travel time variability did not seem to play a role in choosing the buffer interval. Instead the buffer seems to be merely an interval convenient to get ready to start working. B behaved in a fundamentally different way. She gets docked if she is not at work on time, so her decision as to how early to leave from home is a function of travel time variability. However short travel times do not translate into early work arrivals, because when she is early, she stops on her way to work for a cup of coffee. So her buffer time is observed not by how early she arrives at work, but by how early she leaves from home.

Subject I must comply, in principle, with a fixed work start time. However, partially because his supervisor knows he commutes from far, he is allowed to be late without suffering an income or other type of tardiness penalty. Thus, unlike the other fixed schedule people, he does not keep a buffer interval, and in effect plans to arrive exactly on time, as the flexible schedule workers do. Not surprisingly, he reports occasional late arrivals.

These workers' occupations are fairly different, which underscores the limitation of using occupation as an indicator of work schedule flexibility. On the non-work side, they have

in common that none of them has to take care of children.

5.4.4.2 Tradeoff between Work and Work Commute Schedules

In contrast to the group above, some workers schedule their working hours and work trips with the primary intent of avoiding peak travel. These workers share two characteristics:

- They are either free to schedule their work at practically any time of day, or their job has allowed them to flex their work schedule by at least 60 minutes; and
- By and large, they are free of child-related or other household-activity scheduling constraints.

All three professors in the sample fall into this category, as they all consciously avoid the peak hours (both in the morning and in the evening), to the extent that their class schedules allow it. Coincidentally perhaps, they all happen to have spouses who work either part-time or at home, so they are not primarily responsible for meeting the transportation needs of their children. The other person in this group is subject A, who requested and was granted a change of schedule. She stated that her motivation for asking for it was to be able to avoid the morning peak hour (due to the length of her work day, she cannot avoid both morning and the evening peak).

5.4.4.3 Tradeoff between Work Schedules and Non-Work Schedules

All workers in this group have either flexed their official schedule, or established a job schedule considering both the demands of work and their non-work activity preferences and constraints. Workwise, the most common concern is to try not to deviate too much from the university's schedule, for reasons such as the need to interact with colleagues, or to make sure they are available to students and other staff during regular office hours. Concerns about peak hour congestion play little or no role in their work scheduling decision.

With two exceptions, these workers have something in common: they bear a large share of the responsibility for driving young children to and from school or child-care, for seeing them off in the morning, or for being at home when they come back in the afternoon. These workers prefer schedules later than the official hours. It appears that to be on campus by 8:00 A.M., some of them would have to drop off their children at school well before school starts (more than 30 minutes early in some cases), hence the preference for flexing the work start time towards later times. Later schedules also result from a desire to spend time in the morning with the children, as is the case of J.

In addition to child responsibilities, some of these workers engage in non-work activities after work. Subject E attends an aerobics class and religious activities, in and out of home, on various days of the week. While she needs to ensure that her work hours give

sufficient office coverage, she has accommodated her schedule to allow her to attend these activities. The case of C instead is rather unusual: she exchanged vacation time for the option to leave one or two hours before her previous official end time. And she did this to facilitate her volunteer work. Subject J's schedule varies considerably from day to day, partly to accommodate his wife's part-time schedule, and partly to participate in a dance group after work.

Besides child-care responsibilities and the desire to engage in non-work activities, workers cite preferences for working hours (or sleeping hours) as another reason to flex the work schedule. For example, G likes to rise early and as a consequence starts the day early. Because of his early schedule, he avoids most of the morning congestion, but as he tends to stay on campus for about 10 hours every day, he leaves his office during evening peak times. In fact, he stated emphatically that he would not consider staying longer at work only to avoid the evening traffic.

5.5. SUMMARY

These interviews helped clarify several issues related to the extent and nature of activity scheduling flexibility, both for work and non-work activities.

Among university employees work scheduling flexibility is not necessarily related to their occupation or their being on flexitime. In order to understand the flexibility available to

any given worker, questions must be designed to gauge their discretion to choose work hours, including: discretion to work at home, core work hours, discretion to flex the lunch hour, ability (or need) to set schedules that vary by day of the week, and extent (in minutes) to which the work arrival and departure times can be shifted.

It was also established that day to day variability in arrival and departure times is due primarily to systematic, day of the week differences in work schedules. And while lack of trip timing variability does not necessarily imply lack of work scheduling flexibility, it is the most flexible workers who can flex their schedules enough to exhibit large systematic day-to-day variability. These workers' work trip scheduling motivations may vary by day of the week. Their ability to tailor work arrival and departure times to these varying motivations stems in large part from their discretion to work at home and/or a variable number of hours per day. Workers whose jobs do not allow them this kind of scheduling discretion tend to arrive and leave at about the same time every day. Hence, if one were to use activity diaries to elicit work trip timing motivations, the activity that affects their work trip timing choices may or may not be observed depending on the choice of diary day. This underscores the importance of using either several days' worth of diaries, or an interactive subject-interviewer method to elicit information about non-work scheduling flexibility.

Most of the workers in this sample who have some work scheduling flexibility have in fact flexed their work schedules, either to avoid peak hours or to take care of non-work

activities. However, only workers who enjoy both work and non-work scheduling flexibility indicate that their work trip timing choices are determined by concerns over traveling in congested traffic. Among these workers, arrival and departure times past the peak morning and evening times-of-day are more common than early arrival or departure times. These workers' non-work scheduling flexibility results in part from the presence of a non-working adult at home, who takes care of many household maintenance and child-related activities. This suggests that workers' home-related responsibilities are best examined at the household, and not individual, level.

Workers whose work trip timing motivation is the schedule of a non-work activity appear to have only a modest ability to simultaneously shift out of peak hours. This is because their non-work activities, whether discretionary or mandatory, have time-of-day dependent schedules which are not compatible with non-peak travel. While in most cases they are not required to travel at peak times-of-day, saving travel time seems to be a secondary, if at all, motivation for work trip scheduling.

We conclude that this sample suggests the presence of three behavioral mechanisms that explain the time-of-day for work travel decision. Commuters with non-flexible work schedules plan to arrive and leave from work at their official start and end times. Commuters who enjoy both work and non-work scheduling flexibility plan their trips with the goal of avoiding travel during peak times-of-day. And commuters who can flex their work hours but are required to, or choose to, engage in regular, time-of-day

dependent activities before or after work plan their trips balancing the requirements of work and non-work activities.

6.
ESTIMATION OF TRAVEL TIMES BY TIME-OF-DAY

6.1 BACKGROUND

In the context of work trip timing choice, the demand for travel at different times of day is characterized by people's desires for work and non-work activities and activity schedules. The other side of the trip timing problem is the supply side, that is, the transportation costs entailed by each possible activity schedule. One of these costs is the travel time incurred to access work at a given time of day [4]. When choosing between alternative times of day, the travel time difference between these times may characterize the supply of transportation. This chapter describes the estimation of travel time as a function of time of day. To estimate these functions we use reported door-to-door travel times. This is a considerable improvement over the way in which travel time differentials have been estimated in previous works. Moreover, this travel time study sheds some light on the time-of-day characteristics of travel time, an issue that has actually received little attention in the transportation literature.

In most prior studies of trip timing choice, travel time differentials have been estimated from network models or from floating car runs (McFadden et al 1977, Abkowitz 1981,

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[4] Other transportation costs that may vary by time of day include parking (or its availability), fuel consumption (proportional to travel time), road tolls, waiting and transfer times (for transit users due to differences between peak and off-peak vehicle headways), and transit fares.

Hendrickson et al 1981, Small 1982). Neither of these methods is likely to provide an accurate prediction of time-of-day travel times. Network models provide only two estimates, peak and off-peak travel times. Travel times in between the peak and off-peak need to be interpolated, usually linearly, which may or may not represent actual conditions. Moreover, the confidence intervals of network peak and off-peak travel time estimates are generally unknown. Hence it is unclear how well these models estimate actual travel times. For example, we compared the travel times reported in the 1990 BATS with the estimates obtained from MCTFCST, a network model calibrated with the same data. We found that for approximately 50% of the work trips reported in BATS, the travel time reported in the survey is more than 1.5 times the peak travel time estimated by the network given each trip's origin and destination zones. In addition, the peak time of day, as well as the times at which the peak period begins and ends, are chosen as a function of the aggregate regional travel demand. These times of day are assumed to be the same for all corridors and destinations, which is not necessarily the case.

While floating car runs can provide all of the above information, it is expensive and time-consuming to measure door-to-door travel times when one is interested in multiple origins and/or destinations. Thus it is common practice to collect travel times on only one section of an entire commute route, usually a freeway or major arterial. But this ignores the fact that congestion occurs also on the local streets, so that the measured travel time differentials are at best a lower bound on the actual differentials.

In contrast to network or floating car estimates, reported travel times provide corridor specific, door-to-door travel time. And as described later in this chapter, these data allow us to individually characterize the peaking pattern of each study corridor. Reported travel times are of course not free from error. These errors may be due to forgetfulness or misestimation on the part of the respondent, ambiguous and/or poorly-worded survey questions, and data entry mistakes.

When defining the characteristics of transportation supply, studies of trip timing choice have typically considered only differences in mean travel times (McFadden et al 1977, Small 1982). In effect these studies ignore the stochasticity of travel times. Yet travel time variability should inform both the specification of the choices and the selection of attributes for the different choices. Time of day is discretized so that choices are expressed as time-of-day intervals, but these intervals appear to be chosen independently of travel time variability. When the intervals are short, for example 5 minutes to 10 minutes long, the mean difference in travel times between adjacent intervals may be small compared to the standard deviation of these times. Hence people may not actually perceive a difference in the travel times of adjacent departure time intervals. Travel time variability may also affect trip timing choice because this variability is higher during peak hours than non-peak hours. Some people may choose off-peak hours more due to the higher uncertainty associated with peak travel times, rather than the shorter average travel time. A few studies have simulated the effect of travel time variability on trip timing choice using assumed travel time distributions, but these distributions have been chosen

so that their variance is constant, and not a function of time-of-day (Noland and Small 1995, Hendrickson and Plank, 1984).

The role of travel time variability may not be easily discernible from the role of mean travel time because they have the same effect on trip timing choice. But trip timing variability should at least be considered in the estimation of mean travel times. In studies that measure travel time between a single origin and destination, it has been found that the coefficient of variation of travel times increases with mean travel time, and that conditional on time-of-day, the distribution of travel times is approximately normal or lognormal (Smeed and Jeffcoate 1971, Richardson and Taylor 1978, Dandy and McBean 1984). When the distance traveled is varied, it appears that the standard deviation of travel time increases with increasing distance (Herman and Lam 1974, Polus 1979). Of these studies, only Herman and Lam propose a relationship between travel time variability and mean travel time, but in their functions they do not account separately for the distance and time-of-day effects. In summary, the distribution of travel times is not homoscedastic; instead, its variance appeas to be a function of time-of-day and distance traveled.

Given this background, this chapter makes two contributions. First, the estimation of travel time differentials is required to later study the effect of work and non-work flexibility on trip timing choice. But perhaps more importantly, our empirical examination of the time-of-day characteristics of travel time and their effect on travel

time estimation sheds light on an issue that has received insufficient attention, and yet is crucial for the understanding of trip timing choice.

6.2 DATA DESCRIPTION

Travel times are required for two commute corridors: Highway 24, which links East Contra Costa County with Oakland and Berkeley, and the Interstate 80/580 corridor, which links North Contra Costa County with Berkeley (see Figure 3.3). This requirement stems from the sampling design for the Activity Scheduling Survey, as described in Chapter 3.

East Contra Costa Co. is geographically separated from Berkeley by the Oakland / Berkeley Hills. Highway 24 runs between these two regions via the Caldecott Tunnel. Alternative routes between East Contra Costa and Berkeley are without exception two-lane roads which wind their way through the hills. There are no similar natural barriers between North Contra Costa and Berkeley. While the I-80 freeway is the only highway connecting these two regions, there are a few parallel arterials which are also used to commute between UCB and North Contra Costa. Hence, while most residents of East Contra Costa are likely to commute on Highway 24, residents of North Contra Costa can choose between the freeway and an arterial route. Morning and evening travel times are thus required for all the different facilities.

Reported travel times were obtained from the University of California 1996 Faculty and Staff Housing and Transportation Survey (F&S Survey)[5]. While this survey dates from two years prior to the Activity Scheduling Survey, it has advantages over field measurement data: each travel time observation is door-to-door, and there are observations available for several different residential origins. A copy of the survey questionnaire is available in Appendix 3.

Two subsets of observations were extracted from the 1996 F&S Survey. These correspond, respectively, to employees who live in North and East Contra Costa Co. All observations were restricted to employees whose primary commute mode is either drive alone or carpool. Each observation includes the following information:

- average one-way travel time
- additional travel time due to child drop off or pick up duties
- travel corridor
- residential zipcode
- usual work arrival time
- usual work departure time.

Several limitations of the data are noted:

- The travel time data were requested as "average one-way" travel time. This

[5] The Faculty and Staff Housing and Transportation Survey is conducted by the Office of Student Research, Physical and Environmental Planning, Department of Planning, Design, and Construction, University of California at Berkeley.

ignores the fact that because of differences between the levels of congestion encountered in the morning and evening, the morning commute time may be systematically different from the evening commute time. In requesting an average, some information is lost about time-of-day differences in travel time.

- Differences between morning and evening travel times may also arise due to differences in the geometry of the trip. That is, the morning commute route may be different from the evening commute route. The survey asked for the morning commute route only.
- The survey asked for "additional travel time due to child transportation duties", yet the average one-way travel time was not requested *exclusive* of child-related (or other) stops. Because the question was ambiguous, some people may have reported travel time including these stops, while others may have reported travel time exclusive of these stops. As we cannot tell how the question was answered, we cannot use the information about child-related stops to obtain an estimate of travel time exclusive of these stops.
- The questionnaire did not allow for the possibility that work schedules might vary systematically by day of the week. People with variable work schedules would have to arbitrarily choose from their various work schedules in order to answer questions about their "usual" arrival or departure time, or worse, they might average travel times from different times of day.
- To report their home-to-work travel distance, respondents were offered some pre-defined ranges. Unfortunately, these ranges were large enough that most

people commuting from either North or East Contra Costa fall within a single category, 5 to 10 miles.

- People who travel on surface streets were not asked to identify a major street or corridor.

Since there is no certainty as to how the questions were interpreted by the respondents, the following assumptions were made: the morning commute time is equal to the evening commute time, and equal to the average one-way travel time. This travel time estimate is exclusive of any time spent at child care or school related stops on the way to or from work. This would be the travel time associated with traveling between home and work, arriving at and departing from work at the times reported as the usual work schedule. Travel distance was independently estimated as the length of a straight line between the centroid of each residential zipcode zone and campus. The evening commute route was taked to be the same as the morning commute route. And finally, we pooled the observations of North Contra Costa residents who travel on surface streets to obtain a single travel time function for surface street travel, under the assumption that at any given time-of-day, traffic distributes itself among the various routes so that travel time is independent of the route taken.

6.3 TRAVEL TIME FUNCTION ESTIMATION

6.3.1 Travel Time Model

Travel time T on a corridor that does not experience recurrent congestion is a function of the distance traveled and any corridor access time; in particular the travel time would be independent of the time of day at which the trip is made. But when the travel corridor is subject to recurrent congestion, then the travel speed is not independent of time of day, for example work arrival time S: speed would be highest during non-peak hours, and lowest at some time S_M during the peak hour. When congestion is localized at a single bottleneck, and the length of the queue is small compared to the total distance traveled, then the additional travel time due to congestion depends solely on time of day S. Instead, if congestion is distributed along the corridor, this additional travel time would be a function of both the distance traveled D and time of day S. In general, both the pure time-of-day effect and the combined time-of-day and distance effects may be observed.

We choose to represent the relationship between travel time T and work arrival or departure time S as a linear model, shown in Equation 6.1 and depicted in Figure 6.1. The model says that the maximum travel time, $t_0+\alpha*D$, is incurred by travelers arriving at time S_M, and that it decreases at a rate $\beta_E + \gamma_E*D$ or $\beta_L + \gamma_L*D$ as the work arrival time is advanced or postponed with respect to S_M. As indicated in (6.1) the rate at which travel time builds up may not necessarily be the same rate at which it subsides. This model is

only valid for times-of-day later than S_E and earlier than S_L. We assume that travel time before S_E is equal to the travel time at S_E, and similarly that travel time after S_L is equal to the travel time at S_L [6].

$$T_i = t_0 + \alpha * D_i + \beta_E * (S_i - S_M) * \delta_i + \beta_L * (S_i - S_M) * (1 - \delta_i) + \gamma_E * (S_i - S_M) * D_i * \delta_i + \gamma_L * (S_i - S_M) * D_i * (1 - \delta_i) + \varepsilon_i \quad (6.1)$$

In (6.1), δ_i is a dummy variable that indicates if arrival occurs before or after S_M. The parameters to be estimated are t_0, β_E, β_L, γ_E, γ_L, and S_E, S_M, and S_L.

The error ε_i in (6.1) arises from different sources. Some of the error is due to the data reporting problems discussed above: the averaging of travel times realized at different times-of-day, and ambiguity about which work schedule to report or whether to include the duration of stops in the reported travel time. Travel distance was approximated on the basis of residential zipcode, so there may be some error due to variations in zipcode zone area across zipcodes, as well as the location of the zipcode zone relative to the freeway. Another source of error is related to how people account for travel time variability when reporting their "usual" travel time. For example, if travel time is 20 minutes three times per week and 30 minutes twice a week, some people may report their usual travel time as

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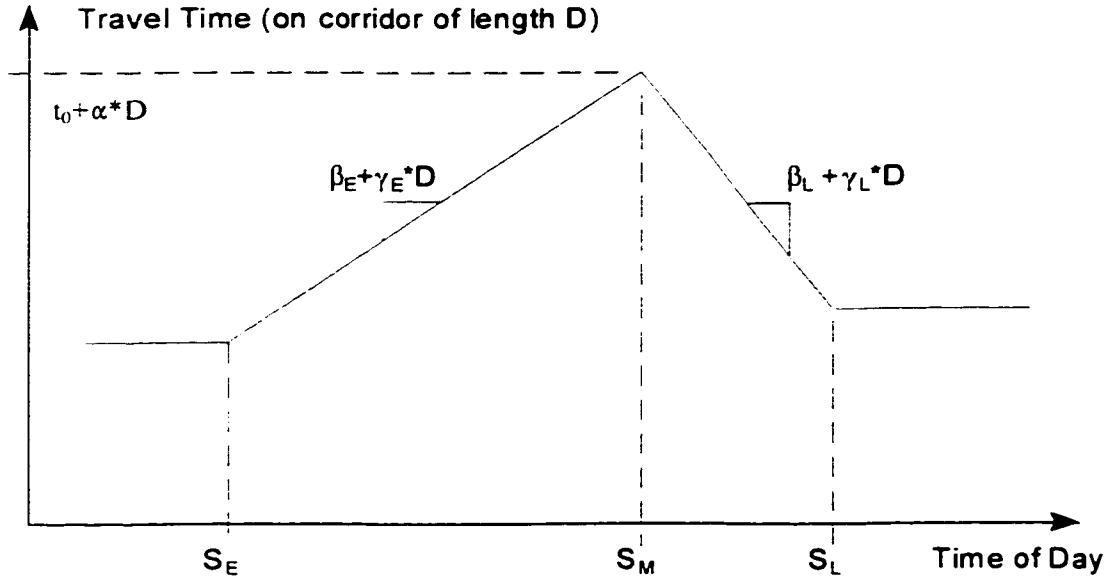
[6] Floating car runs conducted on a section of Highway 24 and on local streets near campus confirmed that travel times during non-peak hours are approximately constant. A similar conclusion is reached by examining Interstate 80 travel time data collected by the California Department of Transportation.

FIGURE 6.1
Corridor Travel Time Model



20 minutes, others as 30 minutes, and perhaps others as 25 minutes.

A preliminary analysis of the data showed high correlation (above 0.9) between (S_i-S_{i-1}) and $(S_i-S_{i-1})*D_i$. To avoid multicollinearity problems, we exclude the pure time-of-day congestion effects from the model specification. Pure time-of-day effects were not likely to be observed in the I-80 corridor data or the surface street data. Although in the morning there is a bottleneck on I-80 downstream from the exit to UCB, it is far away enough that its queue does not reach this exit. In this corridor congestion spreads approximately along the entire length of the corridor. Pure time-of-day effects were more likely on the Highway 24 corridor, because during peak periods the Caldecott Tunnel acts as a bottleneck. However, floating car runs on Highway 24 indicated that for UCB

commuters delays at the tunnel were relatively small. In the morning traffic does not back up at the tunnel entrance, although it slows down somewhat; in the evening, UCB commuters join the queue about one hundred meters upstream from the tunnel entrance. Excluding the pure time-of-day congestion effects from the model estimation, the model to be estimated is:

$$T_i = t_0 + \alpha * D_i + \gamma_E * (S_i - S_M) * D_i * \delta_i + \gamma_L * (S_i - S_M) * D_i * (1 - \delta_i) + \varepsilon_i \qquad (6.2)$$

6.3.2 Estimation of the Time-of-Day Parameters

The time-of-day parameters S_E, S_M, and S_L were estimated through a combination of visual data inspection and prior knowledge of traffic behavior on these corridors. To control for the effect of distance in this estimation, we estimated travel time T_i on the first two right-hand terms of (6.2), and used the residuals of this estimation to calculate the time-of-day parameters (see Figures 6.2 to 6.7). Table 6.1 shows the parameter estimates, as well as the number of observations available for each corridor and time period. Peaking in all three facilities is affected by the commute into San Francisco, as both Highway 24 and Interstate 80 are major regional commute corridors feeding into the Bay Bridge. The point where UCB commuters enter Highway 24 is located farther from the Bay Bridge than the point where UCB commuters enter I-80, which may explain why Highway 24 peaks earlier in the morning and later in the evening. The influence of the

FIGURE 6.2
Pure Time-of-Day Effect on Travel Times
Highway 24, AM Commute

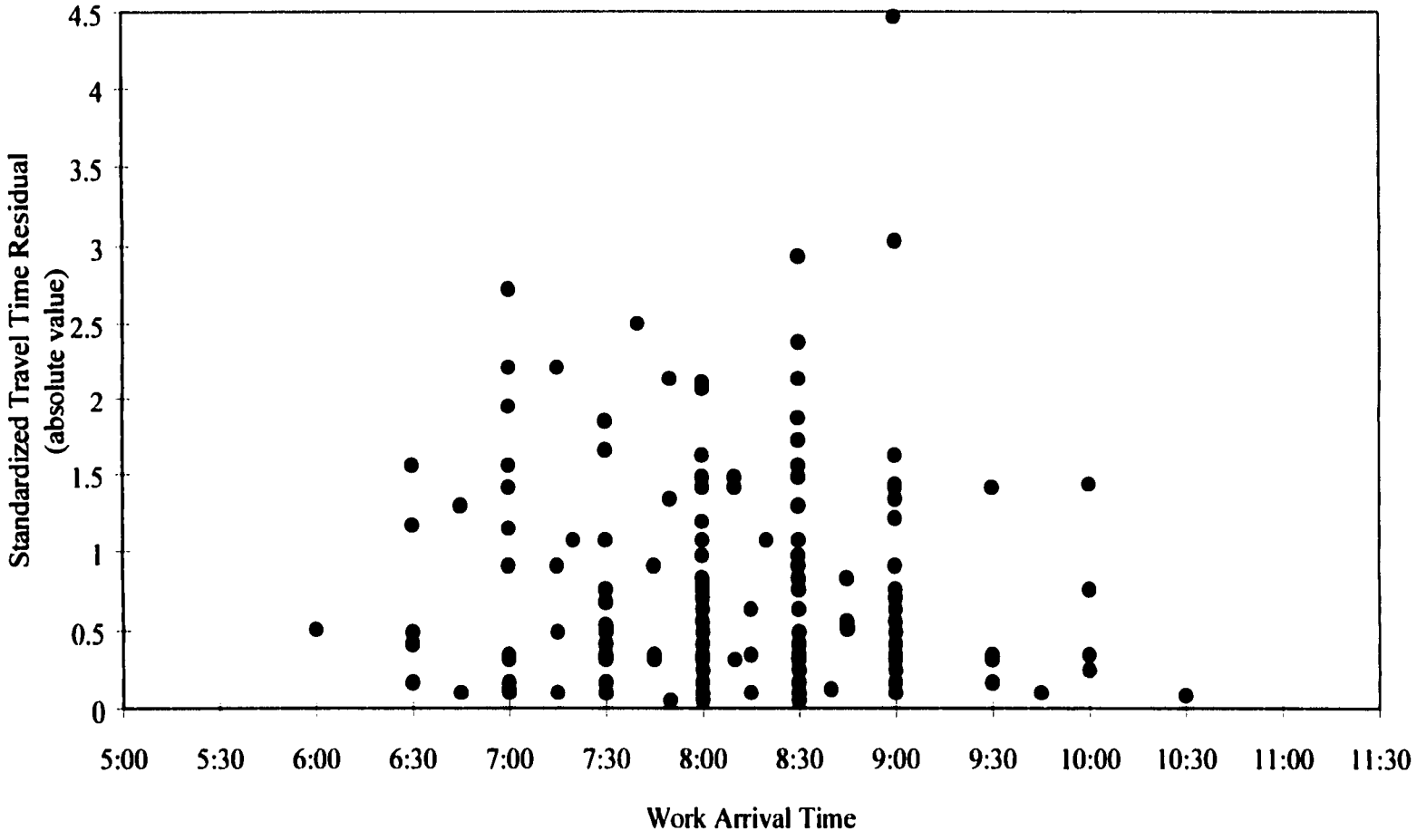


FIGURE 6.3
Pure Time-of-Day Effect on Travel Times
Highway 24, PM Commute

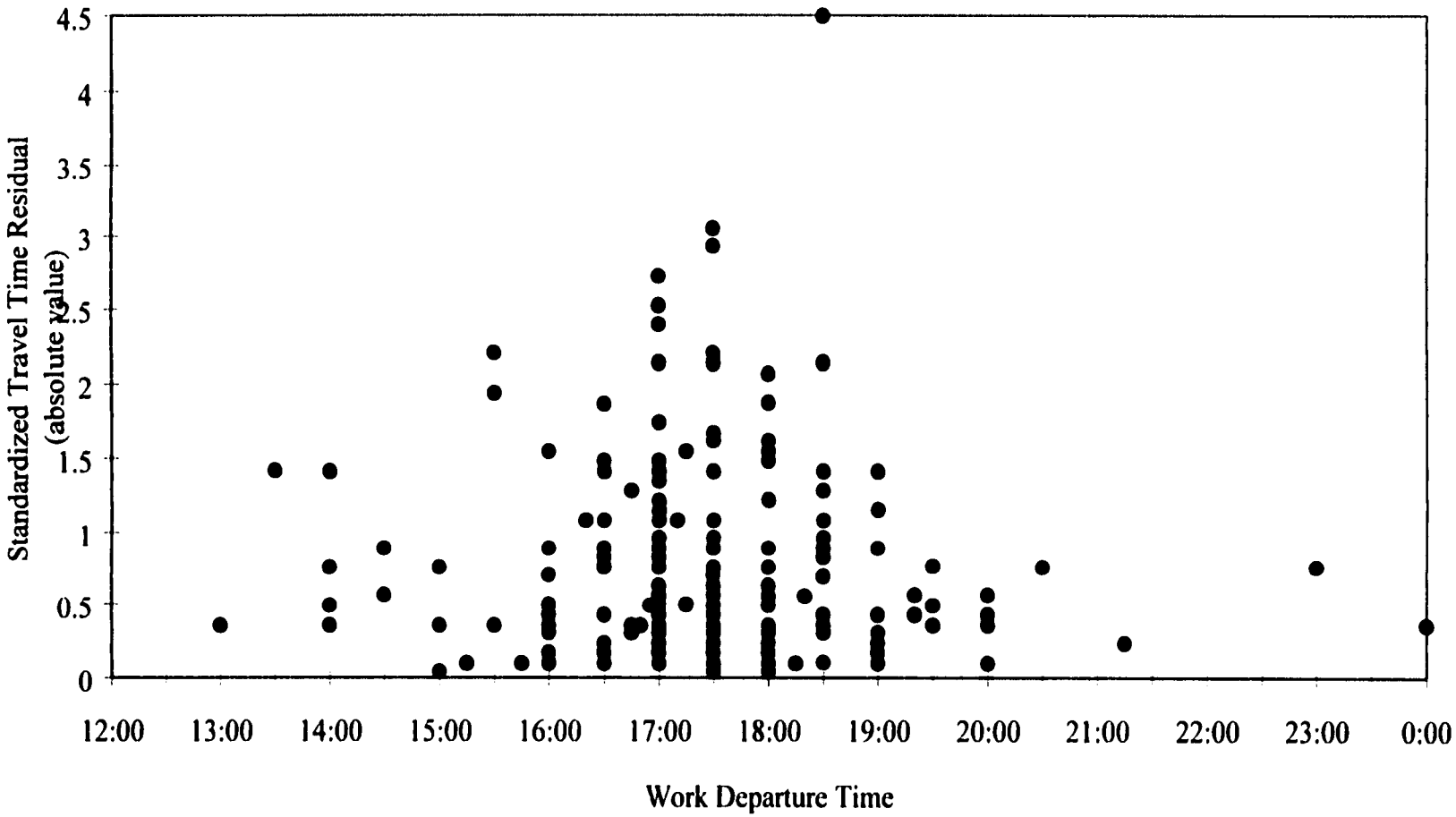


FIGURE 6.4
Pure Time-of-Day Effect on Travel Times
Interstate 80, AM Commute

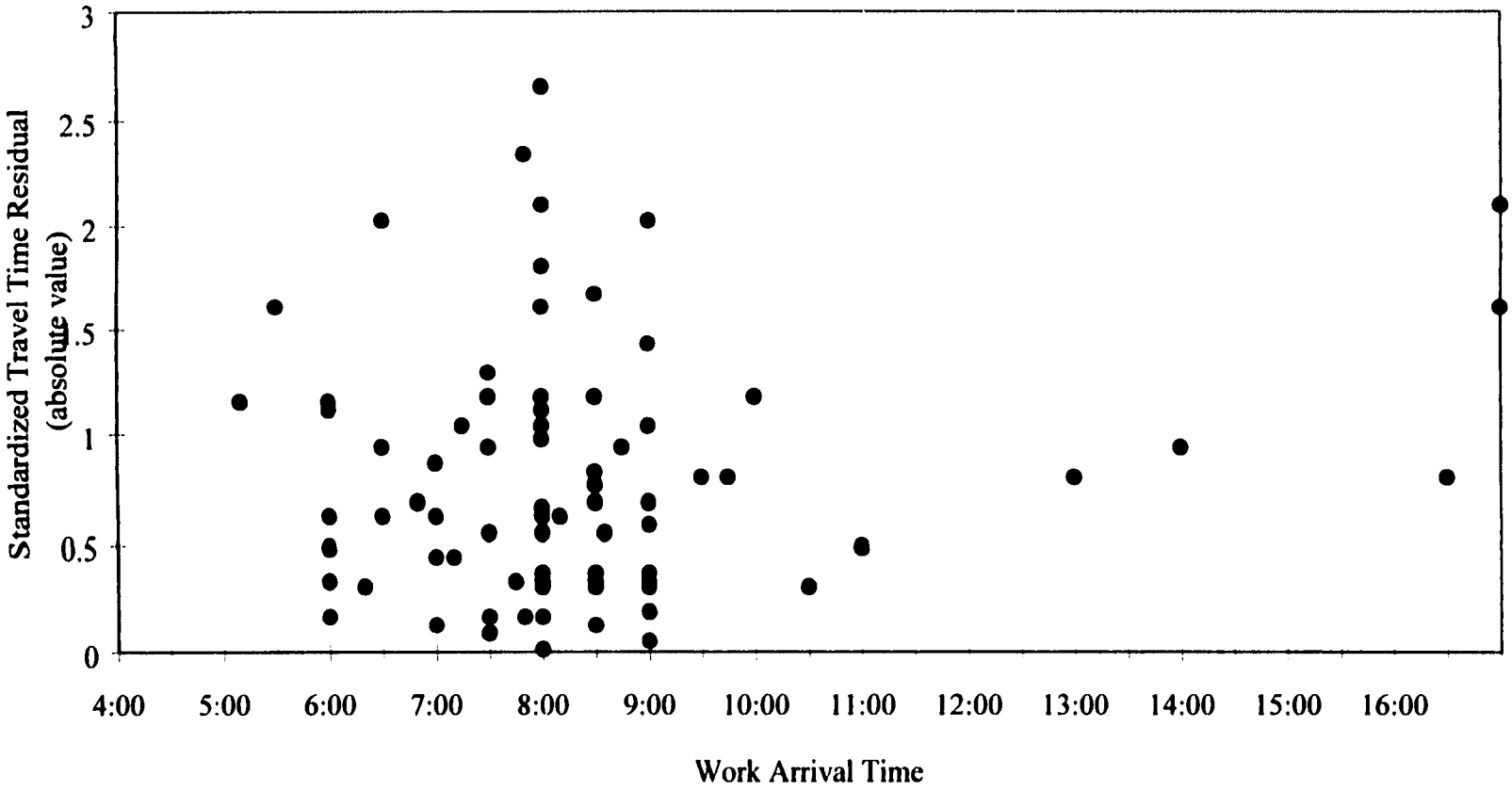


FIGURE 6.5
Pure Time-of-Day Effect on Travel Times
Interstate 80, PM Commute

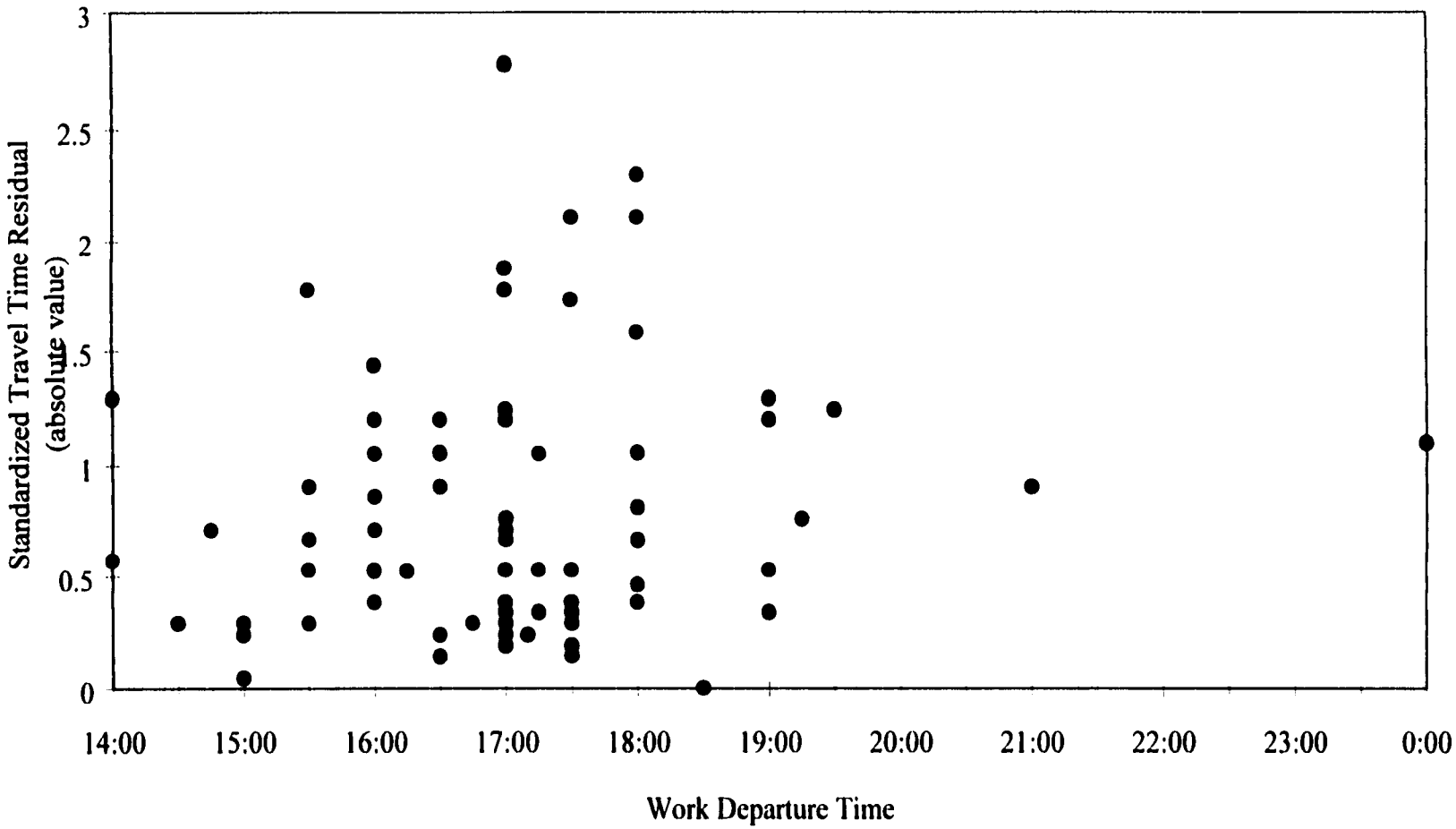


FIGURE 6.6
Pure Time-of-Day Effect on Travel Times
Surface Streets (I-80 Corridor), AM Commute

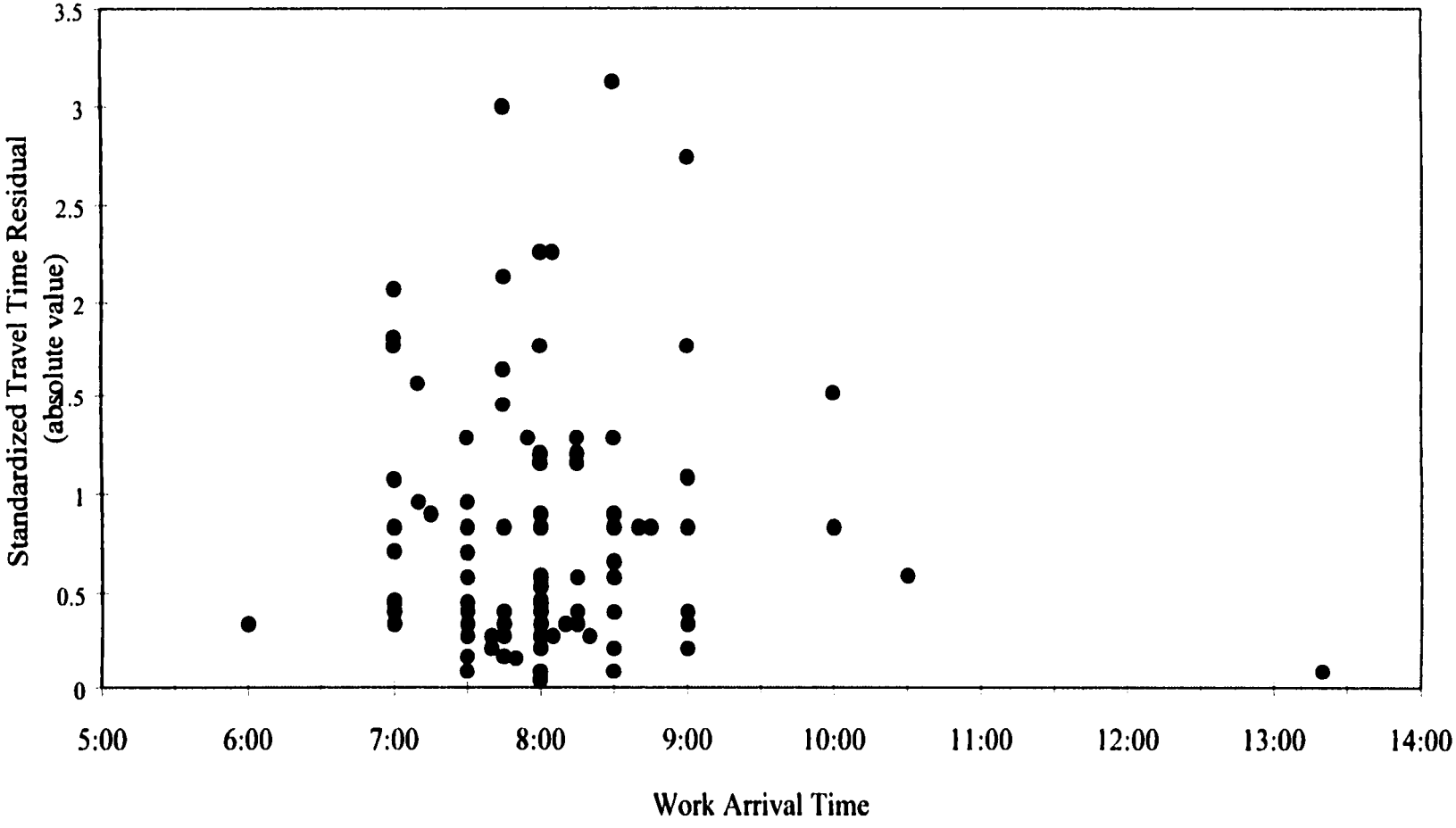
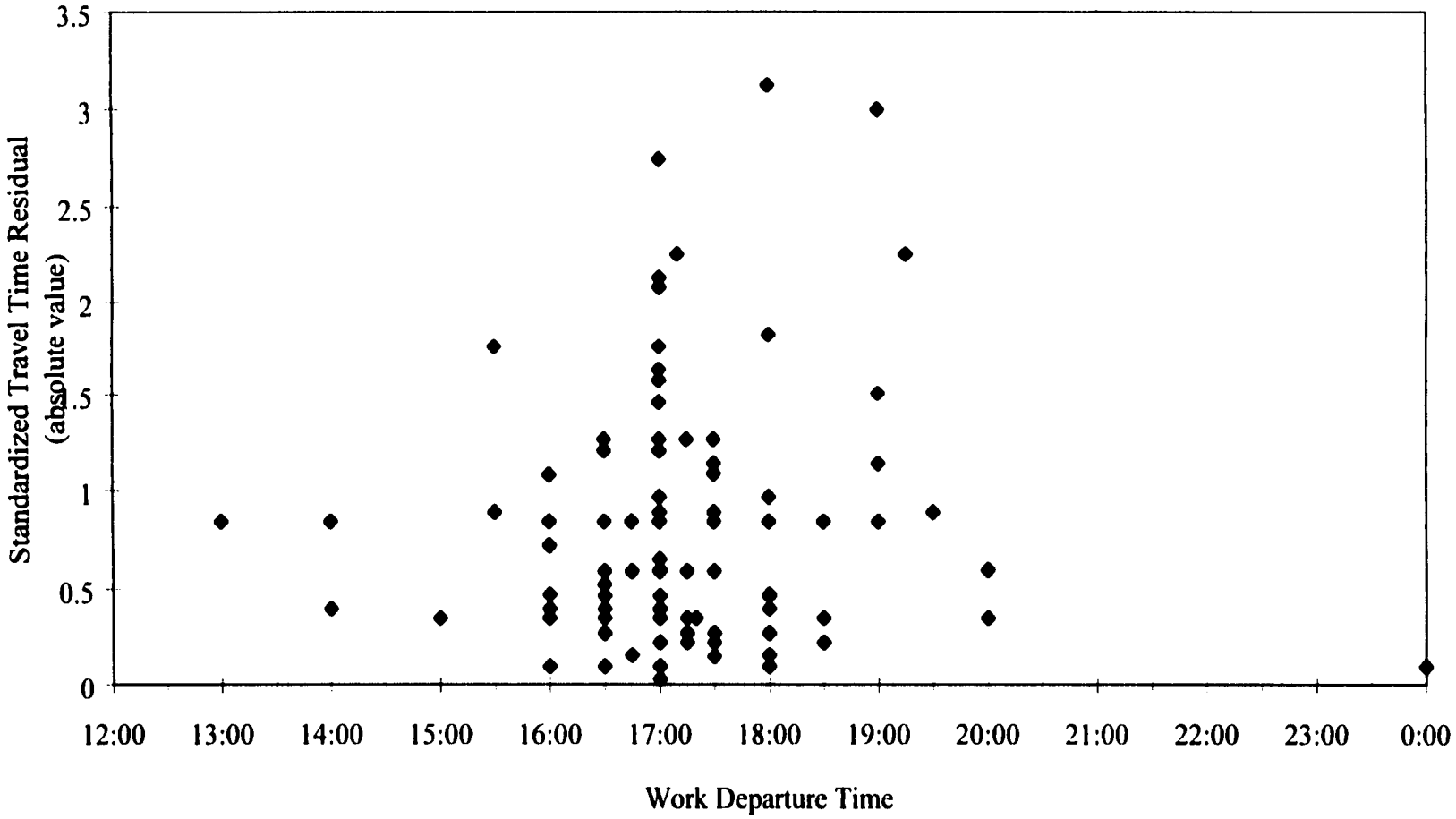


FIGURE 6.7
Pure Time-of-Day Effect on Travel Times
Surface Streets (I-80 Corridor), AM Commute



San Francisco commute may also explain why in the evening, the most common work end times at the UCB campus (4:30 P.M. and 5:00 P.M.) are associated with the longest commutes only for surface street commuters.

TABLE 6.1
Travel Time Estimation.
Sample Size and Time-of-Day Parameters

Period & Corridor	Sample Size	Peak Period Time-of-Day Range		
		Start Time S_E	Peak Time S_M	End Time S_L
Morning:				
I-80 Freeway	89	6:30	8:00	10:30
I-80 Local St.	108	6:30	8:15	10:30
H-24	190	6:00	8:00	10:00
Evening:				
I-80 Freeway	82	15:00	17:30	19:00
I-80 Local St.	95	15:00	17:00	19:00
H-24	189	15:00	17:30	19:30

6.3.3 Estimation of the Travel Time and Speed Parameters

Equation (6.2) was initially estimated for each facility and time period (AM or PM) using Ordinary Least Squares (OLS). The OLS estimates show the expected signs, and in most cases they are also statistically significant at 95% confidence (see Table 6.2). Observations outside of the time-of-day range of the estimation, that is $S_t < S_E$ or $S_t > S_L$

were included in the estimation with time-of-day $S_t = S_E$, or $S_t = S_L$, respectively. This improves the accuracy of the estimation, as there were few observations near the shoulders of the peak period. It does not bias the parameter estimates because non-peak travel times are approximately constant.

TABLE 6.2
Travel Time Function Parameter Estimates.
OLS Estimation.

	Parameter Estimates (absolute value of t-statistics in parenthesis)			
	Access Time	Pace at Peak Time-of-Day	Travel Time Savings	
			Early Travel [a]	Late Travel [a]
Corridor and Time Period	t_0 (min)	α (min/mi)	γ_E (min/mi-hr)	γ_L (min/mi-hr)
Morning				
I-80 Freeway	12.3 (2.6)	3.6 (5.9)	-0.65 (3.3)	-0.62 (2.8)
I-80 Surface St.	2.2 (0.5)	4.4 (6.8)	-0.75 (2.6)	-0.50 (1.1)
H-24	12.2 (7.1)	2.3 (12.3)	-0.61 (4.8)	-0.42 (4.0)
Evening				
I-80 Freeway	13.3 (2.6)	3.4 (5.2)	-0.44 (2.1)	-0.45 (1.4)
I-80 Surface St.	4.4 (1.2)	3.8 (6.5)	-0.48 (1.4)	-0.48 (1.8)
H-24	13.1 (7.5)	2.2 (11.0)	-0.26 (2.5)	-0.26 (2.3)

[a] Early and Late with respect to the peak time-of-day for each corridor and commute period.

As anticipated, in all cases the OLS residuals appear to exhibit non-constant variance. The variance of the OLS residuals is high for times-of-day close to the peak time-of-day S_M, and decreases towards the shoulders of the peak (see Figures 6.8 and 6.9) [7]. At the

[7] In Figures 6.8 and 6.9, time of day S has been standardized as follows: if $S < S_M$, $S'=2*(S-S_M)/(S_M-S_E)$; if $S>S_M$, $S'=2*(S-S_M)/(S_L-S_M)$.

same time, the variance of the residuals is not constant across distance groups, and it does not necessarily vary monotonically with distance (see Figures 6.10 to 6.12). Even so, White's test of homoscedasticity indicated that only in one case, the evening commute on Highway 24, do the data exhibit heteroscedastic behavior (see Table 6.3).

TABLE 6.3
White's Test of Homoscedasticity.[a]

Period and Corridor	Test Statistic (χ^2 with 7 d.o.f) [b]
Morning:	
I-80 Freeway	2.1
I-80 Local St.	1.4
H-24	10.4
Evening:	
I-80 Freeway	0.6
I-80 Local St.	0.5
H-24	16.7

[a] See Greene 1993 for a detailed explanation of the homescedasticity test.
[b] Critical χ^2 (95% confidence): 14.1

FIGURE 6.8
OLS Residuals by Time of Day
Morning Commute

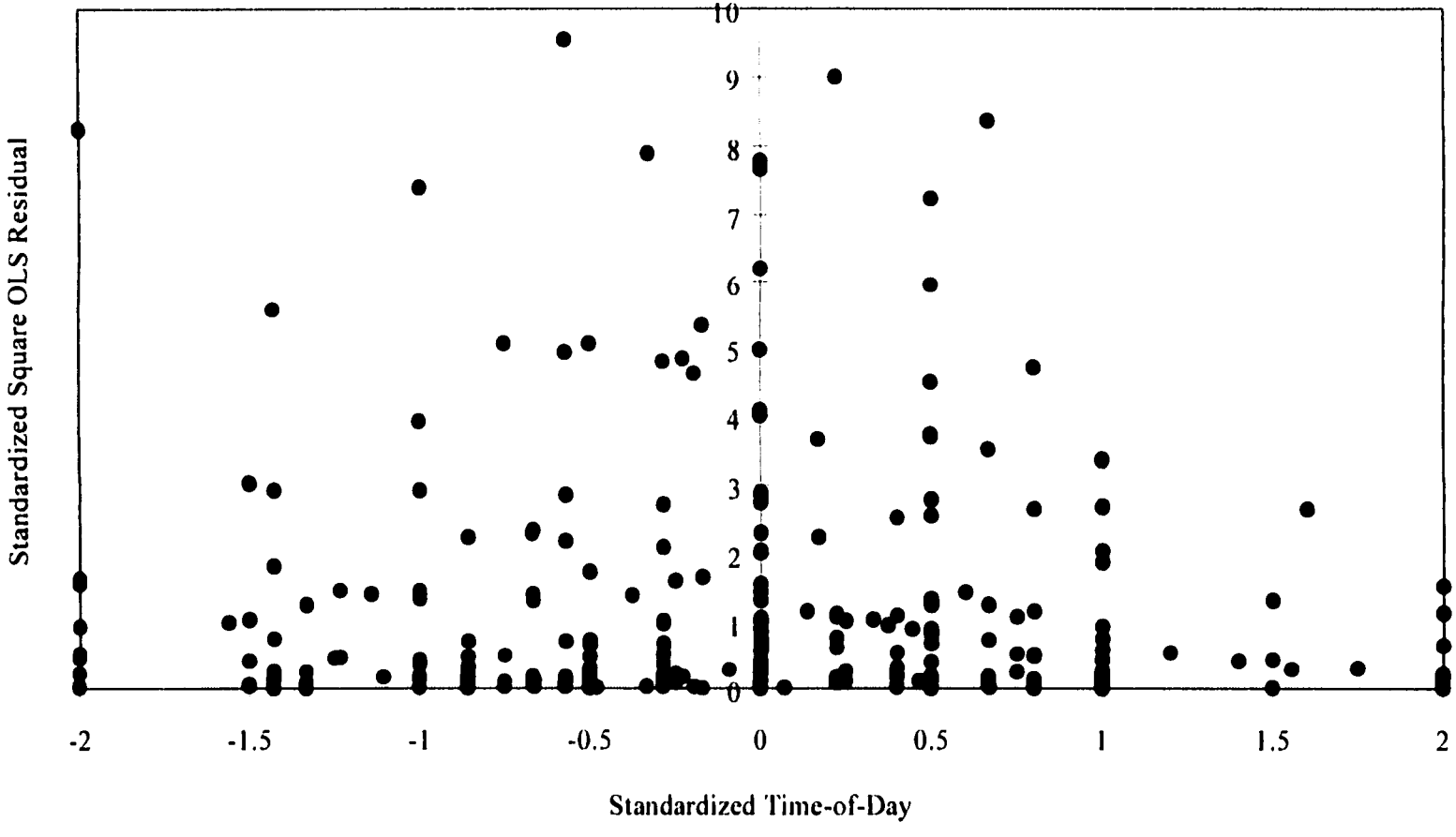


FIGURE 6.9
OLS Residuals by Time of Day
Evening Commute

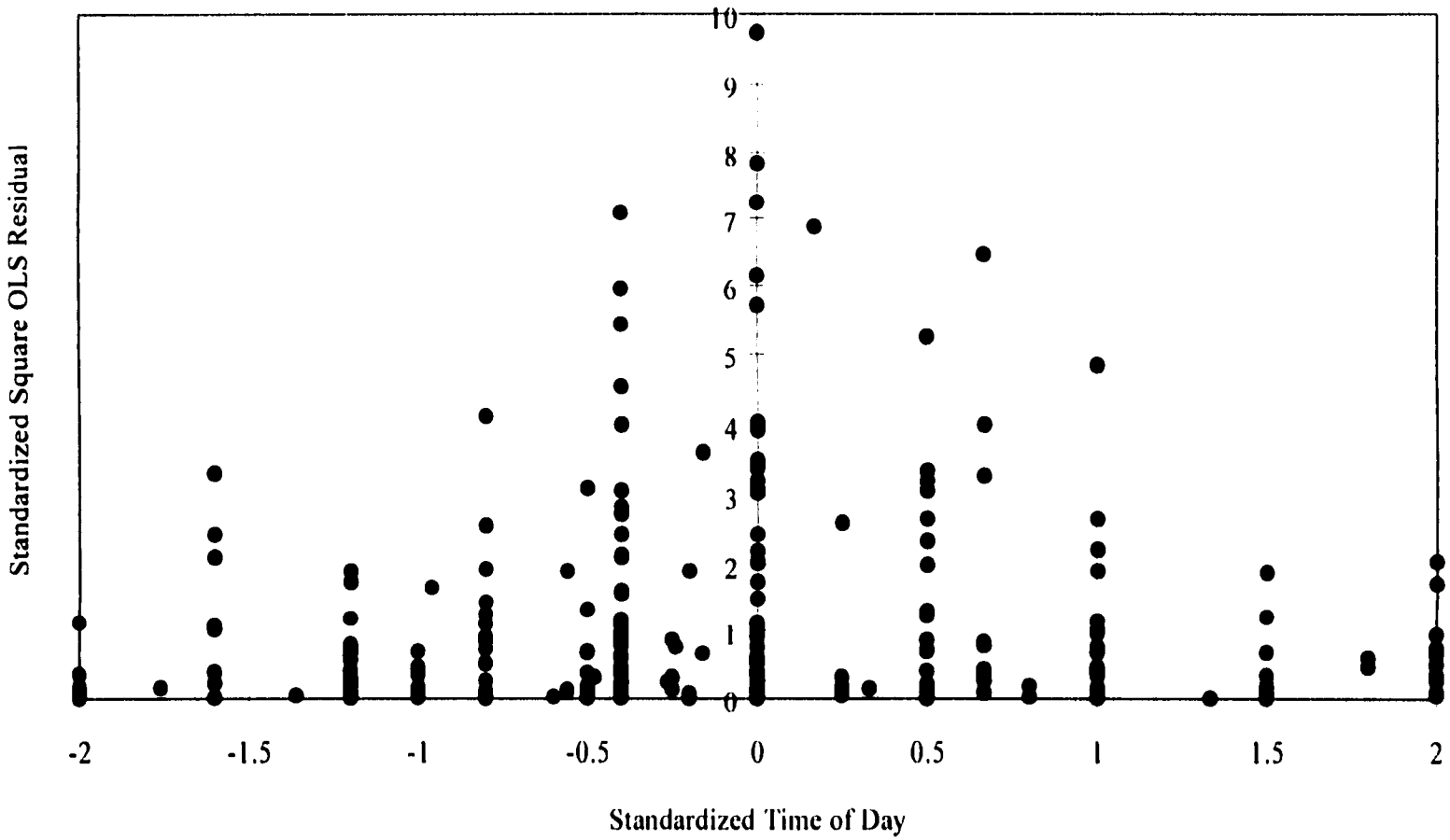


FIGURE 6.10
OLS Residuals by Distance Traveled
Highway 24

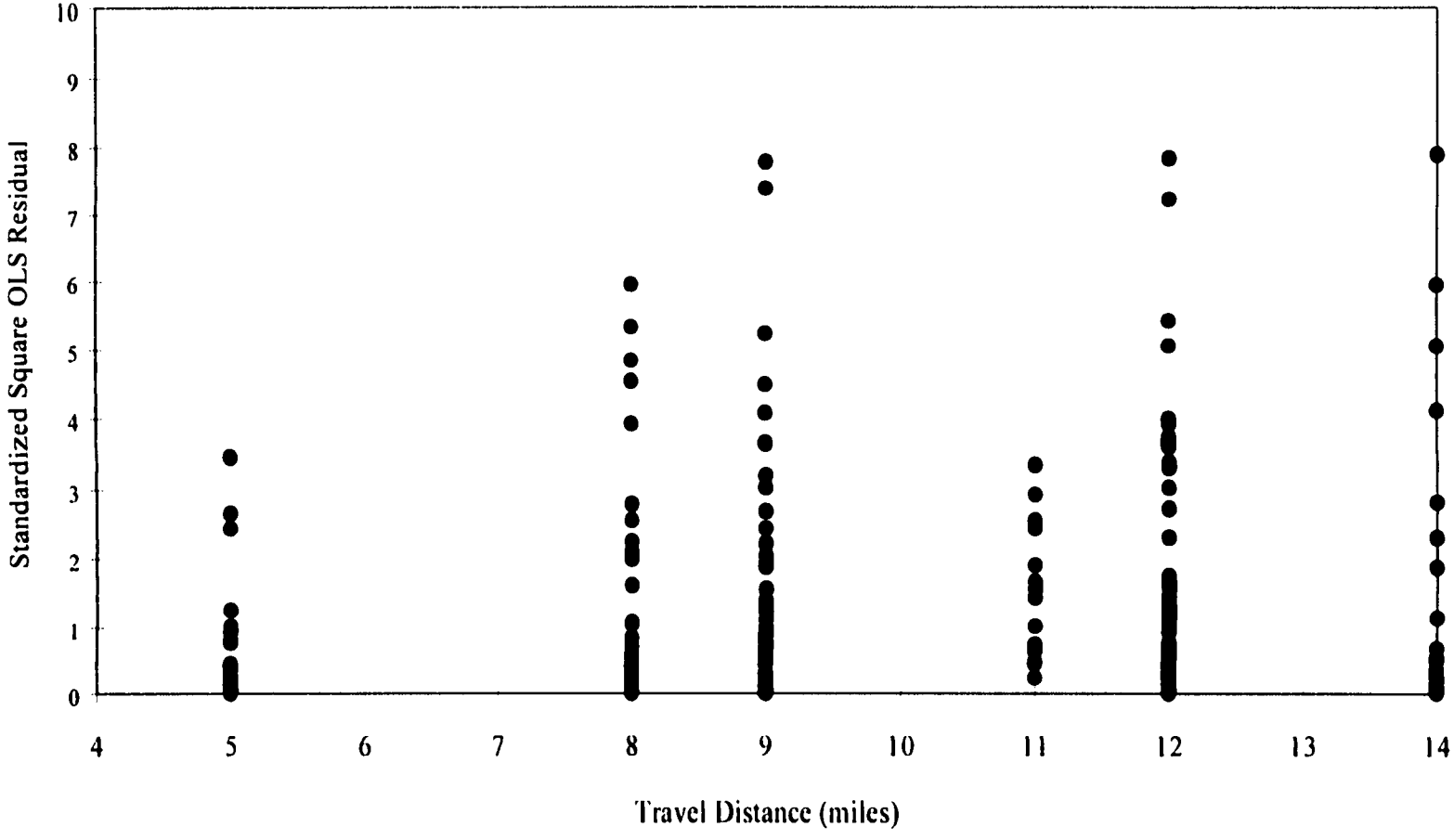


FIGURE 6.11
OLS Residuals by Distance Traveled
Interstate 80

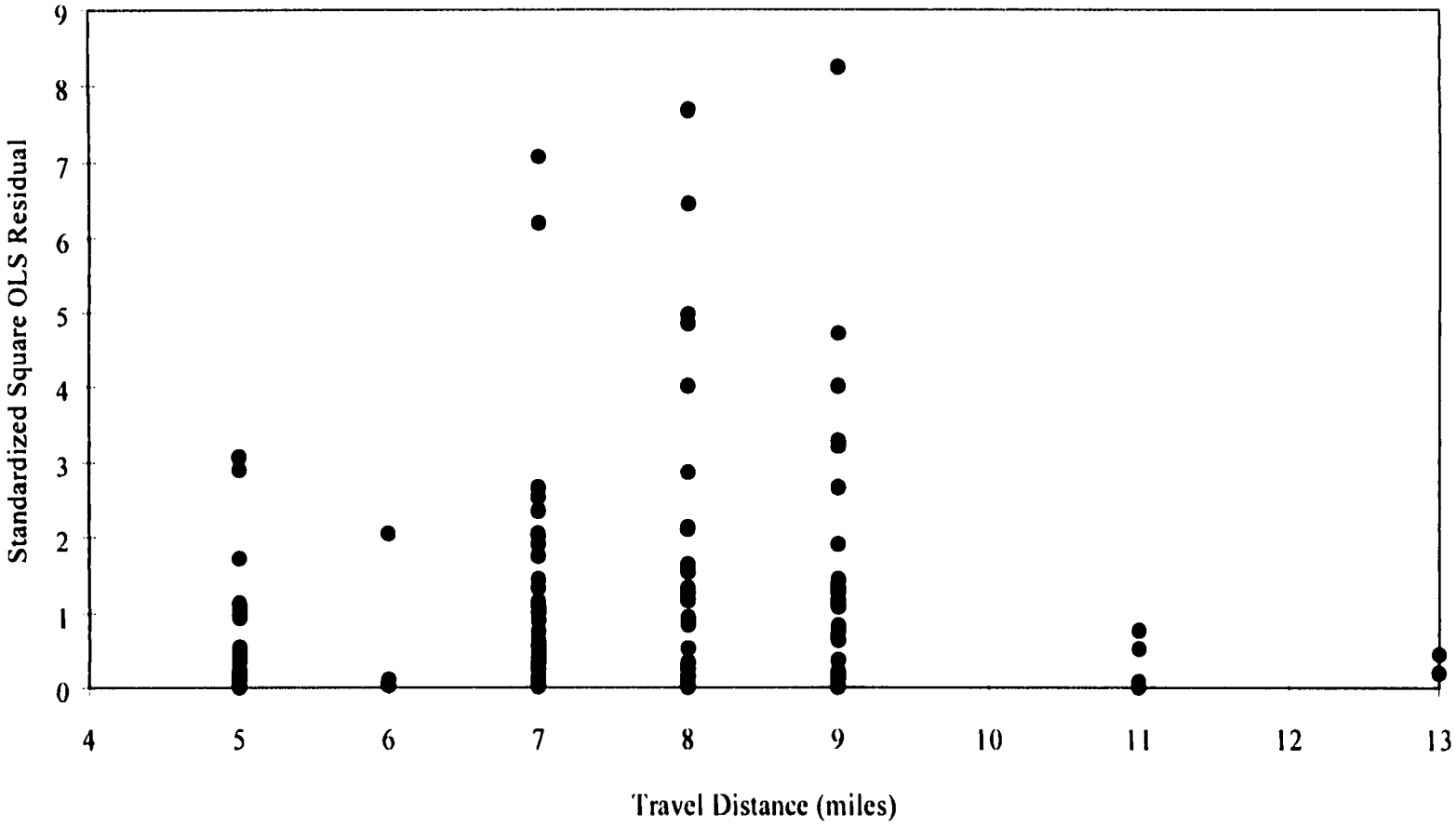
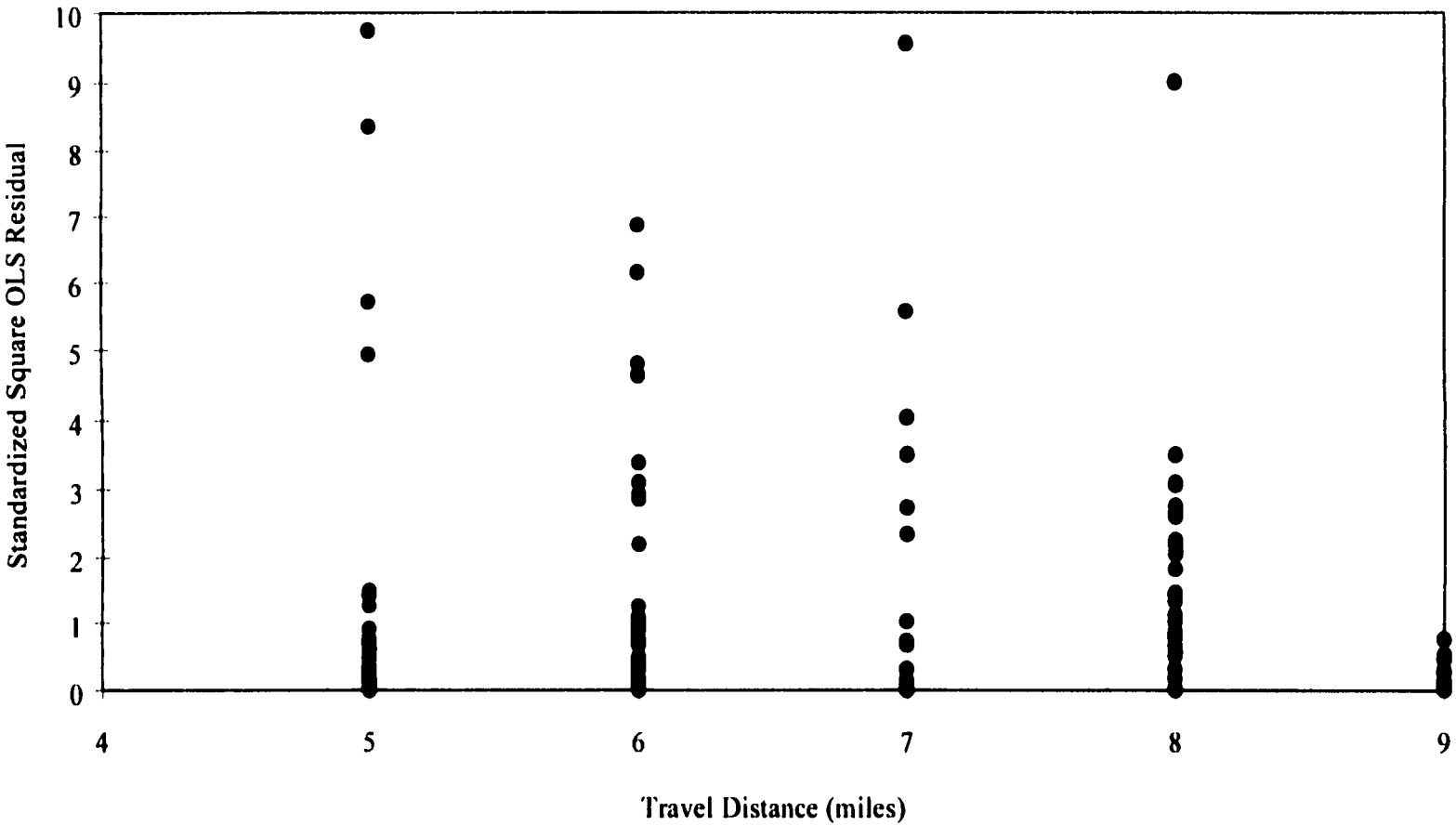


FIGURE 6.12
OLS Residuals by Distance Traveled
Surface Streets, I-80 Corridor



Different data weighting schemes were tested to correct for this heteroscedasticity. The proposed weights varied as a function of time of day, distance, or both. Regardless of the weighting scheme, the parameters computed by Weighted Least Squares (WLS) differed little from the OLS parameters. We chose to represent the time-of-day heteroscedasticity as depicted in (6.3): the variance of travel times is highest at the peak time-of-day, and decreases towards the shoulders of the peak with the square of the time-of-day deviation. Equation (6.3) represents the travel time variance of the two I-80 corridors (freeway and surface streets), and the evening commute on Highway 24.

$$Var(\varepsilon_i) = \sigma^2 * [1 - k * (S_i - S_M)^2] \qquad for \quad S_E \le S_i \le S_L \tag{6.3}$$

In the case of the Highway 24 (morning commute) a correction for distance, in addition to the one for time of day, provided estimates that were marginally more efficient than with the time-of-day correction alone (see Equation 6.4). Observations were grouped according to distance, and weights w_D calculated for each group as the reciprocal of the ratio of the average sum of square residuals of all observations in a distance group, to the variance of the residuals. Thus for observations at the same time of day, higher weights are assigned to those with lower distance group variance, and vice versa.

$$Var(\varepsilon_i) = \sigma^2 * [w_D + k * (S_i - S_M)^2] \qquad for \quad S_E \le S_i \le S_L \tag{6.4}$$

To estimate k in (6.3) and (6.4) a two-step approach is required: the OLS residuals are regressed on a constant and $(S_i - S_M)^2$,

$$e_i^2 = \sigma_u^2 + \sigma_I^2 * (S_i - S_M)^2 \qquad (6.5)$$

k is then estimated as the ratio $-\sigma_I^2/\sigma_u^2$, and the time-of-day weights calculated as the reciprocals of (6.3). The two-step approach yields consistent estimates of k, though not efficient ones. However, this is sufficient to obtain efficient estimates of the parameters of Equation 6.2 (Greene 1993).

Table 6.4 shows the WLS estimates for (6.2). As can be seen by comparing with the estimates in Table 6.2, accounting for heteroscedasticity improves the efficiency of the estimates somewhat. Similarly, there is little change in the parameters that measure the increase in travel time due to congestion, though in general the travel time curves appear to be somewhat steeper. Most coefficients are significantly different from zero at 95% confidence.[8] And the regressions are all significant (5% significance level), as measured by the F-statistic. Hence the triangular travel time model described by (6.2) appears to fit the data well.

[8] The access time for someone who uses surface streets should be smaller than the access time for highway users. If the average speed on the local streets is similar to the average speed on arterials, then this access time should be close to zero.

TABLE 6.4
Travel Time Function Parameter Estimates.
WLS Estimation.

	Parameter Estimates (absolute value of t-statistics in parenthesis)			
	Access Time	Pace at Peak Time-of-Day	Travel Time Savings	
			Early Travel [a]	Late Travel [a]
Corridor and Time Period	t_0 (min)	α (min/mi)	γ_E (min/mi-hr)	γ_L (min/mi-hr)
Morning				
I-80 Freeway	11.6 (2.6)	3.8 (6.3)	-0.74 (4.5)	-0.60 (3.2)
I-80 Surface St.	2.7 (0.7)	4.3 (6.9)	-0.71 (2.7)	-0.55 (1.6)
H-24	12.5 (9.9)	2.3 (14.2)	-0.60 (4.5)	-0.39 (3.6)
Evening				
I-80 Freeway	12.8 (2.7)	3.4 (5.6)	-0.45 (2.6)	-0.48 (1.6)
I-80 Surface St.	4.5 (1.3)	3.8 (6.9)	-0.53 (1.5)	-0.51 (3.0)
H-24	13.2 (7.8)	2.2 (11.2)	-0.35 (3.6)	-0.28 (2.9)

[a] Early and Late with respect to the peak time-of-day for each corridor and commute period.

Figure 6.13 shows the 90% confidence bands for the Highway 24 AM commute travel time function. The confidence bands for individual travel time predictions do not fan out as much as the mean travel time confidence bands, because travel time variance decreases further away from the peak time of day. It is clear that there is considerable variability in travel times not accounted for by the model. Any given travel time realization could be as much as 50% higher than the mean travel time. And while the model predicts that these travel times could also be 50% lower than the mean, in reality this is probably less likely than the model indicates. Travel times are unlikely to be much shorter than the mean travel times observed at S_E and S_L. This suggests that the distribution of reported usual travel times may not be normal, which is surprising since these times are expected

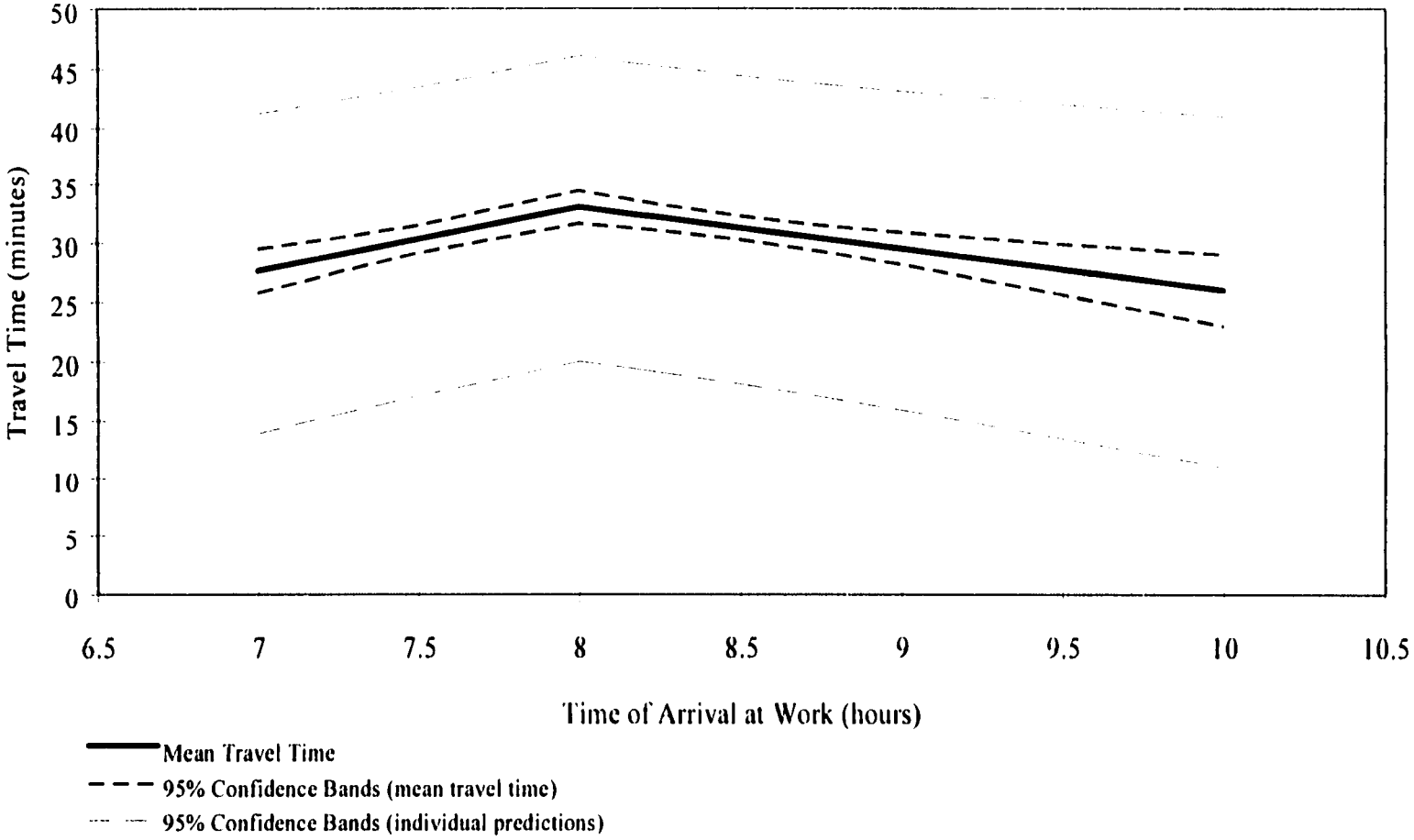
to be the average of many realizations.

6.3.4 Implications for Work Trip Timing Choice

The travel time estimation sheds light on particular travel time characteristics of these corridors which are likely to affect trip timing behavior. On the three facilities, the morning commute is more peaked than the evening commute. And all corridors appear to exhibit somewhat higher average speeds during the evening peak periods than during the morning peak periods. This suggests that there are more gains to be had from shifting the work schedule so as to avoid the morning commute, than from shifting it so as to avoid the evening commute. Moreover, the early shoulder of the morning commute is more peaked than the late shoulder, indicating that it would be more advantageous, per unit of time-of-day, to shift towards early in the morning than towards late in the morning. Conversely, there appears to be equal advantage to shifting early or late in the evening.

Traveling on highway 24 is, on average, faster than traveling on the I-80 corridors. Both in the morning and in the evening, the average speed at the peak time-of-day is higher on 24 (approximately 26 miles per hour) than on the other corridors (between 15 and 18 miles per hour). And not surprisingly, this corridor is less peaked than the other two corridors, both in the morning and in the evening. Overall, it seems that people commuting from East Contra Costa County face less congestion than people commuting from North Contra Costa County. Hence I-80 commuters have more incentive to shift

FIGURE 6.13
Travel Time Confidence Bands.
Highway 24, AM Commute, Distance = 9 miles.



their work schedules to avoid peak hours than H-24 commuters.

The most common work day lengths at UCB are shorter than the interval between peak periods. Thus many people might be able to avoid either the morning or the evening peak, even if they travel at the peak time-of-day at the other trip end. About 70% of employees work between 8.0 and 9.0 hours per day, while the intervals between peak periods are 9.25, 8.45, and 9.5 hours for the I-80 freeway, the I-80 surface street corridors, and H-24 respectively. For example, a person who works about 8 hours per day and commutes on H-24 has an offset between her work day length and the peak period interval of 90 minutes. This means that if she were to arrive at work at 8:00, the peak time-of-day on H-24, she would still be able to leave 90 minutes before the evening peak time-of-day.

Residents of North Contra Costa County face a tradeoff between access time and average speed, when choosing whether to use the freeway or the surface street arterials. The travel time to access the freeway is about 8 minutes longer than the surface street access time, while the average pace (the reciprocal of speed) on the freeway is about 0.5 minutes per mile lower than the average surface street pace. As expected, for short trips it is advantageous to use the surface street while for long trips it is advantageous to use the freeway.

In order to travel at non-peak times both in the morning and in the evening, a trip would

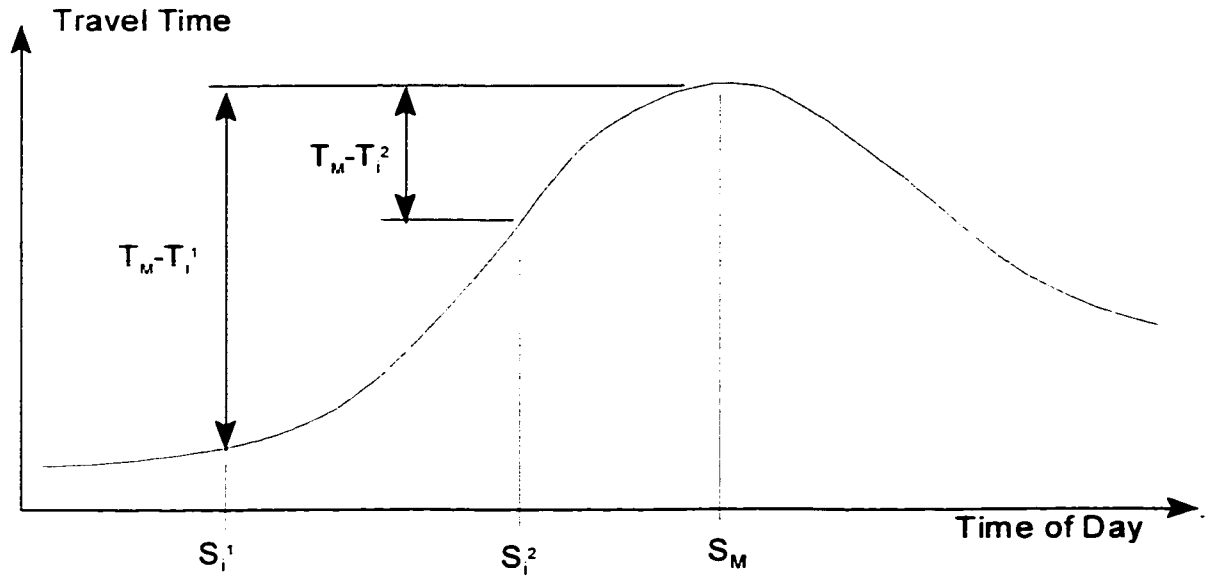
have to be scheduled between 90 minutes and 120 minutes away from the typical UCB start and end times (8:00 A.M.to 8:30 A.M. and 4:30 P.M. to 5:00 P.M. respectively). Only workers with substantial work scheduling flexibility are likely to be able to shift their work schedules by this much. And because these shifts represent a considerable deviation from normal teaching and business hours, it is unlikely that they will occur by chance. Instead, they are probably the result of an effort directed at peak hour avoidance, or due to particular non-work demands.

6.4 TRAVEL TIME DIFFERENTIAL METRIC

We use the travel time functions estimated above to calculate travel time differentials. To do so, we introduce the concept of travel time savings. Travel time savings is the difference between the peak travel time, and the travel time at a person's chosen work start (or end) time. Travel time savings are related to activity scheduling flexibility, as explained next.

Consider a corridor with the travel time characteristics shown in Figure 6.14. Suppose that commuters who have little work scheduling flexibility have no option but to travel at the peak time-of-day S_M. Further assume that all commuters are averse to congestion: among the time-of-day choices available given all their activity scheduling preferences and constraints, they would choose to travel at the time that yields the lowest travel time.

FIGURE 6.14
Travel Time Savings Metric.



Consider two people, i and j. Person i travels at time S_i, while person j travels at time S_M, the peak time of day. We assume that the only difference between i and j is that while j has no work scheduling flexibility, i has sufficient work scheduling flexibility to schedule her work trip as early as S_i. Hence work scheduling flexibility allows person i to reap savings in travel time equal to T_M-T_i. Therefore, all else equal, we expect that people with higher work scheduling flexibility will exhibit higher travel time savings. Now consider person k. We assume that she has as much work scheduling flexibility as person i, so that she too could schedule her work trip at time S_i. However, unlike i (and j), the timing of k's work trip is affected by a non-work activity. Person k may choose any work start time S_k that is later than S_i. Her travel time savings amount only to T_M-T_k, less than her total

possible savings $T_{sf}-T_i$ due to her lack of flexibility to schedule the non-work activity at a more convenient time-of-day.

Hence travel time savings increase with increasing flexibility to schedule both work and non-work activities, and vice versa. This metric allows us to compare whether in fact, workers with higher work and non-work flexibility schedule their trips at times further away from the peak times-of-day than workers who lack either type of flexibility. In the next two chapters we elaborate this methodology.

Table 6.5 shows the estimated travel time savings for a 10 mile commute undertaken either one hour before the peak time-of-day, or one hour after the peak time-of-day, on the three facilities under study. These savings appear modest, considering that these corridors are known to be congested. For example, floating car runs on the access roads between the UCB campus and Highway 24, a 2.5 mile section common to most Highway 24 users, indicated differences in the evening of 4 minutes when traveling one hour before the peak time-of-day and 6 minutes when traveling after the peak time-of-day. It appears then that our functions underestimate the true travel time savings.

TABLE 6.5
Travel Time Savings for a 10-Mile Commute.

	Work Arrival Time		Work Departure Time	
Facility	One Hour before the Peak	One Hour after the Peak	One Hour before the Peak	One Hour after the Peak
I-80 Freeway	7.4 min.	6.0 min.	4.5 min.	4.8 min.
I-80 Surface St.	7.1 min.	5.5 min.	5.3 min.	5.1 min.
H-24	5.8 min.	4.0 min.	2.7 min.	2.6 min.

6.5 SUMMARY

The estimated models exhibit known characteristics of travel time in the study corridors. Most importantly, the parameters that measure the dependence of travel time on time of day indicate that travel time decreases further away from the peak. This confirms that there are travel time advantages to off and non-peak travel in these corridors. Most of these parameters are statistically significant with 95% confidence. We also observe the access time vs. average speed tradeoff between freeway and surface street alternatives. Furthermore, it is known that the Highway 24 corridor is less congested than the Interstate 80 corridor, and our estimates confirm this fact.

We found that travel time in congested traffic has a variance that depends on the level of congestion, which in turn varies with the time of travel and possibly also the total distance traveled. Consistent with the literature, travel time variance is highest at the

peak time-of-day, and decreases towards the shoulders of the peak. However, we were not able to discriminate between different specifications for the rate of decrease as a function of time-of-day. Similarly, in only two of the six datasets the travel time variance exhibits a monotonic increasing relationship with the distance traveled. Several different heteroscedastic models were tested, but none appear to differ significantly from the homoscedastic models, in terms of the parameter estimates.

One possible avenue for improving travel time estimation is to consider non-normal error distributions. In principle, as these are reported usual travel times, they should be normally distributed. However, it may be that the errors inherent in people's estimation and reporting of their usual travel time are more likely to result in larger, rather than shorter, reported travel times than their actual average one-way travel time. If so, the distribution of reported travel times may exhibit a right tail longer than expected on a normal distribution.

The estimated travel time savings appear modest when compared to estimates obtained from floating car runs. It is possible that our models underestimate the true travel time savings available on these corridors. This may be because of the many different sources of error present in the data. If so, this may in turn underestimate the effect of work and non-work flexibility on trip timing choice. This issue is taken up again in Chapter 8.

As discussed in Section 6.3.4, the peaking characteristics of these travel corridors define

the kinds of work scheduling strategies that are likely to result in non-peak travel. Travel time savings are more easily obtained by shifting away from the morning peak period, regardless of corridor, and in turn by shifting early instead of late. However, because the peak period lasts for about four hours, to travel in non-peak traffic requires a large shift from the university's normal work schedule. To the extent that this schedule is similar to the majority of daytime work schedules, and that these in turn determine the schedules of non-work activities such as daycare, schools, or recreational classes, it is likely that peak hour avoidance for UCB employees is incompatible with these non-work schedules. This would suggest that significant work and non-work scheduling flexibility would be required to shift completely into non-peak commute hours.

7.
DESCRIPTIVE ANALYSIS OF THE ACTIVITY SCHEDULING SURVEY

This and the next chapter examine the information collected by the Activity Scheduling Survey. As described in Chapter 3, this survey was conducted at the Berkeley campus of the University of California (UCB). The aim of the present chapter is to provide a thorough description of the sample subjects. We examine selected demographic and occupational characteristics, and compare them against the entire UCB staff and faculty population, and against the full-time working population of the San Francisco Bay Area. Considerable attention is given to characterizing subjects' work scheduling flexibility, particularly the extent to which they seem to be able to choose their work schedules on a medium term basis. We also examine their stated work scheduling motivations: peak hour avoidance, personal activities, family obligations, etc. When the primary work scheduling motivation is related to a non-work activity, we look at the purpose of the activity and its scheduling discretion. The examination of subjects' travel time savings in light of their work and non-work scheduling flexibility is left for Chapter 8.

The chapter begins with a description of the survey methods: subject selection criteria, sampling frame and procedures, and survey instruments. The rationale for choosing UCB as the survey site was explained in Chapter 3, and thus will not be repeated here.

7.1. SURVEY DESIGN

7.1.1 Subject Selection Criteria

Subjects for the study were selected among the UCB campus employees on the basis of the following criteria:

- Subjects must work at least 35 hours per week.
- Subjects' place of residence should be located either in East Contra Costa County (cities of Orinda, Moraga, Lafayette, Pleasanton or Walnut Creek), or in North Contra Costa County (cities of El Cerrito, Richmond, San Pablo, Pinole, El Sobrante, Hercules, Rodeo, or Crocket). See Figure 3.3.
- Subjects must travel between home and work by car (either drive alone or carpool), both in the morning and in the evening.
- If their place of residence is in East Contra Costa County, then subjects should travel on Highway 24 at least for some part of their trip.
- If their place of residence is in North Contra Costa County, then subjects may travel to campus either on Interstates 80/580, or on a parallel arterial route.

7.1.2 Survey Instruments

The survey consists of three main parts: a self-administered questionnaire, an activity diary, and an interview. All survey materials are included in Appendix 2. The survey

differs from a traditional household-based travel behavior survey primarily in two ways: it explicitly asks for information about the work schedule and its flexibility, as well as the schedule and flexibility of non-work activities. As described next, work scheduling flexibility was addressed in the questionnaire, while non-work scheduling flexibility was examined using the activity diaries and interviews.

Survey Questionnaire:

The questionnaire asked for information on personal and household characteristics, information about the morning and evening commute (departure time, arrival time, travel time net of stop durations, travel route), and information about the work schedule and its flexibility. The latter includes questions about the discretion available to choose work hours, as well as the discretion to shift the work schedule by some amount of time earlier or later than the current schedule, considering separately work and non-work factors.

Activity Diary:

Subjects were asked to keep a record of all the non-work activities in which they participated during a regular working day. The record included the start time, end time, and purpose of all activities performed during any regular work day. Specifically, it should include all activities performed in the morning, between the get-up time and the work arrival time, and in the evening between the work departure time and bedtime.

Interview:

A personal interview was conducted with each subject to discuss the non-work activity schedule, as recorded in the diary. For each activity listed in the diary (except personal hygiene), subjects were asked several questions: frequency of activity participation, usual schedule for the activity, usual variability on that schedule, level of discretion available to cancel the activity, and willingness to cancel the activity. Each interview lasted typically 20 minutes.

7.1.3 Sample Design

The sample frame consisted of two lists of the workers who fulfill the characteristics described in Section 7.1.1. These lists were prepared by the University's Personnel Office, using the zipcode of each employee's place of residence to identify residence location. The list is incomplete, because it does not include people who elect to keep their personal information private. In total, it contained 721 workers who reside in North Contra Costa County, and 283 workers who reside in East Contra Costa County. They represent most of the UCB employees who live in North Contra Costa but only 40% of UCB employees who live in East Contra Costa. In addition to their name, the list included their work telephone number, job title, and work address. This information was updated using the most recent campus telephone book.

A stratified random sample design was used, using place of residence and occupation as

the stratifying criteria. Place of residence defined two subgroups, North vs. East Contra Costa. Occupation also defined two subgroups: faculty, research and professional occupations vs. administrative, technical, and clerical occupations. This sample design was chosen because the four strata are not independent. In particular, there is a higher proportion of high-income occupations in the East Contra Costa group than in the North Contra Costa group. A simple random sample would have yielded few administrative / clerical workers from East Contra Costa, and few faculty / professional workers from North Contra Costa.

7.1.4 Sampling Procedure

Names were drawn at random from each stratum. Potential subjects were contacted by telephone at their place of work, and invited to answer a set of screening questions. Workers who fulfilled the required occupational, residency and travel mode requirements were invited to participate in the study. Those who agreed were mailed the survey questionnaire and activity diary. A week after these materials were mailed, workers were contacted again to check on their progress filling out the questionnaire, and to set up an appointment for the diary interview. Additional follow up calls were made if necessary until an appointment time was agreed upon.

Table 7.1 shows the final completion, rejection, and refusal rates. Overall, 42% of all people contacted completed the questionnaire, diary, and interview, resulting in a final

sample size of 69 subjects. We are confident that the survey results will not be biased due to subject self-selection, since only a small proportion of people from each residential area refused to participate. Faculty were more likely to refuse to participate than administrative staff, and this is reflected in the higher refusal rate obtained among East Contra Costa residents. Many more potential subjects were rejected because they did not live in the target residential areas, or because they did not commute by car. In particular, residents of North Contra Costa County are more likely to use non-auto travel modes (BART and bicycle) than residents of East Contra Costa County, hence the lower participation rate. More attempts than actual contacts were made, because the initial list included people who do not work for the university anymore, who work at a facility located outside of the campus, or who did not answer the telephone during the period in which the study was being conducted.

TABLE 7.1
Survey Completion Rates.

	North Contra Costa		East Contra Costa	
	Sample Size	Pct.	Sample Size	Pct.
Total Number of Attempts	258		136	
Total People Contacted	112		51	
Accepted to Participate	61	54%	33	65%
Completed the Survey	49	44%	20	39%
Refused	15	13%	10	20%
Rejected (Travel Mode)	30	27%	8	15%
Rejected (Place of Residence)	6	0.05	0	0%

7.2. SAMPLE DESCRIPTION

7.2.1 Demographic Characteristics

A comparison of demographic characteristics between sample subjects and the sample population indicates that the sample is fairly representative of the UCB employee population (Table 7.2). Approximately two-thirds of the subjects are female. More than one-half are 45 years old or older, and none are younger than 25 years old. Seventy percent are either married or living with a partner, and about 35% have children younger than 18 years old living with them.

The proportion of workers aged between 45 and 54 years old is higher in the sample than among university staff. This results because, according to the 1996 Faculty and Staff Housing and Transportation Survey, workers in this age cohort are more likely to commute by car than all other university employees. They are also more likely to live in the North Contra Costa Area than other university staff.

Compared to the population of full-time workers employed in the San Francisco Bay Area, sample subjects are disproportionately female and more likely to have children living in their household. This means that the proportion of workers who are likely to face child-related work scheduling constraints is higher in the sample than in the regional population. Also, sample subjects are more senior than full-time workers in the regional

population. We observed through the exploratory interviews that old workers tend to engage in out-of-home non-work activities with less frequency than young workers. This could imply that the sample subjects are less likely than the general population to engage in non-work activities.

TABLE 7.2
Survey Sample Demographic Characteristics.

Demographic Characteristics	Study Sample	UCB Staff and Faculty [a]	San Francisco Bay Area [b]
1. Gender			
Male	39%	43%	57%
Female	61%	57%	43%
2. Age			
Younger than 25 years old	0%	2%	9%
25-34 years old	13%	19%	32%
35-44 years old	33%	31%	32%
45-54 years old	41%	32%	18%
55-64 years old	12%	12%	8%
65 years old or Older	1%	4%	1%
3. Marital Status			
Single	29%	36%	- [d]
Married [c]	71%	64%	-
4. Number of Children in the Household, Younger than 18 Years Old			
None	65%	63%	77%
One or More	35%	37%	23%

[a] Source: 1996 Faculty and Staff Housing and Transportation Survey.
[b] Source: 1990 Bay Area Travel Survey.
[c] Includes people who live with a partner.
[d] Information not available.

Hence, our sample may not accurately capture the incidence of non-work activity engagement by activity purpose in the general population. However, this does not not invalidate the survey as a means of analyzing relationships between non-work activities and work schedules.

7.2.2 Occupational Characteristics

Table 7.3 shows the occupational composition of the sample. Even though the survey sampled more heavily from the East Contra Costa area, where the majority of faculty and managers live, the sample contains the same combined proportion of these workers as is found in the population of UCB staff. Professors were more likely than staff employees to refuse to participate or to not return the completed survey questionnaire.

Sample subjects appear to be more senior, in terms of tenure at the university, than the population of UCB employees. This is due to our choice of subjects' residential location: only between 5% to 6% of full-time workers employed at UCB for one year or less live in North or East Contra Costa Counties, while 9% to 11% of these workers live closer to campus, for example in Berkeley, Albany, or El Cerrito (Faculty and Staff Housing and Transportation Survey, 1996). The sample's seniority is likely to bias the sample toward workers with high work scheduling flexibility. This works to our advantage, since our main interest is the examination of the work scheduling motivations of workers who have work scheduling flexibility.

TABLE 7.3.
Occupational Characteristics of Survey Sample Subjects.

Occupational Characteristics	Sample		UCB Staff
	Total	Pct.	Percent.
1. Occupation			
Professors and Researchers	9	13%	16%
Administrative Managers and Directors	5	7%	4%
Professional Staff:			69%[d]
Administrative Assistants	16	23%	
Specialty Assistants[a]	9	13%	
Other Administrative Occupations[b]	14	20%	
Librarians and Computer Analysts	5	7%	
Lab Technicians and Storekeepers	6	9%	
Mail Processors and Data Entry Operators	2	3%	
Other[c]	3	4%	
2. Number of Years Employed at UCB			
One Year or Less	4	6%	10%
2 to 5 years	17	25%	25%
6 to 10 years	18	26%	25%
11 to 15 years	12	18%	14%
16 to 20 years	8	12%	12%
More than 20 years	9	13%	14%
3. Number of Years Employed at Current Position			
One Year or Less	10	15%	-
2 to 5 years	30	44%	-
6 to 10 years	16	23%	-
11 to 15 years	9	13%	-
16 to 20 years	1	1%	-
More than 20 years	2	3%	-
4. Number of Staff Members under Supervision			
None	29	42%	-
1	10	14%	-
2	7	10%	-
3 to 5	13	19%	-
6 or More	10	14%	-

[a] Includes Undergraduate, Graduate, Budget, Employment and Admissions Assistants.

[b] Includes Administrative Analysts, Administrative Specialists, Writers, and Accountants.

[c] Includes Chefs, Physical Therapists, and Athletic Trainers.

[d] The UCB Faculty and Staff Survey does not break down the occupations of professional staff.

7.3 WORK SCHEDULING CHARACTERISTICS

Work scheduling flexibility is often assumed to be a dichotomous characteristic, when in fact the ability to self-schedule work hours is more nuanced than a simple yes or no answer. The survey included various questions to gauge different aspects of people's ability to schedule their work hours. These questions are listed in Table 7.4. Subjects were first asked to state, on a scale from 1 to 5, how much discretion they had to choose their current work schedule. They were asked to indicate whether they are required to work a particular schedule, and if so, to report their work start and end times[9]. Flexibility may be due to the official flexitime program, hence a question was included to learn whether subjects participate in UCB's alternative work schedules program. Another way in which people may flex their work hours is by working at home, or by skipping or shortening their work breaks. This in turn suggests that some workers' scheduling discretion may be limited to a short interval, for example, 15 or 30 minutes with respect to their current schedule, while others may have almost unlimited flexibility to schedule their work. At the same time, depending on particular work circumstances some people may find it easier to reschedule their work toward early morning and evening hours, while others may have more discretion to arrive and leave late. Two questions were included to gauge whether work scheduling discretion diminishes as the hypothetical flex or shift interval increases, early and late respectively, by 15, 30, and 60 minutes with respect to

[9] Usual work arrival and departure times were requested in a prior section of the survey, together with other commute-related information.

the current work schedule. Finally, workers were asked to choose, among two statements that describe work scheduling norms, the one that best identifies their job. Responses to all these questions are discussed in detail next.

Approximately two-thirds of the subjects indicated that the statement *"Your job lets you choose the times at which you start and end your work day"*, describes better the work scheduling policy that applies to their jobs than one that said *"Your job gives you little choice to decide your work schedule"* (see Table 7.5) That is, two-thirds of the sample, or 47 people, have jobs that could be considered flexible. Yet when asked to report on a scale from 1 to 5 on the level of discretion available to choose their current work schedule, several of these flexible workers chose the lowest discretion levels. And moreover, more than two-thirds of the sample subjects indicated that they must arrive and leave work by specific times; that is, on a day-to-day basis, they are not free to vary their work arrival and departure times.

Only about 20% of the sample subjects indicate that they are currently on an alternative work schedule such as Flexible Hours or Compressed Week (Table 7.5). About one-half of all subjects however are able to flex their regular working hours by working through lunch, on weekends or at home. This demonstrates that scheduling flexibility is more due to informal, unwritten rules than to the university's formal flexible hour policy.

TABLE 7.4
Work Schedule Flexibility Questions

Question No.	Question Statement
28	How much discretion did you have to choose your current work schedule? None 1 2 3 4 5 Lots
29	Are you required to be at work by a certain time? [ ] No [ ] Yes. Please indicate what time that is: _____
30	Are you required to stay at work until a certain time? [ ] No [ ] Yes. Please indicate what time that is: _____
31	Are you currently on any of the following alternative work schedules: [ ] Flexible Hours [ ] Compressed Hours [ ] Telecommuting [ ] None of the above
32	Does your job let you substitute regular working hours for working through lunch, on weekends, or at home? [ ] Yes [ ] No
33	Considering your job requirements only, how much discretion do you have to permanently begin and end your work day earlier by: None Lots a. 15 min? 1 2 3 4 5 b. 30 min? 1 2 3 4 5 c. 60 min? 1 2 3 4 5
34	Considering your job requirements only, how much discretion do you have to permanently begin and end your work day later by: None Lots a. 15 min? 1 2 3 4 5 b. 30 min? 1 2 3 4 5 c. 60 min? 1 2 3 4 5
- [a]	Which of the following two options best describes your job: a. Your job gives you little choice to decide your work schedule. b. Your job lets you choose the times at which you start and end your work day.

[a] This question was asked during the interview section of the survey.

TABLE 7.5
Work Schedule Characteristics of Subject Sample.

Work Schedule Characteristic	Sample Subjects Number	Percent
Discretion to Choose Current Schedule		
1 (None)	17	25%
2	9	13%
3	17	25%
4	13	19%
5 (Lots)	13	19%
Required to Start Work on Schedule		
Yes	49	71%
No	20	29%
Required to End Work on Schedule		
Yes	21	70%
No	48	30%
Official Alternative Work Schedule		
Flexitime or Compressed Week	15	22%
None	54	78%
Allowed to Flex Lunch Hour / Work at Home		
Yes	36	52%
No	33	48%
Work Scheduling Norms		
Not Allowed to Choose Work Schedule	22	32%
Allowed to Choose Work Start and End Times	47	68%

Some workers have only a modest ability to choose their work schedule, as reflected by the discretion available to shift the schedule earlier or later (see Table 7.6). About 15 (25%) subjects indicate having little to no discretion (levels 1 or 2) to shift the schedule even by 15 minutes. When the shift interval increases to 60 minutes, fully one-half of the subjects indicate having little discretion to shift the schedule by this much. In this sample, there are 7 (10%) subjects who report no discretion at all to shift, either early or late.

The majority of subjects, however, do have some level of scheduling discretion available. Nineteen and twenty-one people have the highest discretion to shift as much as 60 minutes, early or late, respectively. Of these people, 16 workers (23% of the sample) can easily shift their work schedules both early and late. Among the people that have high discretion (levels 4 or 5) to shift the schedule by 15 minutes, more than half exhibit at least a medium to high level of discretion to shift the work schedule as much as one hour (see Table 7.7). Overall, the majority of workers have a fair amount of discretion to shift their work schedules early or late by 30 minutes, and many have the discretion to do so by as much as 60 minutes. Hence, as far as work is concerned, the majority of workers in the sample have the necessary scheduling flexibility to consider changes in their work trip timing choice that could yield a systematic change in their travel time.

TABLE 7.6
Discretion to Shift the Work Schedule, by Shift Interval.
Effect of Work Constraints.

	Proportion of Subjects at Each Discretion Level, by Shift Interval					
	Early Shifts			Late Shifts		
Discretion Level [a]	15 min.	30 min.	60 min.	15 min.	30 min.	60 min.
5	52%	42%	28%	48%	40%	30%
4	12%	13%	10%	14%	14%	12%
3	13%	14%	9%	13%	14%	9%
2	7%	9%	14%	7%	7%	10%
1	14%	19%	36%	14%	20%	36%

[a] 5 is the highest discretion level, 1 is the lowest discretion level.

TABLE 7.7
Shift Discretion Gradient. Effect of Work Constraints.

	Proportion of Subjects [b]					
Discretion for a	Early Shifts			Late Shifts		
15 min. shift [a]	Discretion for a 60 min. shift			Discretion for a 60 min. shift		
	5 or 4	3	2 or 1	5 or 4	3	2 or 1
5 or 4	60%	10%	30%	67%	7%	26%
3		22%	88%		33%	66%
2 or 1			100%			100%

[a] 5 is the highest discretion level, 1 is the lowest discretion level.

[b] The percentages are estimated with respect to the number of subjects at each 15 min. shift discretion level, hence rows add up to 100%.

About two-thirds of the subjects report exactly the same levels of discretion when asked about shifting early as when asked about shifting late. Those that report different discretion to shift early than late are equally divided between those that have more discretion to shift early and those that have more discretion to shift late. Presumably, work rules are such that workers who already deviate from the normal business hours would find it easier to align their schedule to these hours than to further deviate from it. However the opposite tendency was found. Among the people who have more discretion to shift late, 6 out of twelve have a work start time past 8:30 A.M., while among the people who have more discretion to shift early, 8 out of 10 have a work start time before 8:30 A.M. Thus, it is possible that questions about shift discretion were interpreted as discretion to shift with respect to the normal business hours at UCB, instead of discretion to shift with respect to subjects' current work schedule.

In order to understand the relation between responses to the various work scheduling questions, we used these variables to classify subjects in groups of expected different ability to choose working hours. Subjects were first grouped according to their self-selection as "flexible" or "non-flexible" workers (Question No.37). Each of these two groups was then split into three subgroups, depending on subjects' level of discretion to choose their current work schedule (Question No. 28). And finally, workers in each of these six groups were classified on the basis of whether they must arrive and leave work on schedule (Question No. 29). This resulted in nine and not twelve classes, because in three cases all workers fell into one category, as shown in Table 7.8. The nine classes are

shown in order of increasing expected scheduling flexibility from left to right. For each of these classes, we compute the average level of discretion to shift the work schedule early and late. And we find that, as the expected scheduling flexibility increases, so does their reported average discretion to shift their work schedule.

This classification shows several features of work scheduling flexibility. As expected, the majority of workers with self-described non-flexible work schedules report low levels of discretion in choosing their work schedule, are usually required to follow a schedule, and exhibit low discretion to shift their schedule either early or late. Surprisingly, two non-flexible people report that they had large discretion to choose their current work schedule. This seems to reflect differences in people's interpretations of the various questions. In both these cases, the reported discretion to shift the work schedule is limited: for one person, no more than 15 minutes early or late; for the other person, 30 minutes early, but none to shift late. Yet other subjects with similar shifting discretion chose to identify themselves as flexible workers.

Among workers who describe their job as being flexible, there is considerable variability in terms of their responses to questions about work scheduling discretion and work start/end requirements:

TABLE 7.8
Average Level of Discretion to Shift the Work Schedule.

Work Schedule Shift Interval	Average Level of Discretion to Shift Work Schedule [a]								
	Non-Flexible Work Schedule [b]				Flexible Work Schedule				
	Discretion to Choose Schedule [c]				Discretion to Choose Schedule				
	1 or 2		3	4 or 5	1 or 2	3		4 or 5	
	S/E [d]	No S/E	S/E	No S/E	S/E	S/E	No S/E	S/E	No S/E
Early:									
15 min.	1.7	5.0	3.0	4.5	3.8	4.2	5.0	4.8	4.9
30 min.	1.4	5.0	3.0	4.0	3.0	4.2	4.5	4.5	4.7
60 min.	1.1	5.0	1.8	2.5	2.0	3.0	2.5	3.9	4.3
Late:									
15 min.	2.0	5.0	3.2	3.0	3.6	4.0	4.8	4.8	4.8
30 min.	1.7	5.0	3.0	2.5	3.0	4.0	3.5	4.6	4.7
60 min.	1.6	4.0	2.0	1.5	2.6	2.8	2.2	3.9	4.4
Total Subjects	15	1	4	2	9	8	4	9	15

[a] The numbers reported are the shift discretion levels averaged over the three shift intervals.

[b] Classification based on responses to Question No. 37.

[c] Classification based on responses to Question No. 28.

[d] S/E (Start/End constraint) indicates that workers must observe a schedule; No S/E that they are not required to do so (see Question No.29).

• One quarter of these flexible workers report low levels of discretion to choose their current work schedule (levels 1 or 2), and are required to arrive and leave from work at specific times. This apparent contradiction is explained by the difference between "realized" vs. "potential" schedule flexibility: many of these subjects indicate that they currently work a schedule determined by their place of work, but that they could change their current schedule if they needed to.

• One third of all self-described "flexible" workers report an intermediate level of discretion to choose their work schedule (level 3). Among these workers, there are some rigidities in their work schedules, but not all of them present at the same time: a fixed work start or end time, difficulty to shift either early or late (but not both), difficulty to shift more than 30 min., the requirement to be at work during core hours, and (among the faculty) classes that take place either early in the morning or late in the afternoon.

• About one-third of the workers who report high levels of discretion to choose their work schedules (levels 4 or 5) are nevertheless required to keep a regular schedule on a day to day basis. These include workers whose flexibility stems from the university's flexitime program and workers who would have to get approval from their supervisor or coordinate their schedules with co-workers to ensure full-day coverage. It also includes workers who prefer to keep a regular schedule because it facilitates their interactions with colleagues or their carpool

arrangements. The workers who do not need to keep a regular schedule are typically professors and researchers, and administrative or professional personnel whose tasks are largely independent of their colleagues (for example a writer, several computer analysts, and administrative managers or directors).

Of all self-described flexible subjects, only one-third of them would exhibit high work scheduling flexibility if the criterion was that they select the response that indicates highest flexibility in all survey questions. Yet this would be an unduly restrictive definition of scheduling flexibility, since many workers who are not included in this group seem to have enough discretion to consider travel time and non-work motivations to schedule their work hours. Clearly, no single criterion by itself describes fully the availability or extent of work scheduling flexibility, yet each may describe a different dimension of this flexibility. A factor analysis was undertaken to identify salient tendencies in the data. The results of this analysis are described next.

7.4 CHARACTERIZATION OF WORK SCHEDULING FLEXIBILITY

An exploratory factor analysis was employed to reduce the set of work scheduling flexibility variables to a few, possibly independent, dimensions. The variables included in the analysis are listed in Table 7.9. The scores measuring subjects' discretion to shift the work schedule early or late by 15 min., 30 min., and 60 min. were used to compute two effects: the average level of shift discretion and the loss in discretion to shift as the

shift interval increases. These variables were computed as follows:

- AvgWSFE, AvgWSFL: estimated by averaging for each subject the scores for a 15 min., 30 min., and 60 min. shift, respectively early and late.
- SlpWSFE, SlpWSFL: estimated for each subject as the slope of a linear regression of the shift discretion scores on the shift intervals, respectively early and late.

Table 7.10 shows the results of a principal components solution, rotated using the varimax method. The analysis found three main factors, which together explain 74% of the variance in this set of variables.

Factor 1: Strategic Flexibility

The four variables that have high loadings on this factor measure subjects' discretion to choose their work schedules. Although Table 7.8 shows some subjects reporting little initial discretion to choose their current schedule (SchDis) while at the same time classifying themselves as "flexible" (WorkType), and vice versa, these two variables essentially measure the same tendency. In terms of ability to choose the work schedule, there appears to be no difference between flexibility to schedule early and flexibility to schedule late. This is not surprising since the majority of workers report similar levels of discretion to shift early and to shift late.

TABLE 7.9
Work Scheduling Flexibility Factor Analysis Variables

	Work Scheduling Flexibility Variables		
No.	Name	Description	Values
28	SchDis	Discretion to choose current work schedule.	1 to 5 [a]
29	Start	Whether required to arrive by a given time.	0 (Yes) / 1 (No)
30	End	Whether required to remain at work until a given time.	0 (Yes) / 1 (No)
31	AltSchd	Whether currently taking part in a formal flexitime, compressed schedule, or telecommuting scheme.	1 (No) / 2 (Yes)
32	JobSubs	Whether allowed to substitute regular working hours for working through lunch, on weekends, or at home.	1 (No) / 2 (Yes)
37	WorkType	Whether job allows to choose the times at which to begin and end the work day.	1 (No) / 2 (Yes)
33	AvgWSFE	Average discretion to advance the current schedule.	1 to 5 [a]
34	AvgWSFL	Average discretion to postpone the current schedule.	1 to 5 [a]
33	SlpWSFE	Loss in discretion to advance the work schedule, per minute of early shift.	-0.1 to 0
34	SlpWSFL	Loss in discretion to postpone the work schedule, per minute of late shift.	-0.1 to 0

[a] 1 means no discretion, 5 means lots of discretion.

Factor 2: Quotidian Flexibility

This factor represents workers' ability to vary their work arrival and departure times on a day to day basis. It is primarily constituted by the two variables that classify workers among those who must follow a schedule on a daily basis and those who need not do so. A positive loading on this factor indicates one is not required to arrive and leave at the same times everyday. Hence the negative loading of FlexTime (participation in an official alternative work schedule program) indicates that while these programs let people choose their own work schedule, they may still require punctual attendance. The initial discretion to choose the current work schedule loads with a small positive coefficient, indicating a tendency for high initial discretion to be associated with no work start/end requirements, and vice versa.

Factor 3: Schedule Flexibility Gradient

The third and last factor represents the loss in scheduling discretion that may occur as one tries to move the work schedule further away from its current time. Only the slope variables SlpWSFE and SlpWSFL have high loadings on this factor. The variable that represents participation in an alternative work schedule program has a moderate loading on this factor. This indicates that UCB flexitime workers find it more difficult to shift their schedules by 60 minutes than to shift by 15 minutes.

A promax rotation of the factor pattern showed in Table 7.10 resulted in a similar grouping of the work scheduling flexibility variables.[10] However this rotation revealed that Factors 1 and 2 have an interfactor correlation of 0.40. This is clearly due to the fact that most subjects who lack the medium term ability to choose their work schedule also lack the ability to vary arrival and departure times on a daily basis. The reverse of course is not true, since several workers able to choose their work schedule must still observe it on a day to day basis.

TABLE 7.10
Work Scheduling Flexibility Factor Pattern.
Varimax Rotation.

	Work Scheduling Flexibility Factors		
Variables	Factor 1: Strategic Flex.	Factor 2: Quotidian Flex.	Factor 3: Flex. Gradient
Start	0.33	0.90	0.00
End	0.36	0.90	0.02
FlexTime	0.50	-0.28	-0.44
JobSubs	0.47	0.25	-0.06
SchDis	0.78	0.36	0.03
AvgWSFE	0.78	0.35	0.08
AvgWSFL	0.83	0.19	0.14
WorkType	0.79	0.15	-0.13
SlpWSFE	0.03	0.00	0.95
SlpWSFL	0.02	-0.03	0.96
Variance Explained:	32%	21%	20%

[10] A varimax rotation restricts the principal factors to be orthogonal, while promax does not impose orthogonality.

Strategic flexibility may also be called medium term scheduling flexibility: while it allows workers to choose a schedule, they may not necessarily be able to vary their work arrival and departure times on a day to day basis. Conversely quotidian flexibility may be described as short term work scheduling flexibility. Most workers who exhibit short-term flexibility also exhibit medium term flexibility. As shown in Figure 7.1, these two factors subdivide the sample into three main groups: workers in the bottom left quadrant have below average medium and short term flexibility. These would be the workers with the least ability to reschedule their work hours to account for traffic congestion or non-work concerns. As expected, there are few workers in the upper left quadrant (below average medium term flexibility but above average short term flexibility). Hence short term, quotidian flexibility seems to be granted in addition to, not in lieu of, medium term, strategic flexibility. Workers with above average strategic flexibility appear to be approximately evenly split between those who have high quotidian flexibility, and those who exhibit low quotidian flexibility.

Medium term flexibility may be restricted to shifts of not more than 15 to 30 minutes around the current work schedule. When this is the case, workers exhibit simultaneously average strategic flexibility and a steep schedule flexibility gradient. In Figure 7.2, among workers who have from average to above average medium term flexibility, those in the lower right quadrant exhibit a steep schedule flexibility gradient, while those in the upper right quadrant lose little schedule flexibility as they shift further from their current schedule. Among workers with a steep schedule gradient, work scheduling flexibility is

FIGURE 7.1
Strategic vs. Quotidian Scheduling Flexibility

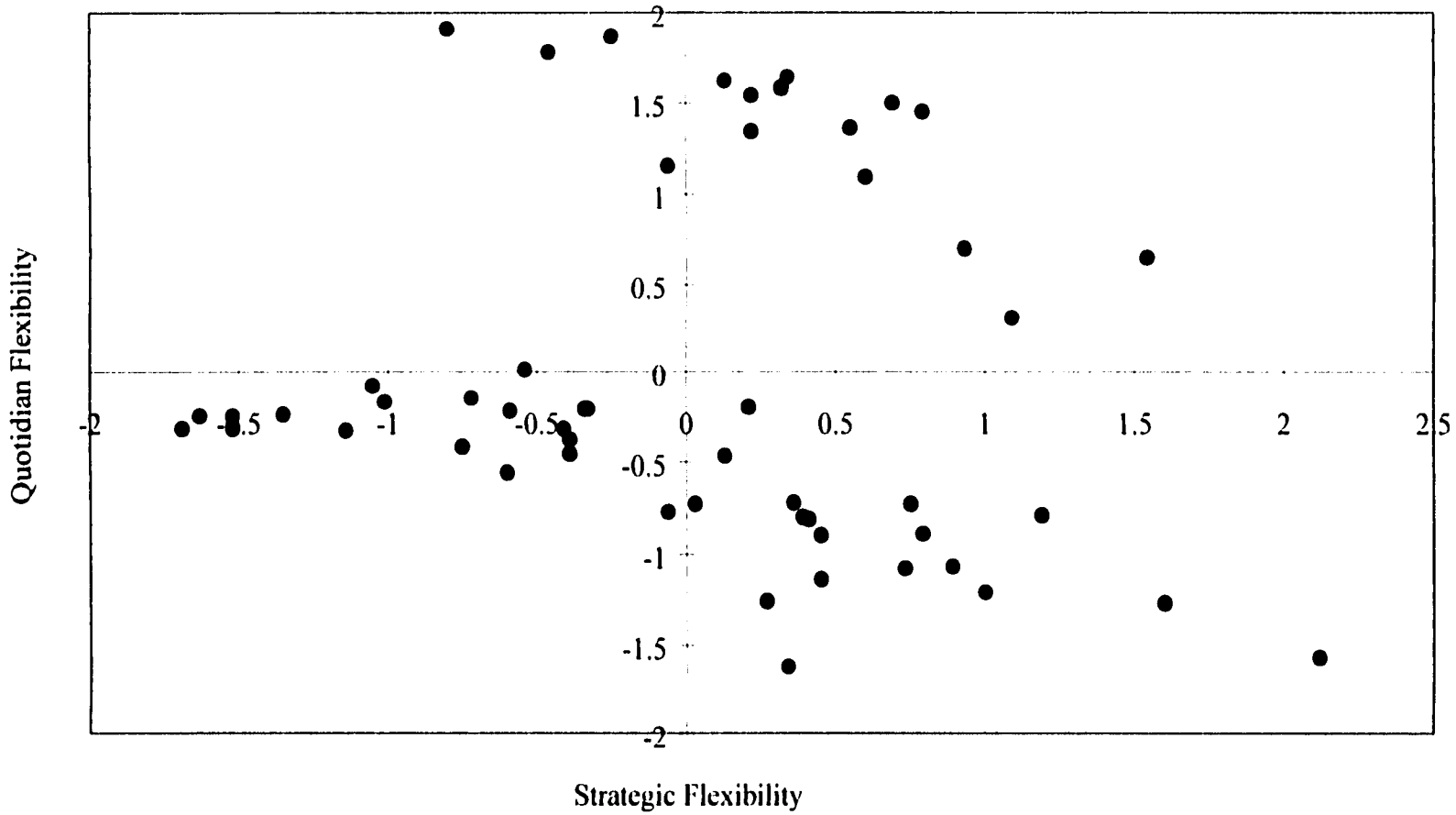
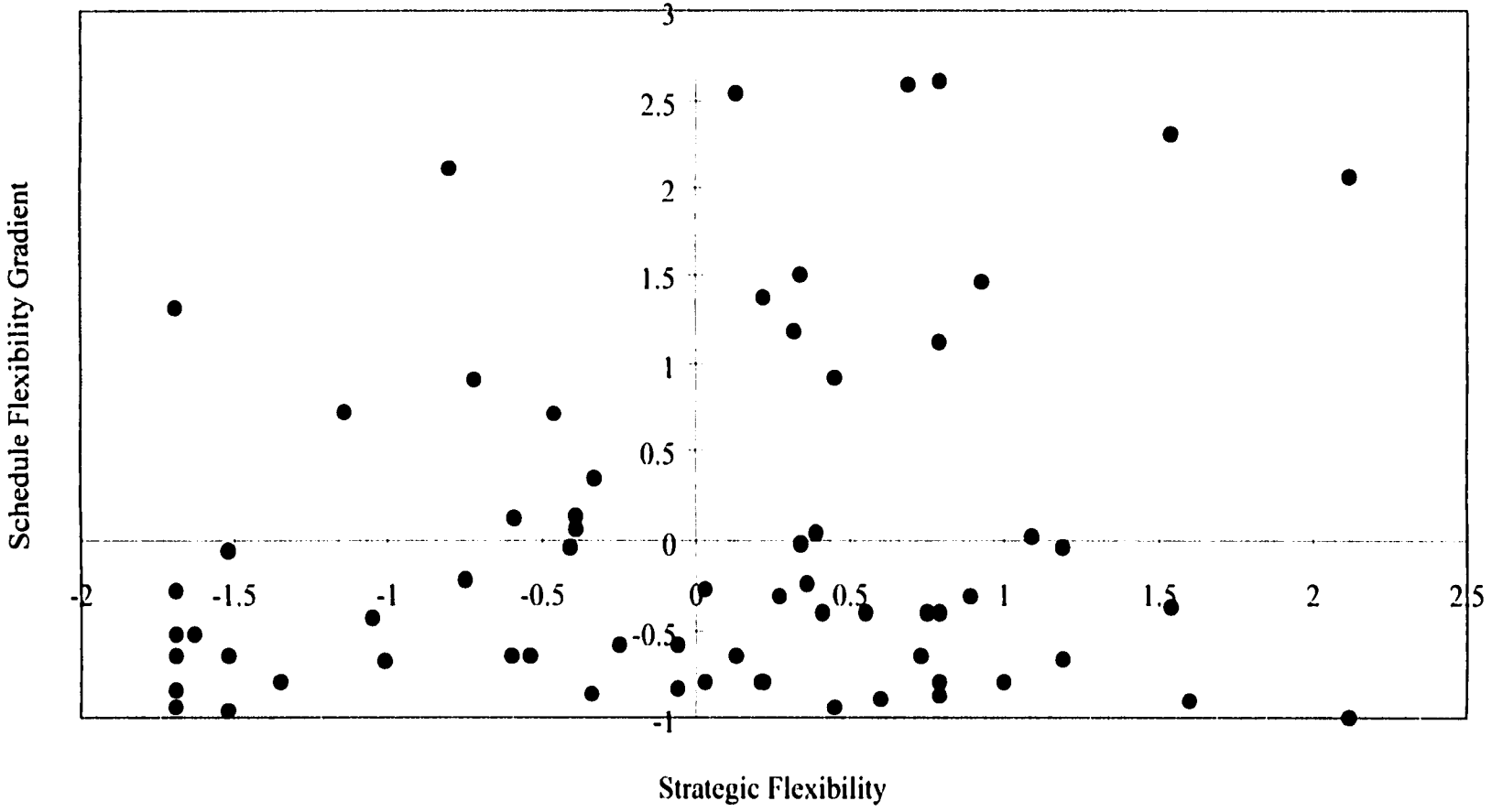


FIGURE 7.2
Strategic Flexibility vs. Schedule Flexibility Gradient



limited to intervals of 15 minutes to 30 minutes, early or late with respect to their current schedule. This is likely to restrict their ability to choose schedules outside of peak commute times, unless their current work start or end times are already near one of the shoulders of the peak hour. Similarly, this limited flexibility is likely to restrict somewhat their ability to jointly schedule work and non-work activities.

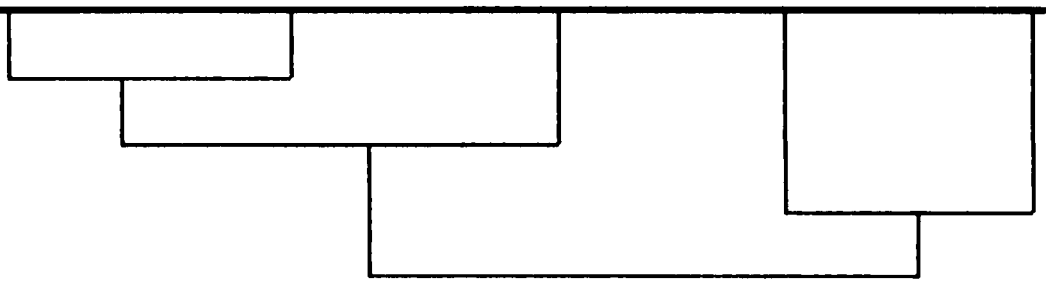
To further identify distinct groups of workers, subjects were clustered on the basis of their scores on the three work scheduling flexibility factors. A hierarchical clustering algorithm based on average square euclidian distance was used. This criterion tends to produce clusters of small variance (SAS Institute 1982, Everitt 1980). At the five cluster level, the major differences between workers due to their work scheduling characteristics can be identified. These five clusters are shown in Figure 7.3. As expected, the cluster analysis identifies the three groups that were evident in Figure 7.1, namely workers with little work scheduling flexibility, workers with high strategic flexibility but low quotidian flexibility, and workers with both high strategic and quotidian flexibility. These groups are identified in Figure 7.3 as Non-Flexible workers, On-Schedule Flexible workers, and Highly Flexible workers, respectively.

A fourth cluster is composed primarily of workers on flexitime. These workers exhibit average strategic flexibility: their medium term work schedule choice is typically constrained to work start and end times that are within 30 minutes of their current times. Hence their schedule flexibility gradient is fairly steep. It appears that these workers do

FIGURE 7.3
Work Schedule Flexibility Clusters

Cluster Name:	**Non-Flexible**	**On-Schedule Flexible**	**Highly Flexible**	**Flexitimers**	**Somewhat Flexible**
Scheduling Flexibility:					
Strategic	Low	High	High	Average	Average
Quotidian	Low	Low	High	Low	High
Gradient	High	High	High	Low	Low
Number of Subjects:	22	16	17	4	7

Dendogram



not gain from the official alternative schedule program as much work scheduling flexibility as workers who obtain it either due to their job tasks or through informal arrangements. Not all flexitime workers belong to this cluster. The ones who have high gradient flexibility (i.e. flat gradients) are assigned to the Highly Flexible or the On-Schedule Flexible clusters, depending on their quotidian flexibility. The fifth and last cluster consists of workers who also have some strategic scheduling flexibility. Like the flexitime workers, their shift discretion is limited to 15 minutes to 30 minutes around their current work schedules. Unlike Flexitimers, they exhibit high quotidian flexibility. Workers in this and the flexitime cluster appear to have similar opportunities to consider non-work activities when choosing their work schedules.

In summary, we have found three characteristics that define work scheduling flexibility: the overall, medium term ability to choose work schedules (strategic flexibility), the day-to-day work scheduling discretion (quotidian flexibility), and the extent to which scheduling discretion is limited to a narrow interval around the current work schedule (schedule flexibility gradient). These characteristics subdivide the sample into five distinct groups of workers. Of these groups, only one appears to have quite limited work scheduling flexibility. Workers in the other groups have jobs that give them opportunities to incorporate non-work activity constraints and preferences in their work schedule choices.

7.5 NON-WORK ACTIVITY SCHEDULING CHARACTERISTICS

The survey addressed the scheduling characteristics of non-work activities in two ways. First, subjects were asked to rate the level of discretion that personal and family factors give them to shift their work schedules early or late (see Questions Nos. 35 and 36). This question gauges whether non-work factors exert a constraining effect on work schedules. The responses to this question are discussed in Section 7.5.1. A more detailed exploration of the scheduling characteristics of non-work activities was undertaken using the information collected via the activity diary and interview portions of the survey. A descriptive analysis of this information is presented in Section 7.5.2.

7.5.1 Discretion to Shift Work Schedules Due to Non-Work Scheduling Flexibility

Many of the sampled workers appear to have the non-work flexibility required to shift work trips so as to avoid peak hour commutes (see Table 7.11). Only about one-third of the sample indicate having little discretion (levels 2 or 1) to shift at least 30 minutes. Conversely, over 50% are allowed by their non-work obligations and/or preferences to easily shift their schedules by 30 minutes, early or late. At a 60 minute shift, workers appear to find it easier to shift early than to shift late. Still, about one-third of all workers have the discretion to start working one hour later than they currently do. And less than 20% of the workers who indicated having high discretion to shift by 15 minutes also indicated little discretion to shift by 60 minutes (see Table 7.12).

TABLE 7.11
Discretion to Shift the Work Schedule, by Shift Interval.
Effect of Non-Work Constraints.

	Proportion of Subjects at Each Discretion Level, by Shift Interval					
	Early Shifts			Late Shifts		
Discretion Level [a]	15 min.	30 min.	60 min.	15 min.	30 min.	60 min.
5	60%	54%	48%	49%	45%	34%
4	9%	4%	3%	7%	6%	9%
3	10%	13%	9%	16%	18%	13%
2	9%	10%	7%	10%	10%	10%
1	12%	18%	33%	16%	21%	33%

[a] 5 is the highest level of discretion, 1 the lowest level of discretion.

TABLE 7.12

Schedule Flexibility Gradient. Effect of Non-Work Constraints.

	Proportion of Subjects [b]					
Discretion for a	Early Shifts			Late Shifts		
15 min. shift [a]	Discretion for a 60 min. shift			Discretion for a 60 min. shift		
	5 or 4	3	2 or 1	5 or 4	3	2 or 1
5 or 4	75%	6%	19%	76%	8%	16%
3		43%	57%		54%	46%
2 or 1			100%			100%

[a] 5 is the highest discretion level, 1 is the lowest discretion level.

[b] The percentages are estimated with respect to the number of subjects at each 15 min. shift discretion level, hence rows add up to 100%.

There are eight people who indicate having no non-work discretion at all to shift their schedule even by 15 minutes early, and eleven people who cannot shift their schedule late by even 15 minutes. Fully one-third of the sample cannot shift early or late by 60 minutes due to personal or family factors. It is likely that these people could not schedule their work trips to avoid peak hours.

It is remarkable that when asked to consider non-work constraints only, the resulting distributions of workers by discretion level are quite similar to the distributions obtained due to work-related constraints. We compare these distributions, using the average shift discretion, and the shift discretion gradient. The shift discretion gradient is calculated as the slope of a linear regression of the shift discretion scores on the shift intervals. Hence a zero gradient indicates similar scores at all shift intervals, while a large gradient indicates a high score at 15 minutes and a low score at 60 minutes, i.e., high lose of discretion with increasing shift interval.

In Tables 7.13 and 7.14, workers whose work-related scheduling discretion is equal to their non-work related discretion appear in the diagonal, early and late shifts respectively. These workers constitute approximately one half of the sample. In the case of early shifts, there are more workers above than below the diagonal. This indicates higher discretion due to non-work factors than due to work factors. No such difference is apparent for the case of late shifts. In this case however, we observe a bimodal response pattern: workers have either high discretion to shift late, or no discretion to shift late.

TABLE 7.13
Average Discretion to Shift Work Schedules Early, by Work and Non-Work Factors.

	Frequency of Responses				
	Work-Related Discretion Index (Average)				
Non-Work Related Discretion Index (Average)	[5]	] 5 to 4]	] 4 to 3]	] 3 to 2]	] 2 to 1]
[5]	**15**	4	5	2	5
] 5 to 4]	0	**1**	0	2	1
] 4 to 3]	3	2	**7**	0	0
] 3 to 2]	1	1	1	**2**	1
] 2 to 1]	0	4	0	2	**8**

TABLE 7.14
Average Discretion to Shift Work Schedules Early, by Work and Non-Work Factors.

	Frequency of Responses				
	Work-Related Discretion Index (Average)				
Non-Work Related Discretion Index (Average)	[5]	] 5 to 4]	] 4 to 3]	] 3 to 2]	] 2 to 1]
[5]	**11**	4	3	1	3
] 5 to 4]	2	**3**	1	1	2
] 4 to 3]	5	1	**7**	0	0
] 3 to 2]	3	0	0	**5**	0
] 2 to 1]	0	3	1	1	**10**

When we examine the shift discretion gradient, we observe more workers with zero gradient due to non-work factors than a zero gradient due to work factors (see Tables 7.15 and 7.16). This means that subjects were more likely to give equal ratings to the three shift intervals when reporting their non-work related discretion than when reporting their work related discretion. Overall, there are more subjects above than below the diagonal in both tables; this indicates that as the shift interval increases, subjects are more likely to loose some scheduling discretion due to work than due to non-work factors.

In summary, non-work considerations allow workers somewhat more discretion to shift their work schedules than job-related constraints. However they do limit some workers' ability to schedule their own working hours. And in particular, non-work related discretion seems less dependent on the shift interval, which suggests that it tends to form a bimodal distribution: workers either have, or not, discretion due to non-work factors. The next section examines in more detail the types of non-work activities reported as affecting the scheduling of work trips.

TABLE 7.15
Scheduling Discretion Gradient, by Work and Non-Work Factors.
Early Shifts.

	Frequency of Responses			
	Work-Related Discretion Gradient			
Non-Work Related Discretion Gradient	[0]	]0 to 0.4]	]0.4 to 0.8]	]0.8 or higher
[0]	**28**	9	5	2
] 0 to 0.4]	3	**4**	2	0
] 0.4 to 0.8]	2	1	**6**	0
] 0.8 or higher]	1	0	0	**4**

TABLE 7.16
Scheduling Discretion Gradient, by Work and Non-Work Factors.
Late Shifts.

	Frequency of Responses			
	Work-Related Discretion Gradient			
Non-Work Related Discretion Gradient	[0]	]0 to 0.4]	]0.4 to 0.8]	]0.8 or higher
[0]	**35**	8	2	1
] 0 to 0.4]	2	**1**	4	0
] 0.4 to 0.8]	2	2	**5**	0
] 0.8 or higher]	1	0	0	**4**

7.5.2 Non-Work Activity Preferences and Constraints

7.5.2.1 Identification of Non-Work Motivations in Work Schedule Choice

In this section we examine the work scheduling motivations of subjects with some ability to flex their work schedule. That is, we exclude the workers who belong to the non-flexible cluster, since they lack both medium and short term work scheduling flexibility. This is because the extent to which a non-work activity affects work schedule choice depends on the extent to which the schedule can be chosen. While non-flexible workers too engage in non-work activities before or after work, they must use strategies unrelated to work schedule choice when the schedules of work and non-work activities collide.

Non-work scheduling flexibility was derived primarily through attitudinal data, collected during the interview phase of the survey. The following procedure was used to identify any non-work motivation in work schedule choice.

Prior to the interview, workers kept a diary of all non-work activities in which they participated on a given day, both before and after work. During the interview, subjects were asked to indicate, for each non-work activity recorded in the diary, their level of discretion to either cancel or reschedule the activity, and asked to rate it on a scale from 1 (little discretion) to 5 (lots of discretion). When they indicated that the activity was highly discretionary, they were also asked to indicate how willing they would be to cancel

or reschedule the activity. The purpose of this last question is to gauge whether workers have preferences over the scheduling of discretionary activitites. In addition, they had to rate their discretion and willingness to change their departure time from home in the morning and their arrival time at home in the evening. Again, this is required because there may be time-of-day constraints or preferences that affect these times, unrelated to any particular in or out-of-home activity. For example, they may find it taxing to get up early enough to leave home before a given time, or they may prefer to be at home before the children arrive from school.

After rating the activities recorded in the diary, workers were asked to state their primary work scheduling motivation. We followed a two-step approach. First we they were presented with two statements, and asked to choose the one that most closely described their job[11]:

(a) Your job gives you little choice to decide your work schedule.

(b) Your job lets you choose the times at which you start and end your work day.

If a subject chose *(a)*, we inferred that their work schedule is primarily determined by their employer. Subjects who chose *(b)* were further asked to rate, also on a scale from 1 to 5, the importance of each of the following motivations in determining their current work schedules: family responsibilities before or after work, personal activities before or

[11] Responses to this question were also used in the analysis of work scheduling flexibility.

after work, and avoiding morning and/or evening peak hours. The alternative "Other" was available so that subjects could add motivations other than the ones listed above which they considered relevant to their work schedule choice.[12]

Subjects who chose *(b)* were then classified depending on the motivations for scheduling their work trips. We chose to do so separately for morning and evening work trips, to be able to later examine whether evening activities affect the timing of the morning trip, and vice versa. Thus for each commute period (morning and evening), the following criteria were used to identify the motivation behind the timing of the trip:

- Subjects who gave the highest rating to "avoiding morning and/or evening peak hours" were assigned to the Peak Avoidance group, regardless of whether they actually travel during non-peak hours.
- Subjects who gave the highest rating to either "family responsibilities" or "personal activities" were assigned to the Non-Work motivation group. For workers within this group, the purpose of the activity with the lowest scheduling discretion rating was chosen as the motivation for the work trip. This activity may be highly discretionary: for example, several carpoolers rated their discretion to stop carpooling as very high. Sometimes the scheduling constraint was associated

[12] At the time of the interview, we could not readily infer from the responses to the work flexibility questions the extent to which workers were able to choose their work schedules. Yet this flexibility is a necessary condition to be able to consider non-work motivations. Hence the need for a question at this point in the interview that would discriminate between those who had little work scheduling choice, and those who had some work scheduling choice.

not with a particular activity, but with the home departure or arrival time: for example, a preferred home arrival time may reflect the need to be there when children arrive from school, and not scheduling preferences for any particular activity undertaken in the evening.

- A few subjects used the "Other" category to add work-related motivations as the determinant of their work schedule, hence they were assigned to the Work-Related group.

Therefore, for each person indicating that their job lets them choose their work start and end times, we identify the principal motivation for their choice of work schedule. In cases where this motivation is the schedule of a non-work activity, we obtain the purpose of the activity and a rating for how difficult it would be to change its schedule. Three of the people who chose statement *(a)* above were identified by the factor and cluster analyses as being flexible. For two of them, the work scheduling motivation was inferred to be work-related, while for the other it appeared to be carpooling, and thus was assigned to the Non-Work group. Only one person who chose statement *(b)* was identified as being non-flexible, and hence is excluded from the following discussion.

7.5.2.2 Work Scheduling Motivations of Commuters on Flexible Work Schedules

The work trip timing motivations of flexible work schedule commuters are quite varied, as shown in Table 7.17. Out of 46 commuters, congestion avoidance is a primary

motivation for only 12 subjects in the morning, and 9 subjects in the evening. Five subjects choose their schedules primarily driven by work-related needs, in spite of having the option to flex their working hours. They cite reasons such as colleague interaction or the supervision of subordinates. Hence for the majority of subjects, the schedule of the work trip resulted from the schedule of a non-work activity, or from time-of-day preferences to schedule these activities.

TABLE 7.17
Work Scheduling Motivations of Flexible Work Schedule Commuters.

	Work Arrival Time		Work Departure Time	
Work Scheduling Motivation	Frequency	Percent	Frequency	Percent
Peak Hour Avoidance	12	26%	9[a]	20%
Work-Related Reasons	5	11%	5	11%
Non-Work Activities (AM):				
Serve Child Passenger	7	15%	2	4%
Serve Adult Passenger	2	4%	1	2%
Carpool	4	9%	2	6%
Out-of-Home Activities	1	2%	10	22%
Time-of-Day Preferences[b]	4	11%	1	2%
Dinner / Time with Family	0	0%	8	17%
Other In-Home Activities	0	0%	2	4%
None[c]	11	24%	5	17%
Total Subjects	46		45	

[a] Three subjects are primarily concerned about avoiding the morning peak, but not the evening peak.

[b] These preferences indicate preferred sleeping hours or a desire to avoid parking lots at night.

[c] These are subjects who have a non-work constraint or motivation only on one trip end. See Table 7.18 for a cross-tabulation of morning/evening non-work motivations.

Of all workers who indicated that a non-work activity influences their work trip timing, there are 13 who reported both an activity constraint in their morning and evening commutes, and 16 people who have a constraint either in the morning or in their evening commute (see Table 7.18). Even though the latter appear to be free to schedule the non-constrained trip end so as to avoid congestion, it is unlikely that most of these people would schedule one trip end independently of the other. This is because most people work a fixed number of hours per day. Few of them would be willing to work longer days with the purpose of avoiding traffic. And only some of them are likely to have the flexibility required to either work at home or work a variable number of hours per day. In the next two sections we discuss the scheduling discretion associated with these non-work activity motivations separately for morning and for evening commutes. The combined effect of morning and evening non-work activities on daily work travel times is examined in Chapter 8.

(a) Morning Non-Work Activities

About half of the workers who have a non-work activity tied to their home departure time are limited by the need to serve a passenger, typically the spouse or children, or by prior carpool arrangements (see Table 7.17). The need to serve school trips tends to limit both the earliest and the latest times at which these subjects leave home: parents are reluctant to drop off their children too early, while at the same time they must ensure that the children arrive on time. This activity elicits the lowest indices of scheduling discretion

among all the different motivations (see Table 7.19). Moreover, the majority of parents who drive their children to school or day care in the morning prefer to arrive at home early, so that the children are not alone for long and to spend time with them (see Table 7.18).

TABLE 7.18
Cross-Tabulation of Morning and Evening Non-Work Scheduling Motivations.

	Frequency of Responses, Non-Work Motivations							
	Evening Trip							
Morning Trip	Serve Child Pax.	Serve Adult Pax.	Carpool	Out-of-Home Actvts.	Time-of-Day Prefs.	Dinner / Time with Family	Other In-Home Actvts.	None
Serve Child Pax.	1			2		4		
Serve Adult Pax.				1				1
Carpool			2		1			1
Out-of-Home Actvts.								1
Time-of-Day Prefs.				1		1		2
Avoid Peak Hours				1		2		
None	1	1		5		1	2	

In this sample, carpooling is a highly discretionary activity. Workers indicated that they carpool more out of choice than out of necessity. They reported high levels of discretion to cancel the activity, meaning that they could easily switch to driving alone[13]. But at the same time, they appear quite unwilling to do so, as indicated by the low average index of willingness to cancel. This occurs in spite of the fact that carpooling can be quite constraining, since it requires people to leave the house within a short time interval everyday. Workers in this sample were able to make carpooling arrangements both by finding partners that work a similar schedule, and by changing their work schedule so they could match somebody else's. In either case, changing the timing of the carpool would likely require finding new partners, hence the unwillingness to reschedule this activity. There are two carpoolers in the sample who return home by transit.

Preferences for particular sleep times were mentioned as often as carpool arrangements among the work scheduling motivations. In general, these are workers who like to sleep late. Their sleep time preferences in effect determine the earliest time at which they would leave from home. As expected, these workers have lots of discretion to reschedule this activity; that is, to either get up earlier or later. But they consistently expressed little willingness to do so (see Table 7.19).

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[13] Carpooling at UCB is advantageous mostly because of the parking benefits it entails. Carpoolers share the cost of a (reduced fee) central campus permit. In addition, they are entitled to faculty/staff occasional use permits and regular permits at a discounted fee. Parking spaces are reserved for carpoolers until 10:00 AM on most lots. To qualify for a carpool permit, drivers are required to carpool at least three days per week. All partners must be in the vehicle at the time they enter the parking lot. Carpoolers who drive on I-80 may use the HOV lane as long as there are three or more people in the vehicle. There are no travel time advantages to carpooling on H-24, since this highway does not have HOV lanes.

TABLE 7.19
Level of Discretion / Willingness to Reschedule or Cancel Non-Work Activities, Flexible Work Schedule Commuters.

	Average Index [a]			
	Work Arrival Time		Work Departure Time	
Non-Work Activity	Discretion	Willingness	Discretion	Willingness
Serve Child Passenger	2.7	2.7	4.0	2.0
Serve Adult Passenger	2.5	2.5	5.0	5.0
Carpool	5.0	2.2	5.0	3.0
Out-of-Home Activities	5.0	2.0	3.4	2.7
Sleeping Preferences	4.8	3.0	5.0	3.0
Dinner / Time with Family	-	-	3.5	3.2
Other In-Home Activities	-	-	3.0	3.0

[a] Measured on a scale from 1 (lowest) to 5 (highest).

(b) Evening Non-Work Activities

As in the morning, serve-passenger trips affect the timing of the evening commute trip. Fewer people do serve passenger trips in the evening than in the morning, primarily because most of the older children go back home after school on their own. But even if the children are old enough to travel by themselves, parents still expressed preferences related to the latest home arrival time. In some cases they do not wish to leave the children home alone for long, but more often they want to have time to spend with their family. In households with children, dinner time tends to occur at about the same time everyday. It is likely that this time is agreed upon after considering parents' schedules, but on a day to day basis, it acts as a constraint on the latest time at which parents plan to

leave work. Similarly, parents want to have plenty of time early in the evening to help children with homework or do other activities before their kids get tired, so that they may leave work early and later continue working at home after the children have gone to bed.

Besides family-related activities, engaging in out-of-home activities also places some limitations on the evening commute. Out-of-home activities include exercising, attending religious services, and volunteering at the local school. Some of these activities may be considered discretionary, especially when compared to family activities. Yet on average, subjects reported levels of scheduling discretion similar for both out-of-home and family-related activities.

Similarly, in-home activities, unrelated to child care, elicit low levels of scheduling discretion. This was surprising, because these activities represent time spent in hobbies. Higher scheduling discretion indexes were expected because the activities are discretionary and not dependent on a particular schedule. Yet, it appears that evenings is the only time at which these people could allocate enough time to pursue their interests, and hence they express little discretion (and willingness) to cancel the activity or reschedule it.

7.6 SUMMARY

We have identified three characteristics that define work scheduling flexibility: the

medium term ability to choose the work schedule, the day-to-day discretion to vary work arrival and departure times, and the loss of scheduling discretion that ensues the farther one wishes to reschedule working hours from the current schedule. Of these characteristics, the first and the last are expected to better explain workers' ability to incorporate congestion avoidance and non-work activity concerns into their work schedule choice[14].

These three work scheduling flexibility characteristics identify, in this sample, four distinct groups of workers. Within each group, workers exhibit approximately homogeneous work scheduling flexibility. In terms of their ability to consider non-work motivations when scheduling work, these groups are:

- Non-flexible workers, who lack both medium and short term flexibility.
- Workers with about average medium term flexibility. These includes workers officially on an alternative work schedule program, and workers who cannot easily shift their schedules beyond 30 minutes early or late.
- Workers with high medium term flexibility, but low day-to-day scheduling discretion. These workers can choose their work schedules, but on a day to day basis they need to arrive and leave according to a schedule.

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[14] Depending on the nature and extent of variability in corridor travel times, it may be that short-term scheduling discretion also influences work schedule choice. For this to be the case, travel times would have to be highly variable for each person. Workers who lack quotidian discretion may choose, under these circumstances, to leave home early enough that most of the times they would arrive before their work start time, thus hedging against late arrivals. We established in Chapter 6 that travel times are more variable during peak than non-peak periods, but we cannot tell whether travel times are variable within or across individuals. Moreover, since both lower travel time variability and lower mean travel time are characteristics of non-peak periods, we cannot analyze separately these two effects.

- Highly flexible workers. These people can choose their work schedules, and they can also vary their work arrival and departure times on a daily basis.

It is notable that, among the UCB employees, workers officially on flexitime or other alternative work hours programs seem to exhibit less work scheduling flexibility than workers who enjoy this flexibility as an occupational perk, and probably less than the general flexitime population. The majority of flexitime programs implemented in industry establish flex bands at the beginning and end of the day that are about two or three hours wide. In these circumstances, flexitime workers are typically not limited to 30 minute shifts around their work schedules, although they still need to arrive and depart at the same times every day. The UCB program does not establish flex bands or core periods. Instead, the decision as to how much to flex is jointly made between workers and their supervisors. Thus it is surprising that, considering how prevalent flexible hours are at UCB, workers seem to gain relatively little flexibility through the official program. Perhaps, it is primarily workers with otherwise highly inflexible schedules who are the ones who officially solicit flexitime. Workers who can easily reach an agreement with their supervisors may be more likely to do so without needing to invoke work scheduling rules.

On average, non-work activities and concerns give workers somewhat more scheduling flexibility than work scheduling norms. Even so, non-work activities influence work scheduling decisions in about half of all work flexible subjects. Some of these activities

are highly discretionary, yet workers consistently indicate little willingness to cancel the activity or to change its schedule. In the next Chapter we examine whether an activity's discretionarity is related to its effect on work schedule choice.

As was found with the exploratory interviews, in some cases non-work activities appear to directly affect only one trip end, either the work arrival or the work end times, while in other cases people report that both trip ends are constrained. In the next chapter we explore whether those with only one constraint are able to schedule their other trip end so as to avoid congestion. We believe this to be unlikely, since most people's work day length is typically determined by work needs.

More people express concerns over avoiding the peak morning commute than over avoiding the peak evening commute. This is consistent with one of the trip timing strategies inferred from the travel time estimates: the morning commute is more peaked than the evening commute and therefore it more advantageous to avoid the morning peak than to avoid the evening peak.

The sample differs from the San Francisco Bay Area population in two ways: it is likely to contain a higher proportion of workers with above average work scheduling flexibility, and it exhibits a higher proportion of workers likely to engage in child-related non-work activities. The first difference arose by design: UCB was chosen as the study site partly because it was expected that a high proportion of its employees would have flexible work

schedules. The second difference however was not anticipated. Its main consequence is to prevent us from making inferences about the incidence of child-related non-work activities in the general population. It does not affect our understanding of the effect of these activities on work schedule choice.

8.
ACTIVITY SCHEDULING FLEXIBILITY AND TIME-OF-DAY CHOICE

8.1 INTRODUCTION

In this chapter we explore whether increasing activity scheduling flexibility results in non-peak travel, hence shorter travel times. We first examine the effect of work scheduling flexibility on work trip timing choice. Then, for the subset of subjects who exhibit some work scheduling flexibility, we look at the effects of non-work scheduling flexibility on their work travel time-of-day choices. Then we examine the joint effects of work and non-work scheduling flexibility. The chapter ends with an assessment of the non-peak travel potential of granting additional work scheduling flexibility to currently non-flexible workers.

Travel time savings, as defined in Chapter 6, is the core metric used here to examine the effects of activity scheduling flexibility on work travel time-of-day choice. A more conventional trip timing choice metric is the time of day at which trips are made. More specifically, this metric is time-of-day deviations, that is trip time measured relative to the peak time of day. When all subjects travel in the same corridor, then the results of the analysis are invariant to the use of time-of-day deviations or travel time savings as the trip timing metric. But since the study includes three travel corridors with different peaking

patterns, we use time-of-day deviations in addition to travel time as a basis for aggregating across corridors.

The relationship between time-of-day deviations and travel time savings for the sample subjects is show in Figures 8.1 and 8.2, respectively for the morning and evening commute. This relationship obviously follows the triangular shape of Equation (6.2). It shows that as the time-of-day deviation increases, travel time savings vary depending on the travel corridor. A few subjects travel near the shoulders of the peak, and thus obtain high travel time savings. High travel time savings are obtained by some H-24 commuters, whose travel distance to campus is approximately 14 miles. Commuters who use surface streets typically travel no more than 8 to 9 miles, but some of them exhibit large travel time savings because this corridor peaks somewhat late in the morning.

8.2 EFFECT OF WORK SCHEDULING FLEXIBILITY ON WORK TRIP TIMING CHOICE

In this section we examine the relationship between work scheduling flexibility and work trip timing. First we look at whether workers who lack work scheduling flexibility are more likely to travel during peak than non-peak hours. Then we examine whether workers who have work scheduling flexibility are more likely to travel during non-peak than peak hours.

FIGURE 8.1
Travel Time Savings by Time-of-Day Deviations
Morning Commute

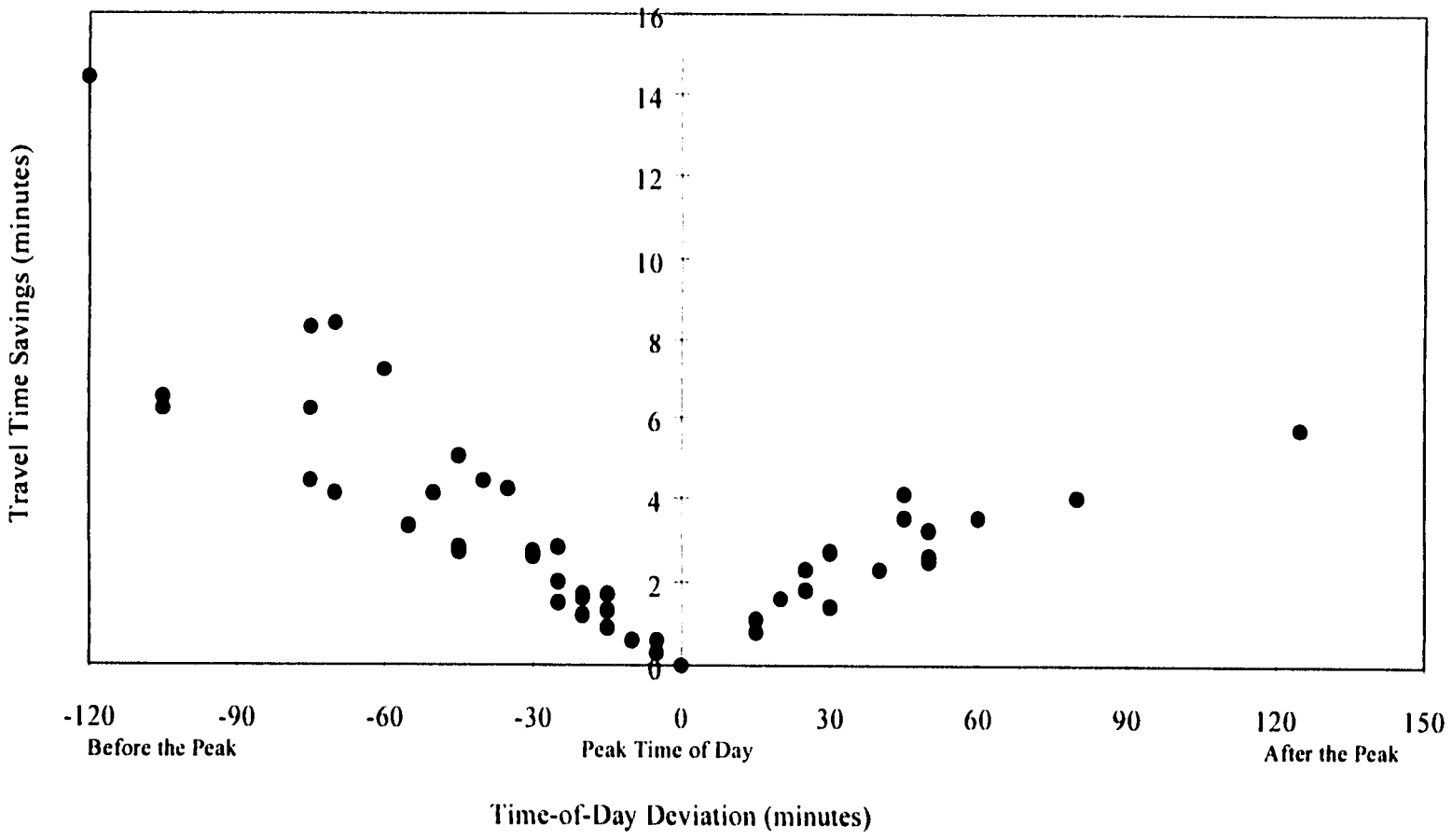
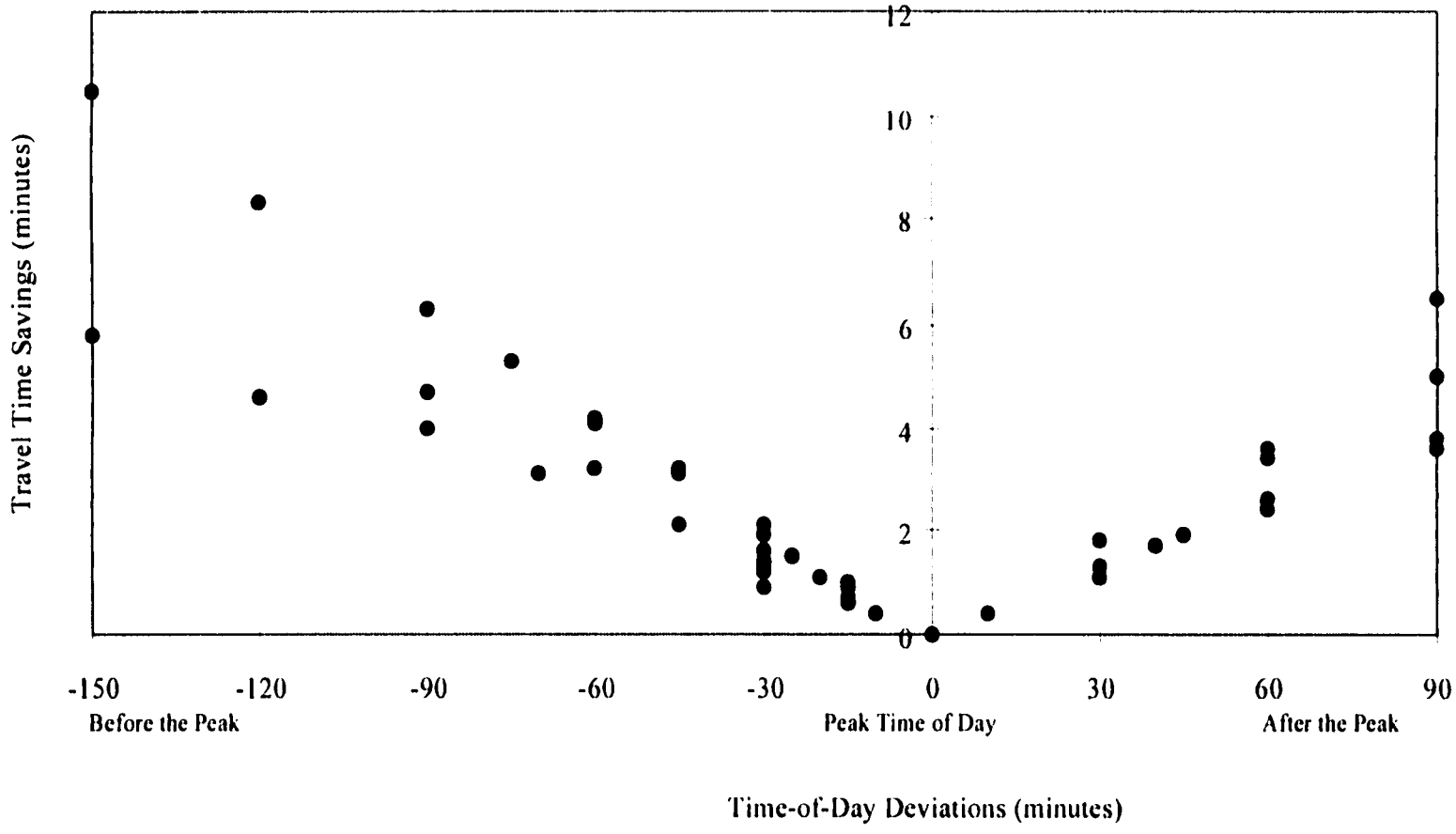


FIGURE 8.2
Travel Time Savings by Time-of-Day Deviations
Evening Commute



Workers who lack work scheduling flexibility do not necessarily travel during peak times of day. In this sample, several Non-Flexible workers arrive at or leave from campus 60 minutes or longer before or after the peak (see Figures 8.3 and 8.4). Previous studies (Small 1982, Hendrickson et al. 1984) suggest that this is because they would rather incur a schedule delay (with respect to their nominal schedule) than travel during congested hours. But in fact, a large time-of-day deviation does not imply a large schedule delay. This is because for some people the official work start or end times do not coincide with the peak time-of-day. Hence, their nominal work schedules allow them to save some travel time without having to incur a schedule delay. As shown in Table 8.1, most non-flexible workers arrive within 15 minutes of their nominal work start time, and leave within 15 minutes of their nominal work end time, that is their schedule delay is at most 15 minutes. Yet fewer workers arrive or depart within 15 minutes of the peak times of day. Instead their work schedules allow them to travel further away from the peak than 15 minutes. Some non-flexible workers do incur schedule delays, and large time-of-day deviations, because their work arrival or departure times depends on the schedule of another family member: typically they commute with a spouse that has an earlier work schedule.

Conventional wisdom suggests that flexibility to schedule work hours gives people opportunities to schedule their trips outside of peak periods. As a result, travel time savings may increase with increasing work scheduling flexibility. As shown in Figures 8.3 and 8.4, workers in the clusters with highest strategic flexibility (On-Schedule

Flexible and Highly Flexible) exhibit on average larger time-of-day deviations than other workers in the sample. But it is also clear that several of these workers do not in fact travel far from the peak time of day. Before turning to the work scheduling motivations of flexible workers, we first examine the effect of work scheduling flexibility on their travel time savings.

Since there are three components to this flexibility, we examine the effect of each of these components on travel time savings. We first use the work flexibility clusters to examine differences between the groups due to higher or lower flexibility on one factor, and then perform a disaggregate analysis that controls simultaneously for the three work flexibility factors.

TABLE 8.1
Schedule Delay and Time-of-Day Deviations of Non-Flexible Workers

	Number of Non-Flexible Workers			
	Morning Commute		Evening Commute	
Time Interval [a]	Schedule Delay	Time-of-Day Deviation	Schedule Delay	Time-of-Day Deviation
75-30 min. Early	2	5	0	2
30-15 min. Early	1	3	0	11
15- 0 min. Early	15	9	0	0
0-15 min. Late	1	3	16	4
15-30 min. Late	0	1	0	4
30-90 min. Late	0	1	3	4

[a] Early and Late defined with respect to the nominal work start or end time for schedule delay, or with respect to the peak time of day for time-of-day deviations. Zero schedule delay and zero time-of-day deviation are included in the Early interval for morning trips, and in the Late interval for evening trips.

FIGURE 8.3
Time-of-Day Deviations by Work Flexibility Cluster
Morning Commute

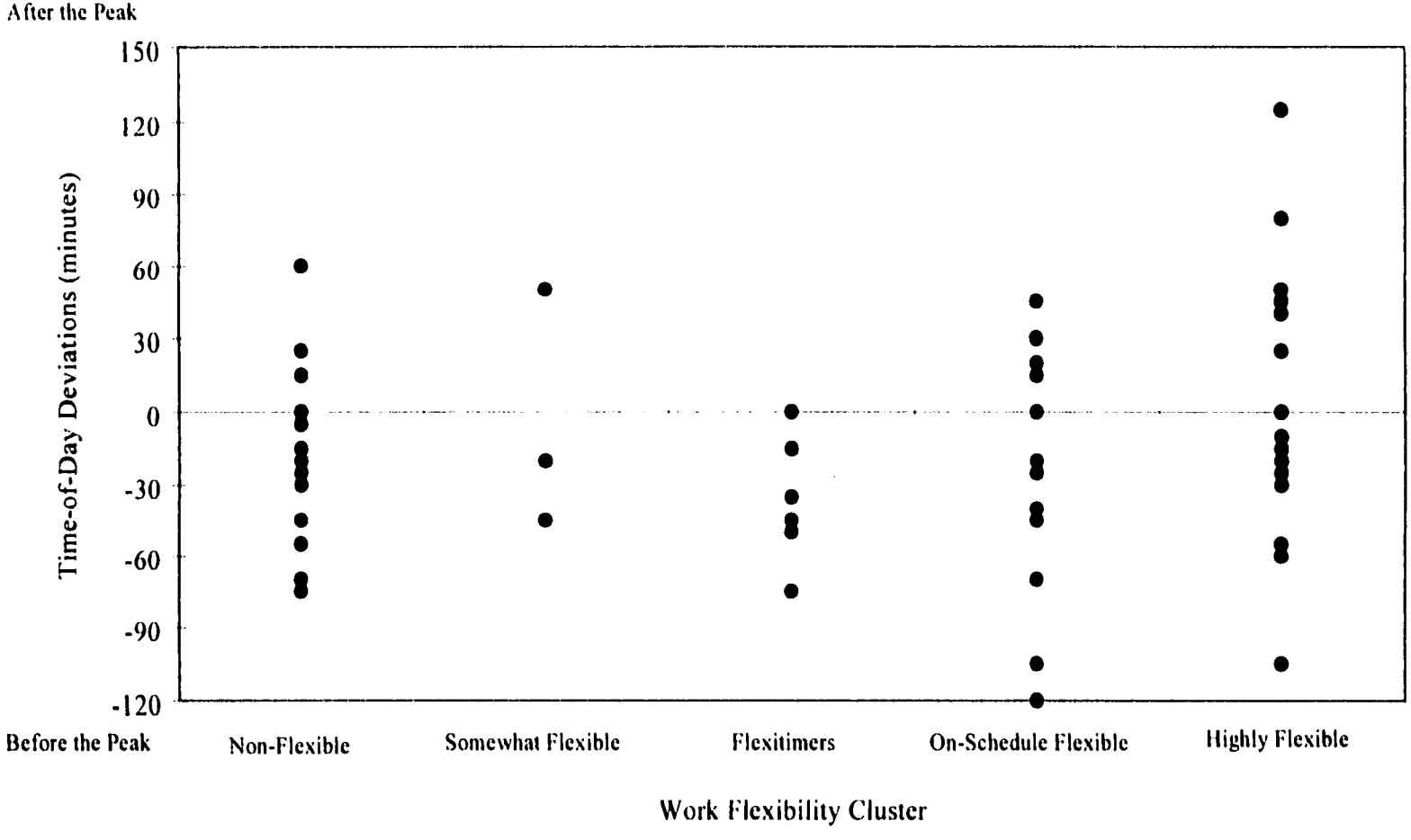


FIGURE 8.4
Time-of-Day Deviations by Work Flexibility Cluster
Evening Commute

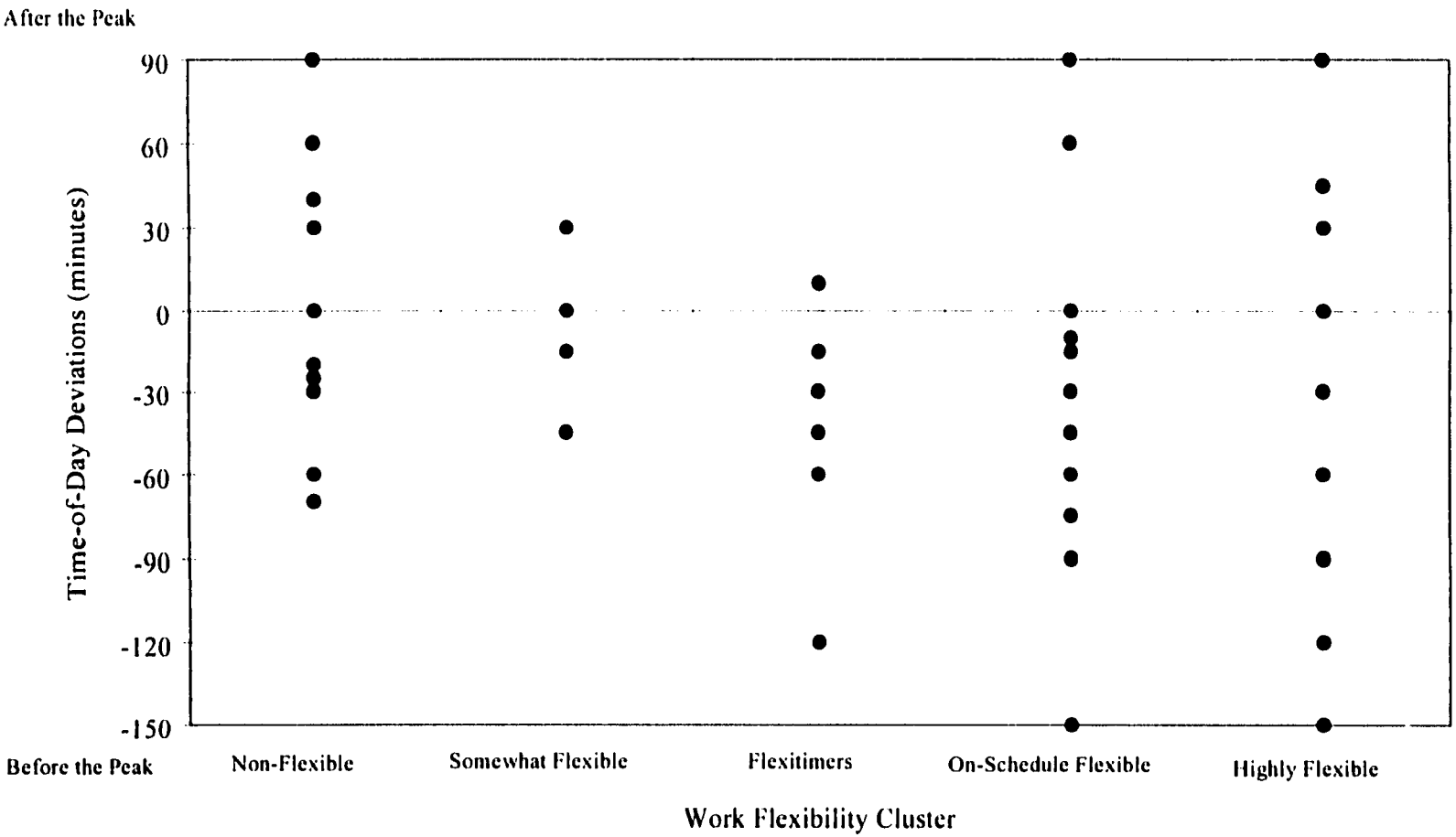


Table 8.2 lists the travel time savings of each work flexibility cluster. We know that Highly Flexible workers have more strategic and quotidian flexibility than Non-Flexible workers.[15] And it is clear by comparing these two clusters that commuters with low work scheduling flexibility exhibit, on average, lower travel time savings than commuters with high work scheduling flexibility (the t statistic for this difference of means test is 3.0). A comparison between On-Schedule and HighlyFlexible workers allows us to isolate the effect of quotidian flexibility from the effect strategic flexibility. On-Schedule Flexible workers exhibit similar strategic and gradient flexibility as Highly Flexible workers, but lower quotidian flexibility. This lack of flexibility does not appear to affect their time-of-day travel choices, since the average difference in travel time savings between these two clusters is not significantly different from zero.

TABLE 8.2
Travel Time Savings by Work Schedule Flexibility Cluster.

		Daily Travel Time Savings (minutes)		
No.	Cluster Name	Cluster Size	Average	Standard Error
1	Non-Flexible	23	3.3	0.4
2	Somewhat Flexible	4	3.3	0.2
3	Flexitimers	7	5.9	2.0
4	On-Schedule Flexible	16	6.5	1.5
5	Highly Flexible	17	6.3	0.9

[15] Non-Flexible and Highly Flexible workers have a low schedule flexibility gradient. For Non-Flexible workers, this means that their flexibility is on average low independent of the magnitude of a hypothetical shift interval. For Highly Flexible workers, this means that their flexibility is on average high and also independent of the shift interval.

To examine the effect of the three work flexibility factors, we express travel time savings as a function of the three flexibility factors, as follows:

$$TT.Savings = \alpha_0 + \alpha_1 * Strategic\ Flex. + \alpha_2 * Quotidian\ Flex. + \alpha_3 * Gradient\ Flex. + \varepsilon \qquad (8.1)$$

Equation (8.1) is incomplete, since it does not explicitly include the effect of non-work or other factors on time-of-day choice. But it allows to examine the relative importance of the three work flexibility factors.

Table 8.3 shows the estimates for the coefficients of (8.1). Clearly, travel time savings increase with increasing strategic flexibility, as we found above. It appears that, as is commonly believed, the ability to choose one's working hours on a medium-term basis does result, on average, in shorter travel times. This is a preliminary conclusion since we have yet to examine whether non-work activity participation affects this relationship.

Quotidian flexibility does not play a role in time-of-day choice for work travel, since the coefficient of this variable is not significantly different from zero. This confirms the finding obtained from the examination of travel time savings by cluster. For commuters to take advantage of this type of flexibility to save travel time, they would need to have daily access to accurate, pre-trip information on non-recurrent travel conditions such as accidents. If they did, they could adjust their work trip timing daily so that on average they would exhibit lower travel times than people bound by a work schedule. The fact

TABLE 8.3
Effect of Work Scheduling Flexibility on Travel Time Savings
(in minutes of travel time)

Variable	Coefficient Estimate	t Statistic
Constant (α_0)	5.1	10.3*
Strategic Flexibility (α_1)	1.1	2.2*
Quotidian Flexibility (α_2)	-0.3	-0.6
Gradient Flexibility (α_3)	0.5	1.0

* Statistically different from zero with 95% confidence.

that quotidian flexibility is not an important determinant of travel time savings suggests that, either this kind of information is not available, or that when commuters do take advantage of this type of flexibility, they do so for reasons unrelated to congestion aversion.

We observe that although travel time savings increase with the schedule flexibility gradient, the estimated coefficient is not significant. This indicates that when the strategic flexibility is limited to shifts of 15 to 30 minutes around the current schedule (high negative gradient), workers' travel time savings are not noticeably lower than the travel time savings of more flexible workers. This result partly reflects that many Highly Flexible workers and most Non-Flexible workers have zero gradient, yet the former exhibit on average higher travel time savings than the latter. It may also reflect that additional discretion to schedule trips further away from the current schedule is reflected not only as higher gradient flexibility, but also as higher strategic flexibility. Thus part of

the effect of gradient flexibility is already captured by the strategic flexibility factor.

The relationship between the three work flexibility factors and trip timing choice can also be estimated using absolute time-of-day deviations as the dependent variable in (8.1), instead of travel time savings. Table 8.4 shows the results of this estimation. As expected, strategic flexibility has a positive and significant coefficient, indicating that in fact higher strategic flexibility results in trips scheduled farther from the peak time of day. But unlike the travel time savings case, we obtain a significant coefficient for gradient flexibility during evening commutes. Together with the results above, this suggests that, while the additional flexibility signaled by a low gradient does result in trips scheduled farther from the peak time of day, on average this does not result in a noticeable travel time advantage.

TABLE 8.4
Effect of Work Scheduling Flexibility on Time-of-Day Deviations
(in minutes away from the peak time of day).

	Morning Commute		Evening Commute	
Variable	Coefficient Estimate	t Stat.	Coefficient Estimate	t Stat.
Constant (α_0)	35.7	10.1*	46.3	10.9*
Strategic Flexibility (α_1)	7.4	2.1*	9.1	2.1*
Quotidian Flexibility (α_2)	1.5	0.4	2.2	0.5
Gradient Flexibility (α_3)	3.4	1.0	7.8	1.8*

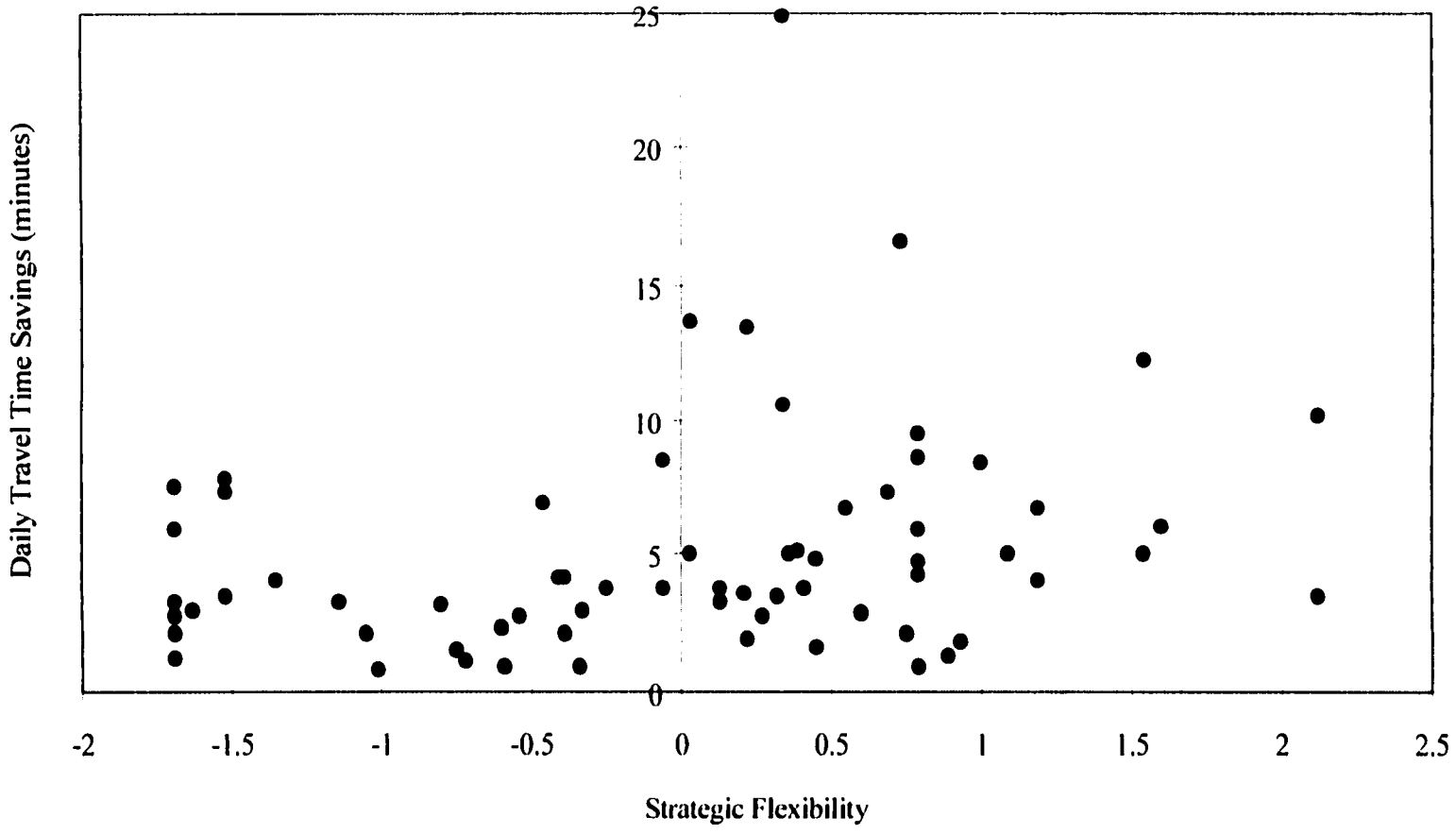
* The asterisk indicates that the coefficient is higher than zero with 95% confidence.

Hence only one type of work scheduling flexibility appears to play a major role in work trip timing: strategic flexibility. Higher strategic flexibility results in higher travel time savings, but this is before accounting for the effect of non-work activities on work trip timing. If congestion avoidance were the primary work scheduling motivation of flexible workers,we would expect to see a significant positive correlation between strategic flexibility and travel time savings. Instead, as shown in Figure 8.5, there is a high variability of travel time savings among workers with high scheduling flexibility: while some flexible workers do exhibit high travel time savings, many attain savings not larger than those of their less flexible colleagues. This occurs because flexible workers are not necessarily choosing to travel away from the peak, and also because non-flexible workers sometimes are able to travel during non-peak hours. Motivations other than congestion aversion therefore must drive the work trip timing decisions of flexible workers. That many flexible workers do not achieve high travel time savings underscores that the ability to choose the work schedule is a necessary, but not a sufficient condition for avoiding peak commute hours. We turn next to an examination the effects of non-work activity scheduling on trip timing choices.

8.3 EFFECT OF NON-WORK SCHEDULING FLEXIBILITY ON WORK TRIP TIMING CHOICE

We showed in Chapter 7 that flexible workers plan their work trips accounting for non-work activity scheduling preferences and schedule rigidities. We employ three different

FIGURE 8.5
Travel Time Savings by Strategic Work Flexibility



approaches to examine the effect of these non-work activities on trip timing choice. In section 8.3.1 we examine whether workers' stated work scheduling motivations have a systematic effect on their trip timing choices. In section 8.3.2, we define non-work flexibility by the number of non-work scheduling constraints in workers' activity schedule, and examine the combined effect of work and non-work flexibility on trip timing choices. Finally in section 8.3.3 we examine whether subjects' stated non-work scheduling discretion shows a relationship with their trip timing choices.

8.3.1 Non-Work Activity Effects by Work Scheduling Motivation

Tables 8.5 and 8.6 show the travel time savings, in the morning and evening commute respectively, of flexible workers by the three main work scheduling motivations: peak congestion avoidance, non-work activities, and work-related concerns. It is clear from these tables that subjects whose work schedules are determined by work considerations or by the schedule of a non-work activity exhibit lower travel time savings than subjects who specifically schedule their trip to avoid the peak commute hour. That is, when the choice of work schedule is driven by a motivation other than congestion avoidance, workers forego some of the travel time savings which their flexibility allows them.

We observe no difference in travel time savings between workers motivated by the schedule of a non-work activity and workers motivated by work-related concerns. This is remarkable because the latter typically have high discretion to choose their work schedule

(both due to work and non-work factors), while at least some workers whose schedules are determined by non-work activities are likely to have little non-work scheduling discretion, and therefore were expected to exhibit lower travel time savings.

An examination of the types of non-work activities which determine flexible workers' schedules reveals that some of these activities may be considered highly discretionary. These include sleeping preferences, out-of-home fitness activities, and some in-home activities. Yet it does not appear that the more traditionally schedule-constraining activities, such as taking children to school or a spouse to work, are more likely to result in lower travel time savings than the more discretionary motivations, whether work or

TABLE 8.5
Travel Time Savings of Flexible Work Schedule Commuters (Morning Commute), by Work Trip Scheduling Motivation.

	Travel Time Savings (minutes)			
Work Trip Scheduling Motivation	Sample Size	Average	Standard Error	t Stat.[a]
Peak Hr. Avoidance	12	5.2	1.0	
Work-Related Reasons	5	2.0	0.6	2.9*[b]
Non-Work Activities	18	1.7	0.3	3.6*
Serve Child Passenger	7	1.9	0.4	3.2*
Serve Adult Passenger	2	2.0	0.5	3.0*
Carpool	4	1.5	0.4	3.6*
Out of Home Activities	1	1.4	-	-
Sleeping Preferences	4	1.5	0.9	2.9*
Evening Non-Work Activity	11	3.5	0.9	1.4

[a] Test statistic for a Difference of Means test with respect to the 'Peak Hr. Avoidance' group.
[b] The asterisk indicates that the difference in means is larger than zero at 95% confidence.

TABLE 8.6
Travel Time Savings of Flexible Work Schedule Commuters (Evening Commute), by Work Trip Scheduling Motivation.

Work Trip Scheduling Motivation	Travel Time Savings (minutes) Sample Size	Average	Standard Error	t Stat.[a]
Peak Hr. Avoidance	9	5.5	0.8	
Work-Related Reasons	5	2.7	0.8	2.5*[b]
Non-Work Activity	26	2.1	0.3	4.1*
Serve Child Passenger	2	1.8	0.1	4.7*
Serve Adult Passenger	1	0.4	-	-
Carpool	2	1.2	1.2	3.0*
Out of Home Activities	10	2.3	0.6	3.3*
Be at Home with Family	8	2.1	0.6	3.4*
Other Activities/Preferences	3	2.6	0.9	2.5*
Morning Non-Work Activity	6	2.6	1.0	2.3*

[a] Test statistic for a Difference of Means test with respect to the 'Peak Hr. Avoidance' group.
[b] The asterisk indicates that the difference in means is larger than zero at 95% confidence.

non-work related.

Workers with rigid schedules typically have both start time and end time constraints. Instead, among workers whose schedule is motivated by non-work activities, some subjects reported that only their work start or their work end time is affected by a non-work activity, while others reported engaging in activities that affect their work scheduling both in the morning and in the evening. It would appear that, in principle, the former could schedule the unconstrained commute so as to avoid some congested travel. Indeed, as shown in Table 8.7, these workers exhibit larger travel time savings than Non-Flexible workers.

TABLE 8.7
Daily Travel Time Savings

Work Trip Scheduling Motivation	Daily Travel Time Savings (minutes) Sample Size	Average	Standard Error	t Statistic[a]
Non-Flexible Workers	23	3.3	0.4	
Flexible Workers:				
Peak Hour Avoidance[c]	10	11.1	1.9	4.0*[b]
Non-Work, AM and PM	13	3.8	0.4	0.9
Non-Work, AM or PM	18	5.1	0.8	1.9*
Work-Related	5	4.7	1.0	1.3

[a] Test statistic for a Difference of Means test with respect to the 'Non-Flexible' group.

[b] The asterisk indicates that the difference in means is larger than zero at 95% confidence.

[c] Subjects who reported non-work motivations for one trip end and peak avoidance for the other trip end were assigned to the Non-Work, AM and PM group.

Commuters who report non-work constraints in both morning and evening trips exhibit instead travel time savings similar to those of Non-Flexible workers (Table 8.7). That is, people whose work start and end times are directly determined by morning and evening non-work activities or scheduling preferences are as likely to travel during peak hours, both in the morning and in the evening, as workers whose jobs give them little work scheduling choice. And similarly, flexible workers whose trip is driven by work concerns end up traveling in as much congestion as workers who have little work scheduling flexibility (Table 8.7).

An alternative way to examine the effect of non-work motivations on trip timing choice is to perform a disaggregate analysis. We regress travel time savings on work scheduling

flexibility (strategic flexibility), and use indicator variables to measure separately the effect of each non-work motivation (peak avoidance, one non-work activity, two non-work activities) on travel time savings, as shown in Equation 8.2. Commuters motivated by work-related concerns are assumed to behave as non-flexible workers.

$$TT.Savings = \alpha + \beta * Strategic\ Flex. + \gamma_1 * PeakAv + \gamma_2 * NWOne + \gamma_3 * NWTwo + \varepsilon \qquad (8.2)$$

where

$$PeakAv = \begin{cases} 1 & if \quad flexible\ work\ schedule\ and\ motivation = peak\ avoidance \\ 0 & otherwise \end{cases}$$

$$NW\# = \begin{cases} 1 & if \quad flexible\ work\ schedule\ and\ \#non\ work\ constrains.\ \# = 1,2 \\ 0 & otherwise \end{cases}$$

As shown in Table 8.8, the disaggregate analysis confirms our previous observations about the effect of non-work activities on work trip timing. Commuters who report non-work activities in the morning and in the evening exhibit the same travel time savings as Non-Flexible workers, while commuters who report being motivated by the schedule of one non-work activity exhibit marginally higher travel time savings (approximately 1.5 minutes higher, on average). However, these additional savings are not highly significant. As expected, Peak Avoiders exhibit significantly higher travel time savings than Non-Flexible workers, approximately 8 minutes on average.

TABLE 8.8
Effect of Work Scheduling Flexibility and Non-Work Motivations on Trip Timing

Variable	Parameter Estimate	t Statistic
Constant[a]	3.6	4.6*[b]
Strategic Flexibility	0.1	0.2
Peak Avoidance	8.1	5.5*
Non-Work Constraint (One)	1.4	1.1
Non-Work Constraint (Two)	0.1	0.1

[a] The constant represents the average travel time savings of non-flexible workers.
[b] The asterisk indicates the estimated coefficient is different from zero with 95% confidence.

It may appear obvious that workers who state that they schedule their commute so as to avoid peak hours indeed exhibit shorter travel times than all other workers. The important finding here is that many commuters who, like the so-called peak avoiders, have the work scheduling flexibility to shift out of the peak hour, choose instead not to do so. Moreover, in many instances the non-work motivation appears to be quite discretionary, which suggests that workers are willing to incur congested travel in exchange for preferred non-work schedules.

Once the effect of the work scheduling motivations is accounted for, it appears that the importance of work flexibility decreases considerably. The estimated parameter of strategic flexibility in (8.2) is not significantly different from zero, while the same parameter in (8.1) was shown to be positive and significant (see Table 8.3). However this is probably because the three work scheduling motivations already capture the work scheduling flexibility effect: only workers with high work scheduling flexibility can

consider non-work motivations when planning their work trips. Therefore these work scheduling motivations obscure the relationships between trip timing and work and non-work flexibility. In the next section we consider an alternative way to measure these relationships.

8.3.2 Non-Work Activity Effects by Non-Work Flexibility

An examination of the non-work activity purposes which affect work scheduling decisions reveals that several of these activities are both discretionary and not highly dependent on time of day. For example, these non-work motivations include sleeping preferences, preferred home arrival times, and self-scheduled out-of-home fitness activities. Workers motivated by these types of activities are quite likely to have more non-work flexibility than workers who need to drop off a spouse at work, or who must be at home before the children arrive from school. That is, low non-work flexibility is not implied by the fact that a non-work activity is the primary motivation of the work schedule.

Instead, non-work flexibility is signaled by the absence from the regular activity schedule of highly mandatory and/or time-of-day dependent non-work activities. Workers who engage in one or more of these constraining activities are considered to have less non-work flexibility than workers who do not perform mandatory time-of-day dependent activities on a regular basis. And moreover, non-work flexibility decreases with the

number of activity constraints: subjects who have constraints in both the morning and the evening have less flexibility than workers who have constraints only in the morning or only in the evening. In our sample there are four different types of these constraining activities: serving child passengers, serving adult passengers, carpooling, and out-of-home scheduled activities (fitness classes, volunteer work, church, a second job). These types of activities appear in the activity diaries regardless of commuters' work scheduling flexibility; that is, non-work flexibility is independent of work scheduling flexibility.[16] Therefore, this alternative classification of non-work activities should allow us to disentangle the effects of work and non-work scheduling flexibility on trip timing choices.

All of these activities are clearly related to the work scheduling motivations examined previously. It is not clear however that carpooling is a non-work constraint: while workers enter into carpools out of choice, their campus arrival and departure times are typically dictated by the work schedule of the least flexible partner. Also, because there is a monetary incentive to carpooling, the resulting travel time savings are only partially explained, if at all, by activity scheduling flexibility. In the analysis that follows, we consider carpooling first as a non-work constraint, and later as a separate work-related constraint.

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[16] Lack of work scheduling flexibility constrains workers' ability to engage in non-work activities that require work schedule adjustments, hence non-flexible workers may be less likely to engage in non-work activities than flexible workers. Our sample does not allow us to test this hypothesis. The non-work activity participation of non-flexible workers is examined in Section 8.4.

In addition to the four types of activities mentioned above, dog care is also present in several subjects' diaries. This non-work activity was not considered in our previous analysis because few people mentioned it as a work scheduling motivation. The need to walk dogs regularly may limit the maximum number of hours, but not the times of day that one can be away from home. When subjects mentioned it as the primary motivation, it was grouped with other in-home activities. An examination of the travel time savings of people who indicate having to walk their dogs both before and after work suggests that this activity does not appear to noticeably affect their trip timing choices, when compared to people who have no non-work constraints. Therefore dog care is not included as a non-work constraint.

Among the non-work motivations of the survey subjects that are not considered to limit non-work flexibility are self-scheduled fitness activities, sleeping preferences, in-home activities such as hobbies, and preferred work departure or home arrival times unrelated to the need for child supervision. These are all activities that could be easily rescheduled or cancelled on short notice.

Table 8.9 shows the correspondance between work scheduling motivations and non-work flexibility. The majority of workers who plan their work trip with congestion avoidance as the primary motivation exhibit high non-work flexibility; that is, they engage in few mandatory and/or time-of-day dependent activities. Similarly, most people who choose their work schedule so that it coincides with the regular business hours at UCB have no

non-work activity constraints. Of all workers motivated by the schedule of two non-work activities, only about half are actually constrained by two mandatory, time-of-day dependent activities. All of these workers however need to take care of at least one of these activities on a regular basis. And one half of the workers motivated by the schedule of one non-work activity actually exhibit high non-work flexibility (zero non-work constraints).

Table 8.9 also shows that many non-flexible workers also lack non-work flexibility. It may seem that, because these commuters already have little discretion to schedule their work, that their lack of non-work flexibility should not further restrict their work trip timing choices. But it should be remembered that, while these workers as a group have the least job flexibility of all workers in the sample, some of them do have some discretion to schedule their work hours. Also, since the peak time of day for morning and

TABLE 8.9
Crosstabulation of Work Scheduling Motivation and Non-Work Flexibility

	Non-Work Flexibility (Number of Activity Constraints)		
Work Scheduling Motivation	Zero	One	Two
Rigid Work Schedule	9	5	8
Congestion Avoidance	9	1	0
Work-Related Reasons	4	1	0
Non-Work Activity, AM and PM	0	6	7
Non-Work Activity, AM or PM	9	9	0

evening travel may not coincide with workers' nominal schedules, when they choose to arrive earlier or depart later than required by their jobs, they may in fact be choosing to travel in more congestion.

To examine the joint effect of work and non-work flexibility on trip timing choice, we regress travel time savings on strategic flexibility and two indicator variables, one for subjects who have one non-work constraints and the other for subjects who have two non-work constraints:

$$TT.Savings_i = \beta * Strategic\ Flex._i + \alpha_0 + \alpha_1 * NWFlex_i^1 + \alpha_2 * NWFlex_i^2 + \varepsilon_i \qquad (8.3)$$

Unlike the indicator variables used in (8.2), $NWFlex^1$ and $NWFlex^2$ take zero/one values independently of subjects work scheduling flexibility. The travel time savings of workers who have no non-work constraints, hence high non-work flexibility, would be equal to β*Strategic Flexibility + α_0. We expect β to be positive, indicating that given similar non-work flexibility, travel time savings increase with work scheduling flexibility. α_1 and α_2 should be negative, indicating that workers who lack non-work flexbility exhibit lower travel time savings than workers who have non-work flexibility, all else equal.

Table 8.10 shows two sets of estimated coefficients for (8.3). One set was estimated including carpooling as a non-work constraint (Model 1), while in the other we separated carpoolers using an indicator variable (Model 2). All coefficients show the expected

signs and are significant with 95% confidence. In particular, the estimate of strategic work scheduling flexibility clearly indicates that, all else equal, travel time savings increase with work scheduling flexibility. The values of strategic flexibility range approximately from -2 for highly non-flexible workers to +2 for highly flexible workers. Thus, for workers who have non-work flexibility, daily average travel time savings vary from about 5 minutes for non-flexible workers to 9 minutes for highly flexible workers. Lack of non-work flexibility reduce these travel time savings by more than 2 minutes in the case of one non-work constraint, and by 4 minutes in the case of two non-work constraints. Hence highly flexible workers who must meet two non-work scheduling constraints have longer daily commutes than people of average work flexibility who are unconstrained by non-work activities.

TABLE 8.10
Work and Non-Work Scheduling Flexibility Effects on Travel Time Savings

	Model 1		Model 2	
Variable	Parameter Estimate	t Stat.	Parameter Estimate	t Stat.
Constant	6.9	10.0*	6.9	10.0*
Strategic Work Flexibility	0.9	1.8*	0.9	1.8*
Non-Work Flexibility				
One Constraint	-2.6	-2.5*	-2.5	-2.3*
Two Constraints	-4	-3.2*	-4.0	-2.9*
Carpoolers	-	-	-3.8	-2.2*

* Indicates statistical significance with 95% confidence (one-tail test).

Carpoolers appear to exhibit a travel time penalty similar to the penalty incurred by workers who have two non-work activity constraints. This result should be interpreted cautiously, because it is possible that our travel time functions do not accurately reflect the travel times of all carpoolers, in particular those of people traveling on the I-80 high-occupancy lane.[17] Excluding carpooling as a non-work constraint does not change the effect of these constraints on travel time savings.

As we did in Section 8.2 when examining the effect of work scheduling flexibility on trip timing choice, we also use time-of-day deviations as the dependent variable in (8.3) to estimate non-work flexibility effects. We find that activity scheduling flexibility results in larger time-of-day deviations in the evening commute than in the morning commute. For example, when compared to non-flexible workers, commuters with high work scheduling flexibility choose trip times that are, on average, 20 minutes further from the peak in the morning, and 36 minutes further from the peak in the evening. Similarly, lack of non-work flexibility results in a higher reduction in time-of-day deviations in the evening than in the morning.

Workers are more likely to avoid the evening peak than the morning peak, even after accounting for the effect of non-work flexibility (see Table 8.11). It may be that because

[17] The carpool lane on I-80 was partially completed in March 1997, posterior to the date of the UCB Faculty and Staff survey, from which data were obtained for the travel time estimation. The activity scheduling survey was conducted in October/November 1998, before the last stage of the carpool lane was opened (Alameda/Contra Costa county line to Powell Street). This means that carpoolers could travel on the high-occupancy lane for most of the freeway section of their trip, but the travel time data does not reflect any resulting travel time advantages.

the evening commute is less peaked than the morning commute (see Table 6.4), a higher time-of-day deviation is required in the evening to obtain significant travel time savings. Other factors, related both to corridors' peaking patterns and to trip timing behavior, may also play a role. I-80 and H-24 peak 30 to 60 minutes later than the UCB business hours in the evening, but in the morning they peak within 30 minutes of the most common work start times (8:00 and 8:30). Therefore a small early deviation from the regular work schedule results in larger time-of-day deviations in the evening than in the morning. Workers who reduce their campus work time by forgoing lunch or breaks are perhaps more likely to leave early in the evening than to arrive very early or very late in the morning. On the other hand, flexible workers who make serve passenger trips in the morning tend to choose arrival and departure times later than UCB business hours, which results in evening travel closer to the peak, as reflected by the results shown in Table 8.11. And out-of-home non-work activities may start at times better suited to the work

TABLE 8.11
Work and Non-Work Flexibility Effects on Time-of-Day Deviations

	Morning Commute		Evening Commute	
Variable	Parameter Estimate	t Stat.	Parameter Estimate	t Stat.
Constant	43.5	8.7*	63.3	10.8*
Strategic Work Flexibility	5.1	1.4	8.6	2.1*
Non-Work Flexibility				
One Constraint	-5.7	-0.7	-31.0	-3.4*
Two Constraints	-25.5	-2.8*	-31.0	-2.9*

* Indicates statistical significance with 95% confidence (one-tail test).

schedules of the majority of commuters, in turn making flexible workers travel at less convenient times than their jobs allow.

In conclusion, it is clear that motivations other than congestion aversion, and in particular non-work activities or work-related concerns, drive the work schedule and work trip timing choices of some flexible work schedule commuters. In doing so, these people forgo most of the travel time savings available due to their work flexibility. On average their travel times are only marginally longer than the travel times of non-flexible workers. Lack of non-work flexibility, regardless of work scheduling flexibility, results in a higher likelihood of peak period trips, and consequently in higher travel times.

8.3.3 Non-Work Activity Effects by Activity Discretion Levels

We examine, among workers for whom a non-work activity is the primary motivation of the work trip, the effect of subjects' stated activity scheduling discretion on trip timing choice. As discussed before, these workers list both mandatory and discretionary activities among their work scheduling motivations, and there appears to be no difference in terms of how unwilling they are to give up or reschedule either type of activity (see Chapter 7). As shown in Table 8.12, in terms of travel time savings, discretionary non-work activities limit the choice of work trip schedule as much as mandatory non-work activities. On average, commuters spend as much extra time in peak period travel to participate in activities which, by their own judgement, are highly discretionary, as they

TABLE 8.12
Travel Time Savings by Non-Work Activity Scheduling Discretion or Willingness

	Daily Travel Time Savings (minutes)					
	Scheduling Discretion			Scheduling Willingness		
Level of Scheduling Discretion/Willingness [a]	Sample Size	Avg.	Std. Error	Sample Size	Avg.	Std. Error
1	4	3.0	0.4	6	2.9	0.4
2	5	6.8	1.3	8	5.2	1.2
3	2	4.2	0.8	8	5.2	1.2
4	7	4.8	1.2	7	4.8	1.2
5	12	4.0	1.0	1	1.6	-

[a] Measured on a scale from 1 (mandatory/highly unwilling) to 5 (highly discretionary/unwilling).

do to take care of personal and family obligations. Even when asked about how willing they would be to cancel or reschedule these activities, there appears to be no relation between the level of unwillingness and travel time savings (see Table 8.12).

8.4 NON-WORK ACTIVITY SCHEDULING OF NON-FLEXIBLE WORKERS

Non-Flexible workers, like their more flexible colleagues, also engage in non-work activities before and after work. We examine the ways in which these commuters schedule their non-work activities, because this is relevant to evaluating whether granting additional work scheduling flexibility to these commuters would affect their trip timing choices. As these workers cannot flex their work schedules, they use different strategies to fulfill these activities. For example, they drop off their children at school as much as one hour before school starts, or arrange with a friend or family member to look after

them in the afternoon. They may participate in discretionary non-work activities only to the extent that they can schedule them given their nominal work hours.

Giving these workers greater leeway to schedule their work would probably not result in their choosing non-peak commute times. In this sample, of 22 subjects with non-flexible work schedules, 12 participate in activities right before or after work which they may find difficult to cancel or reschedule (see Table 8.13). These activities include serving child and adult passengers, spending time in the evening with the family, and engaging in out-of-home activities such as working at a second job, attending church or classes, and leaving time for errands before going home. Hence, assuming that in fact these activities cannot be easily cancelled or rescheduled, additional work scheduling flexibility would typically not result in non-peak travel for the subjects in this group.

The subjects most likely to take advantage of work scheduling flexibility to shift out of the peak hour are those who have high non-work scheduling discretion. But even some of them may be unwilling to shift work schedules. For example, several currently carpool with neighbors or co-workers. A work (and commute) schedule change may require them to give up the carpool or to find a new partner. We know that among the flexible work schedule commuters, carpooling is a highly discretionary activity, but also an activity that few are willing to give up, no doubt in large part because of the parking cost savings that it affords. And it typically results in low travel time savings. At the same time, lack of work scheduling flexibility may have prevented some non-flexible workers from

TABLE 8.13
Non-Work Activities of Non-Flexible Workers

Non-Work Activity Purpose	Index of Scheduling Discretion	
	Sample Size	Average Index
Serve Child Passenger	3	2.0
Serve Adult Passenger	2	1.5
Carpooling	2	5.0
Out of Home Activities	5	3.2
Be at Home with Family	2	2.5

engaging in non-work activities before or after work. They may choose to participate in these activities, and in doing so, perhaps forego travel time savings.

This is not to say that work flexibility would not benefit workers who currently have rigid work schedules. The fact that some flexible workers indicate that they use their work scheduling discretion to participate in non-work activities, or to arrange for more convenient non-work schedules, suggests that work flexibility does have a positive impact on workers' welfare. But what we have found, perhaps to the disappointment of transportation planners, is that the schedules of non-work activities are such that, on average, even flexible workers end up commuting during peak hours. In the next chapter we discuss some of the implications of these findings for the measurement of work trip timing demand, and for the implementation and evaluation of some urban transportation polices.

9.
CONCLUSIONS AND RECOMMENDATIONS

We set out to examine the work trip timing choices of commuters who have some flexibility to schedule their work hours. Not unlike the findings of flexitime studies, we find that work trip timing choices appear to be primarily motivated by one of the following: congestion aversion, work-related concerns, or the schedule of a non-work activity. However, while so far it has been assumed that most flexible workers travel away from peak times-of-day, in fact we find that this is not so. Many flexible workers travel near peak times of day, because they are required to do so by the schedules of their mandatory, time-of-day dependent non-work activities. The scheduling requirements of these types of activities result in a significant travel time cost. Instead, workers who make congestion aversion their primary work scheduling preoccupation rarely have non-work constraints. Not surprisingly they take advantage of their work and non-work flexibility to travel during non-peak hours, and thus on average exhibit shorter travel times than all other workers.

Lack of non-work scheduling flexibility limits the scheduling choices of flexible workers as much as work requirements limit the choices of non-flexible workers. At the same time, some commuters who have high work and non-work flexibility nonetheless choose to travel near peak times of day. Some of these people would rather incur extra commuting time than give up their discretionary activities, while others find that the gain

in travel time does not make up for the inconvenience of a work schedule that does not coincide with the schedules of co-workers. Clearly workers trade off travel time for work and non-work scheduling convenience.

Our detailed, in-depth examination of work and non-work scheduling flexibility and work scheduling motivations in turn help us explain some of the unexpected relationships observed between trip timing, workers' occupation, and workers' demographic characteristics in the BATS data. First of all, it has become clear that characteristics such as occupation or industry of employment are poor indicators of commuters work scheduling flexibility. In our sample, all subjects work for the same industry, and their occupation is either professionals or administrative workers. Yet we found important differences in their ability to schedule their work. This, together with the fact that flexible workers sometimes need or choose to travel during peak times of day, suggest that one should not surprised that the BATS data show increasing travel times with increasing work flexibility.

Weak relationships between demographic factors such as gender and presence of children and travel behavior, such as those found in the BATS study, should not be interpreted as suggesting that non-work activity participation or activity characteristics have little to no effect on time-of-day choice. Instead, our findings indicate that these demographic characteristics are likely to not correlate well with non-work activity characteristics such purpose, time-of-day dependence, or obligatoriness. Therefore it is not surprising that

demographic characteristics fail to explain time-of-day choice.

Another important limitation of the BATS study is the inaccuracy of network travel time estimates. These estimates do not capture differences in travel time by time of day or by travel corridor, and therefore they may obscure the relationships between workers' characteristics and their trip timing choices. The network estimates appear to significantly underestimate the travel time differences between peak and off-peak periods. Moreover, one must assume that the peak time-of-day is the same for all travelers, when in fact it varies with travel corridor, and with the location of home and work with respect to the location of the congested sections. Clearly, accurate estimates of travel time differences by time-of-day are crucial information to understand and explain trip timing choices. Yet detailed travel time information is rarely available, even in severely congested corridors, and hence the reliance on network estimates. While it is time-consuming to collect this information by floating car or similar methods, recent developments have made it possible to obtain accurate travel time estimates from loop detector data. Hence we propose to use the existing network of loop detectors to collect travel time information. This will not only provide the necessary information for work trip timing models, it will also further our understanding of the time-of-day characteristics of travel times.

Our findings further our understanding of work trip timing choice, and in particular they shed light on the inadequacies of current approaches to modeling time-of-day choice.

The effect that non-work activities or motivations have on work schedule choice is rarely, if at all, considered when modeling work trip timing choice. Yet, since these activities are as important as work scheduling norms, it is simplistic to assume that only the latter affect this choice. Moreover, work scheduling norms have been considered only indirectly, by making use of indicators of work scheduling flexibility such as occupation or industry of employment.

In spite of their shortcomings, models that ignore activity scheduling flexibility are currently used by metropolitan planning organizations to forecast trip timing responses due to increasing congestion levels, added highway capacity, and even time-of-day tolls. Needless to say, little is known about how flexible workers would actually respond to any of these events or policies. The current assumption that flexible workers are primarily motivated by congestion aversion simply does not hold. And ignoring the role of non-work motivations in work trip timing decisions hides a potential source of inequality in the face of congestion pricing schemes. Workers forced to travel during peak hours because of the schedules of their non-work activities are not only captive of these times-of-day, but also unaided by supposedly alleviating policies such as flexitime. While they may derive a travel time benefit, assuming that the congestion toll does succeed in reducing congestion levels, they do not have the option of not paying the toll, as more flexible workers do. Therefore, to the extent that one believes that time is not money, congestion pricing may discriminate, not only on the basis of income, but also against a population cohort likely to engage in mandatory, time-of-day dependent activities:

working parents of young children.

This is not to say that flexitime or similar policies to promote alternative work schedules do not help some people to shift out of peak hours. There is ample evidence in the literature, corroborated here, that flexible working hours are a necessary condition for workers to decide on their most convenient work schedule. However the effectiveness of this policy is limited by two factors. On the one hand, many people already enjoy a large degree of work scheduling discretion, mostly due to characteristics inherent to their jobs. They would gain little additional discretion through a flexitime program. But more importantly, many workers who are given the opportunity to travel during non-peak hours are unable or choose not to do so. Because their unwillingness or lack of discretion stems from the non-work environment, it is doubtful that work-based policies will have much impact on their decisions, as far as non-peak travel is concerned. Policies more likely to encourage, or at least facilitate, non-peak travel would be those that increase the opportunities for engaging in non-work activities throughout the day. For example, some large employers already provide day or after-school care at their work sites, but possibly more could be encouraged to follow suit. This would reduce the time required to travel between the daycare center and work, and presumably could be better tailored to meet the travel and work preferences of employees. It is perhaps more likely that increased opportunities will result as a market response to the demand for unorthodox schedules. Already, fitness facilities are available practically round the clock, churches offer early morning weekday service, and many grocery stores are open 24 hours a day.

In order to better understand the tradeoffs between work scheduling, congestion aversion, and non-work scheduling inconvenience, it is important to examine how these tradeoffs vary with congestion levels. It may be that, as the travel time gains from peak avoidance increase, people are more willing to incur higher non-work scheduling inconvenience in exchange for travel time gains. On the other hand, as the peak hour spreads, a substantial reduction in travel times requires a radical departure from the most common business hours, thus less willingness to shift. Future studies can examine this by choosing corridors with larger travel time differentials than the corridors used here.

To date it has not been obvious how to represent work or non-work flexibility in work trip timing models. Efforts in this direction are currently stymied by the lack of data on either of these characteristics. Our investigation contributes a methodological basis to begin considering ways to represent these characteristics, as well as inexpensive alternatives to collect the necessary data.

The data which are currently available to study work trip timing choice do not contain enough information to even discriminate between people who have little work scheduling choice, and those who have some discretion to choose work hours. Our findings suggest that three pieces of information are required: the current work schedule, whether the job allows scheduling discretion, and how much scheduling discretion is available. We found that a priori statements which describe the most common work scheduling norms were able to sort the sample as flexible or non-flexible workers almost as well as an analysis

that combined several different work scheduling measures. To gauge the degree of discretion available, workers could be asked to indicate whether they could shift their work schedules by at least one hour. We are unsure however how successfully people discriminate between work and non-work scheduling limitations when answering this type of question.

Assessing the flexibility associated with the schedules of non-work activities is considerably more difficult. One possibility would be to inquire about the frequency with which any given activity is performed, under the assumption that regular activities are more likely to affect work schedule choice than occasional activities. Another possibility would be to revise the current classification of activity purposes, so that it would better reflect that some activities are time-of-day dependent while others are not. Even with current data, a better understanding of work and non-work activity scheduling could be obtained if one had information about work scheduling flexibility. For example, knowledge of each householder employment status and his or her work scheduling flexibility can be used to investigate how non-work responsibilities are shared between working and non-working partners, as well as among working partners according to their work scheduling discretion. This would shed additional light on the household dynamics that result in the choice of non-work activities, and in turn, of work schedules.

Clearly, additional research is required to refine the indicators of work and non-work scheduling flexibility used here. This is probably better accomplished with techniques

similar to ours: in-depth, detailed interviews of work and non-work scheduling practices. In addition, two more avenues are proposed to further this research. Our findings suggest that it would be possible to gather work scheduling information with one or two simple questions, such as those used in our survey. Hence we propose that such questions be included in large-scale travel behavior surveys. This would provide the necessary data to investigate alternative modeling approaches to the work trip timing choice problem, as well as a better understanding of activity scheduling tradeoffs at the household level.

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APPENDIX 1
PERSONAL INTERVIEW MATERIALS

A1.1 INTERVIEW QUESTIONNAIRE

Part I: Purpose of the Study. Interview Overview. Demographic Information.

Hi, I'm Rosella Picado. I'm a graduate student in the Department of Civil Engineering. I'm conducting a study about the relationship between people's daily travel and the scheduling of their work and household or personal activities. In the course of this interview, I would like for you to tell me about three different aspects of your daily schedule: characteristics of your work, characteristics of your commute to and from work, and characteristics of your non-work activities, both in-home and out-of-home activities.
When we talked on the phone, I asked you a few questions about yourself and your household. One reason for doing that was to make sure I had a diverse sample. But more importantly, I need that kind of information because the decisions people make about when and how to commute are probably related, to some degree, to their household responsibilities.

1. Age group: _____

2. Spouse/Partner: [ ] Yes [ ] No

3. Children: [ ] Yes [ ] No

4. Where do you live? I don't need an exact address, perhaps just a nearest intersection or landmark. _____

Spouse/Partner:

5. How old is you spouse or partner? _____

6. What is his/her occupation? _____

7. Is he/she employed full time or part time? _____

Children:

8. How many? _____

9. How old are they? _____ _____ _____ _____ _____ _____

10. Day-care arrangements: _____

11. Before/After school care for those in school: _____

12. Are there other people that live in your household? [ ] Yes [ ] No

13. What is their relationship to you? _____

_____

13. Do you have any pets? [ ] Yes [ ] No

Part II: Work Schedule Flexibility.

I'd like to ask you a few questions about your work schedule. In particular, I would like to know how flexible your work schedule is: what is your daily schedule, how much it changes from day to day, to what extent do you feel obligated to be at work at certain times of the day, how much control do you have over your schedule, and so on.

21. Tell me about the work you do

[If professor/lecturer: probe for classes (which days), faculty meetings, office hours]

[Probe for meetings]

_____

_____

_____

22. And how do your work days vary from one day to the next? _____

_____

23. What would you say is your typical work schedule? _____

If needed:

You come in at about _____, and in the evening leave around _____.

24. How much does your work start time vary from day to day? _____

[Probe for source of variation]

25. How much does your work quit time vary from day to day? _____

[Probe for source of variation]

[If little variation]:

26. To what extent do you try to arrive and leave at about the same time everyday?

Why is that? _____

[Probe for reasons for regularity: workplace obligation/practice, personal/family convenience]

27. Do others in your workplace arrive about the same time you do? _____

28. Do they leave about the same time you do? _____

29. In terms of deciding your work schedule, how free do you feel to choose when to come in and when to leave? _____

[Probe for limits of start and end times: no later than, no earlier than]

[If not free, then ask what the constraints are (supervisor, fixed schedule, classes, family, students, peer pressure)]

Ask to professors and high level administrative personnel:

30. What does "being late" to work mean to you? _____

31. What does "leaving early" to work mean to you? _____

Ask only to low-level administrative personnel, technicians, low-skill workers:

According to your employer or supervisor's policies,

32. What is considered arriving late at work? _____

33. What are the penalties, if any, for arriving late occasionally, say once every couple of weeks? _____

34. What are the penalties, if any, for arriving late often, for example once every few days? _____

35. What would be considered leaving early from work? _____

36. What are the penalties, if any, for leaving early occasionally, say once every couple of weeks? _____

37. What are the penalties, if any, for leaving early often, for example once every few days? _____

[For those with fixed schedules]:

38. If you needed to, would it be possible for you to work a different schedule?

Part III-A: Work Commute Information (Morning)

Let's now focus on your work commute, that is, your trip from home to work in the morning, and your trip from work to home in the evening. I would like to know what your daily commute is like and how you feel about it, the extent to which you can travel at any time you want, and so on. Regarding your morning trip,

41. Starting from home, please describe your route to campus, for example which roads you take, where do you enter and exit highway 24, etc?

_____

_____

_____

[Probe for: location of congestion, parking]

42. At what time do you usually leave home to go to work? _____

43. And how long does it take you to get there? _____

44. How much does that time vary from one day to the next? _____

[ ] Less than 5 [ ] 5 - 10 min [ ] 10 - 15 min [ ] 15 - 20 min [ ] More than 20

45. Source of variation: _____

46. Is your commute in any way determined by the needs of somebody else in your household? _____

47. Do you usually make any stops on your way to work? [ ] Yes [ ] No

If YES:

Purpose	Duration	Frequency	End	Options?

[Probe for occasional stops, variations in typical commute: departure time, route, mode]

Part III-B: Work Commute Information (Evening)

Now let's talk about your trip in the evening, that is, on your way home from work., and again let's focus on the timing of your trip, and how that is affected by your other activities.

51. You told me before you usually leave work at about _____. How long does it take you to get home? _____

52. Do you find that your travel time varies much from one day to the next? By how much?

[ ] Less than 5 [ ] 5 - 10 min [ ] 10 - 15 min [ ] 15 - 20 min [ ] More than 20

Source of variability: _____

53. Do you go home the same way you come to work? _____

_____

54. In the afternoon, do you hit congestion? [ ] No [ ] Yes 55. Where? _____

_____

56. How does congestion vary with the time at which you leave work? _____

57. Do you often need to pick up someone on your way home? [ ] No [ ] Yes

58. Whom? How often? _____

59. Do you usually make any stops on your way home from work? [ ] Yes [ ] No

If YES:

Purpose	Duration	Frequency	Mandatory?

[Probe for occasional stops]

Part IV: Non-Work Constraints and Preferences Information

Let's now talk about your non-work time. In the course of our conversation, several aspects of your personal life have come up as factors that affect when you travel to and from work, and also how you schedule your work. I would like to talk to you in more detail about these issues. Here I'm looking for information on the extent to which your personal or family life is affected by your work or your commute, or the other way around, the extent to which your ability to schedule your work or your work travel is limited by or organized around non-work activities.

61. What is your morning routine like? _____

_____

_____

[Probe for lack of regularity sp. by day of the week, and reasons]

62. Can you / Do you postpone them if you're late? If you don't feel like it? _____

63. Do you find yourself often delayed or in a rush for one reason or another? _____

65. Now, in the evenings after work, would you say that you have a routine? _____

66. If YES: *Could you describe that routine?* (Note potential constraints)

_____

_____

[Probe for deviations]

Skip to # 69

67. If NO, *Tell me what did you do yesterday/last Thursday after work?* _____

_____

68. And how was that different from any typical day? _____

_____

[Ask if spouse/partner works]

69. What is your spouse's/partner's work schedule?

70. Does he/she have a choice of when to work?

71. [if YES]: *How is that choice related to the times at which you can/cannot be at home?*

72. [If NO]: *Does that affect your own choice of work schedule?*

73. *How free do you feel to change your routine?* _____

74. *Is there a time by which you must be at home? Why?*_____

_____

Suggestions: watch TV, have time to read, make phone calls, prepare dinner, have dinner, spend time with the kids, go to bed on time, have time to run errands (groceries, bank).

75. *Do you make it a point to leave work by a certain time? Why?*_____

_____

[Probe for traffic if not mentioned]

76. *Do you think that your personal/family life in anyway limits the hours at which you can work?* _____

[Probe: is home scheduled around work, or viceversa?]

When do you make time for: [Ask for frequency too]

77. *Grocery shopping, going to the cleaners, banking? Are you mostly responsible for this in your household?*

78. *Cook, do the dishes, do the laundry, clean the house, take care of garden/pets?*

79. *Watch TV, read, study, listen to music, or generally engage in some "time of your own"?*

80. *Spend time in activities that involve your children?*

81. *Do you work at home? Do you work on weekends, at home or at the office?*

So let me summarize to make sure I understand: the things that are fixed in your schedule are:

Work: _____ _____ _____

_____ _____ _____

Part V: Closure

91. Do you feel anxious when your commute takes longer than you normally expect? Why do you think that is?

92. Do you think that you have some slack in your schedule that helps you stay on track when traffic is bad?

[Ask those with flexible hours]:

93. If the morning peak hour was between _____ and _____, would you change the times at which you come and leave work?

94. Assuming there was no traffic at any time of day, would you prefer to work different hours? Why?

[Ask those with fixed schedules]:

94. If you were given the choice of flexible hours, would you change your current schedule? How? Why?

Check list:

[ ] Entire AM and PM routes?

[ ] Alternate routes? Why not use them? When use them?

[ ] Location of congestion

[ ] Are travel times door-to-door?

[ ] Travel time variability

[ ] Home departure and arrival times

[ ] BART strike / Tunnel accident

[ ] Ask about spouse's schedule / plans to work

[ ] Are schedules new/unusual? Probe for changes in lifestyle.

[ ] AM/PM buffers

[ ] Long hrs at office vs Work at home

Please take a look at this list of activities. We have already talked about some of these things. However, I'd like you to go down the list, and tell me how often do you spend time on each activity, and to what extent do you prefer (or have) to do it on a schedule.

74. If you see anything to which you must absolutely dedicate some time on one or more week nights? Do you have a schedule for it?

75. Now do you see anything on which you like to spend time, and you actually do on a regular basis? Do you have a schedule for it?

TABLE A.1
Household / Personal Activity List

Out-of-Home Activities	AM	PM		Wkend
		Going home	After-wards	
1. Grocery shopping				
2. Other shopping				
3. Banking or other personal business				
4. Walk the dog				
5. Eat out				
6. Go to the movies/theater/concerts				
7. Go to a cafe/bar/club				
8. Exercise (jog, bike, walk, go to gym)				
9. Take the kids out				
10. Go to school-related activities				
11. Visit friends or family				
12. Go to church				
13. Take recreational/job-related classes				

TABLE A.1 (continued).
Household / Personal Activity List

In-Home Activities	AM	PM		Wkend
		Going home	After-wards	
1. Cook meals				
2. Eat at home				
3. Do the dishes				
4. Watch TV or videos				
5. Read or listen to music				
6. Work at home				
7. Clean the house				
8. Do the laundry / ironing				
9. Have friends come over				
10. Talk to friends on phone				
11. Spend time with your children				
12. Help children with homework				
13. Go over bills or mail				

A1.2 SCREENING QUESTIONNAIRE

SUBJECT No. _____

Good morning. My name is Rosella Picado. I am a graduate student here at Berkeley, in the Department of Civil and Environmental Engineering. I am conducting a study concerning people's work schedules and their work travel habits. With your permission, I would like to ask you a couple of questions. This will only take a few minutes. May I continue?

[ ] NO ----->[TERMINATE]
[ ] YES

Thank you.

1. [ROUTE] *On your trip from home to campus, do you travel on Highway 24?*

[ ] NO -----> TERMINATE
[ ] YES

2. [MODE] *What mode of transportation do you use to travel from home to the campus?*

[ ] AUTO [ ] CARPOOL [ ] BART [ ] BUS [ ] CYCLE [ ] OTHER

If not AUTO or CARPOOL, then TERMINATE.

3. [AGE] *In reference to your age, are you between:*

[ ] 18-25 [ ] 26-35 [ ] 36-45 [ ] 46-55 [ ] More than 55

4. [MARITAL STATUS] *Are you currently married or living with a partner?*

[ ] NO [ ] YES

5. [CHILDREN] *Are there any children, less than twelve years old, that live with you?*

[ ] NO [ ] YES

Thank you very much. As I mentioned before, I am a Berkeley graduate student, and this research is part of my Ph.D. work. The study I'm conducting is looking at how people organize their work and family time, and what role traffic congestion plays on their schedules. I would like to talk to you in some detail about your work commute and time management, at a time and place that are convenient for you. This meeting would take approximately 30 minutes, and everything we discuss will be kept confidential. Would you be willing to let me interview you?

[ ] NO -----> TERMINATE
[ ] YES

Thank you very much. Now, I would like to send you some information about the study. May I have your campus mailing address?

Name:

_____

Department:

_____

Building:

_____

Would you like to go ahead and set up a time and place for us to meet?

[ ] YES:

DATE: _____

PLACE: _____

_____

TIME: _____

[ ] NO:

[ ] CALL BACK. WHEN: _____ [PHONE] _____

[ ] CANDIDATE WILL CALL ME.

A.3 CONSENT FORM

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

TELEPHONE. (510) 642-5672
FAX. (510) 643-8919

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
TRANSPORTATION ENGINEERING
215 MCLAUGHLIN HALL
BERKELEY, CA 94720-1712

Dear Sir / Madam.

My name is Rosella Picado, and I am a graduate student at the University of California at Berkeley. I am currently working on a study concerning people's schedules and their work travel habits.

You were recently contacted over the telephone about participating in this study. If you agree to take part in this research, I will conduct an interview with you at the time and place of your choice. The interview will involve questions about the timing, duration, and purpose of your typical daily activities (including both work and non-work activities), and also about the characteristics of your trip to and from work. The interview should last between 30 and 45 minutes. With your permission, I will audiotape the interview. I expect to conduct only one interview, however, follow-ups may be needed for additional clarification. If so, I will contact you by telephone.

All information obtained during the course of the interview will be kept confidential. In particular, your responses will NOT be made available to your employer, supervisor, or co-workers. I will take measures to minimize the risk of accidental disclosure. My notes and tapes will be kept in a locked cabinet at my campus office. Your name and any other identifying information will not be used on any reports or other research products. Upon completion of my study, I may save the notes and/or tapes for use in future research by myself or others. However, the same confidentiality guarantees given here will apply to future storage and use of the materials.

Your participation in this research is voluntary. There is no direct benefit to you, however we hope that the research will benefit society by helping transportation professionals understand the impact that travel has on people's work and family schedules. Participation will entail no costs to you, other than your time. You are free to refuse to take part. You may refuse to answer any questions and may stop taking part in the study at any time. Whether or not you participate in this research will have no bearing on your job standing.

Should you have any questions regarding this study or the interview itself, please feel free to call me, Rosella Picado, at (510) 643-6927, or my faculty adviser, Prof. Mark M. Hansen, at (510) 642-2880.

If you agree to take part in this study, please sign the consent form below. Please keep the other copy of this form for future reference.

I have read this consent form and agree to take part in this research

_____

Signature Date

APPENDIX 2
SURVEY INSTRUMENTS

A2.1 RECRUITMENT: SCREENING QUESTIONNAIRE (H-24)

SUBJECT No. _____

Good morning. My name is Rosella Picado. I am a graduate student here at Berkeley, in the Department of Civil and Environmental Engineering. I am conducting a study concerning people's work schedules and their work travel habits. With your permission, I would like to ask you a couple of questions. This will only take a few minutes. May I continue?

[ ] NO ----->[TERMINATE]
[ ] YES

Thank you.

1. [MODE] *What mode of transportation do you use to travel from home to the campus?*

[ ] AUTO [ ] CARPOOL [ ] BART [ ] BUS [ ] CYCLE [ ] OTHER

If not AUTO or CARPOOL, then TERMINATE.

2. [ROUTE] *On your trip from home to campus, do you travel on Highway 24?*

[ ] NO -----> TERMINATE
[ ] YES

Thank you very much. As I mentioned before, I am a Berkeley graduate student, and this study is part of my doctoral research. The study looks at how people organize their work and family time, and what role traffic congestion plays on their schedules. It focuses on the campus community, and specifically on people like you who commute on Highway 24 or Interstate 80. Participation in the study entails filling out a written questionnaire and an activity diary, and then briefly discussing the diary with me, at a time and place of your choice.
Would you be willing to participate in this study?

[ ] NO -----> TERMINATE
[ ] YES

Thank you very much. Now, I would like to send you the survey materials. May I have your campus mailing address?

_____

_____

_____

Mail code: _____

I'll put the survey package in the mail for you, and I will call you in a few days to make sure everything's clear, and to schedule our interview.
Again, thank you very much for your time and participation.

I need to ask you three more questions, for initial classification purposes:

3. [AGE] *In reference to your age, are you between:*

[ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55 or older

4. [MARITAL STATUS] *Are you currently married or living with a partner?*

[ ] NO [ ] YES

5. [CHILDREN] *Are there any children, less than twelve years old, that live with you?*

[ ] NO [ ] YES

A2.2 RECRUITMENT: SCREENING QUESTIONNAIRE (I-80)

SUBJECT No. _____

Good morning. My name is Rosella Picado. I am a graduate student here at Berkeley, in the Department of Civil and Environmental Engineering. I am conducting a study concerning people's work schedules and their work travel habits. With your permission, I would like to ask you a couple of questions. This will only take a few minutes. May I continue?

[ ] NO ----->[TERMINATE]
[ ] YES

Thank you.

1. [MODE] *What mode of transportation do you use to travel from home to the campus?*

[ ] AUTO [ ] CARPOOL [ ] BART [ ] BUS [ ] CYCLE [ ] OTHER

If not AUTO or CARPOOL, then TERMINATE.

2. [HOME] *Is your home located in any of the following cities: El Cerrito, Richmond, San Pablo, Pinole, El Sobrante, Hercules, Rodeo, or Crocket?*

[ ] NO -----> [TERMINATE]
[ ] YES

3. [ROUTE] *On your trip from home to campus, do you travel on Interstate 80 or 580?*

[ ] NO
[ ] YES

Thank you very much. As I mentioned before, I am a Berkeley graduate student, and this study is part of my doctoral research. The study examines how people organize their work and family time, and what role traffic congestion plays on their schedules. It focuses on the campus community, and specifically on people like you who commute on Highway 24 or Interstate 80. Participation in the study entails filling out a written questionnaire and an activity diary, and then briefly discussing the diary with me, at a time and place of your choice.
Would you be willing to participate in this study?

[ ] NO -----> TERMINATE
[ ] YES

Thank you very much. Now, I would like to send you the survey materials. May I have your campus mailing address?

Name:

_____

_____

_____

Mail code: _____

I'll put the survey package in the mail for you, and I will call you in a few days to make sure everything's clear, and to schedule our interview.

I only have three more questions, for our preliminary classification.

4. [AGE] *In reference to your age, are you between:*

[ ] 18-24 [ ] 25-34 [ ] 35-44 [ ] 45-54 [ ] 55 or more

5. [MARITAL STATUS] *Are you currently married or living with a partner?*

[ ] NO [ ] YES

6. [CHILDREN] *Are there any children, less than twelve years old, that live with you?*

[ ] NO [ ] YES

A2.3 SURVEY FORM

ACTIVITY SCHEDULING AND TRANSPORTATION SURVEY

PART I: HOUSEHOLD INFORMATION

1. What is your current home zip code? _____

2. What is your gender? [ ] Male [ ] Female

3. What is your age in years?
[ ] Under 25 [ ] 35-44 [ ] 55-64
[ ] 25-34 [ ] 45-54 [ ] 65 or older

4. How many adults live in your household? (Do not include adult children):
[ ] You only.
[ ] You with Spouse/Partner only.
[ ] You with other Adults.
[ ] You with Spouse/Partner and other adults.

5. If you live with a spouse/partner, does he or she:
[ ] perform paid work full-time out of home?
[ ] perform paid work part-time out of home?
[ ] perform paid work at home?
[ ] perform paid work both in and out of home?
[ ] not perform paid work?

If your household includes children, go to Question 6. Otherwise, go to Question 11.

6. Please list how many children live in your household:
a. 2 years old or younger: _____
b. 3 - 5 years old: _____ d. 13 - 15 years old: _____
c. 6 - 12 years old: _____ e. 16 or older: _____

7. Do any of the children attend day care outside of home?
[ ] No
[ ] Yes. Please list the days of the week and times of day that each child is at out-of-home day care:

Child's age	Day care schedule
_____	_____
_____	_____
_____	_____

8. Do any of the children attend school?
[ ] No
[ ] Yes. Please list the school schedule for each child that attends school:

Child's age	School schedule
_____	_____
_____	_____
_____	_____

9. How many times per week do you drive a child / children to day care or school in the morning? _____

10. How many times per week do you pick up a child / children from day care, school, or after-school activities? _____

PART II: TRANSPORTATION - MORNING COMMUTE

11. List below your typical home departure and work arrival time(s). In the third column, indicate your home to work travel time, ***exclusive of any time spent at stops or activities between home and work.***

	Time at which you: Leave from home	Arrive at work	Travel Time (min)
Mon	_____	_____	_____
Tue	_____	_____	_____
Wed	_____	_____	_____
Thu	_____	_____	_____
Fri	_____	_____	_____

12. Do you regularly make any stops or perform any activities between home and work?
[ ] No - Go to Q. 14 [ ] Yes - Go to Q. 13

13. Please list the purpose of all regular stops or activities that take place between home and work:

Weekday(s)	Stop/Activity Purpose
_____	_____
_____	_____
_____	_____
_____	_____

14. Which option best approximates your morning commute route?
[ ] I-580 [ ] I-80 [ ] Highway 24
[ ] Local streets only [ ] Other: _____

15. If your commute includes a freeway, which freeway entrance and exit do you use on your way to work ? *Please name the streets.*
Entrance: _____
Exit: _____

PART III: TRANSPORTATION - PARKING

16. How long does it take you to reach your work place from your parking / drop off location? _____ minutes.

17. Do you park on or near campus?
[ ] No - go to Q. 20 [ ] Yes - Go to Q. 18

18. Considering the availability of parking, what is the latest time at which you would arrive at work? _____

19. Where do you park your car while at work?
[ ] UCB parking lot / structure. *Please list:* _____
[ ] On local street [ ] Private garage
[ ] Other: _____

PART IV: TRANSPORTATION - EVENING COMMUTE

20. List below your typical work departure and home arrival time(s). In the third column, indicate your work to home travel time, ***exclusive of any time spent at stops or activities between work and home.***

	Time at which you: Leave from work	Arrive at home	Travel Time (min)
Mon			
Tue			
Wed			
Thu			
Fri			

21. Do you regularly make any stops or perform any activities between work and home?

[ ] No - Go to Q. 23 [ ] Yes - Go to Q. 22

22. Please list the purpose of all regular stops or activities that take place between work and home:

Weekday(s)	Stop/Activity Purpose

23. Which option best approximates your evening commute route?

[ ] I-580 [ ] I-80 [ ] Highway 24
[ ] Local streets only [ ] Other: _____

24. If your commute includes a freeway, which freeway entrance and exit do you use on your way home? *Please name the streets.*

Entrance: _____
Exit: _____

PART V: WORK SCHEDULE

25. What is your faculty or staff position?

[ ] Professor / Associate Professor / Assistant Professor
[ ] Lecturer
[ ] Researcher
[ ] Technical Staff
Title: _____
[ ] Executive
[ ] Management/Senior Professional
[ ] Professional Support Staff
Title: _____
Step, if applicable: _____
Supervisor (circle): Y N

[ ] Other: _____

26. How long have you been employed:

a. at UCB? _____ year(s);
b. at your current position? _____ year(s).

27. How many people work under your supervision? _____

28. How much discretion did you have to choose your current work schedule?

None 1 2 3 4 5 Lots

29. Are you required to be at work by a certain time?

[ ] No. [ ] Yes. Please indicate what time that is: _____

30. Are you required to stay at work until a certain time?

[ ] No. [ ] Yes. Please indicate what time that is: _____

31. Are you currently on any of the following alternative work schedules:

[ ] Flexible Hours [ ] Compressed Hours
[ ] Telecommuting [ ] None of the above

32. Does your job let you substitute regular working hours for working through lunch, on weekends, or at home?

[ ] Yes [ ] No

Questions 33-36 ask you to rate your discretion to choose work hours on a scale ranging from 1 to 5, as follows:

1 (No Discretion) : it would be practically impossible to shift your work schedule as indicated;
5 (Lots of Discretion): it would be quite easy to shift your work schedule as indicated.

33. Considering your job requirements ***only***, how much discretion do you have to permanently begin ***and*** end your work day ***earlier*** by:

	None				Lots
a. 15 min?	1	2	3	4	5
b. 30 min?	1	2	3	4	5
c. 60 min?	1	2	3	4	5

34. Considering your job requirements ***only***, how much discretion do you have to permanently begin ***and*** end your work day ***later*** by:

	None				Lots
a. 15 min?	1	2	3	4	5
b. 30 min?	1	2	3	4	5
c. 60 min?	1	2	3	4	5

35. Considering your family and personal activities ***only***, how much discretion do you have to permanently begin ***and*** end your work day ***earlier*** by:

	None				Lots
a. 15 min?	1	2	3	4	5
b. 30 min?	1	2	3	4	5
c. 60 min?	1	2	3	4	5

36. Considering your family and personal activities ***only***, how much discretion do you have to permanently begin ***and*** end your work day ***later*** by:

	None				Lots
a. 15 min?	1	2	3	4	5
b. 30 min?	1	2	3	4	5
c. 60 min?	1	2	3	4	5

INSTRUCTIONS FOR COMPLETING THE ACTIVITY DIARY

Record in the attached forms all activities you engaged in during **one work day**, for the following two time periods:

Morning:	**Evening:**
from the time you get up in the morning until the time you arrive at work	from the time you leave from work (for the day) until the time you go to bed

- *Record your activities the first **working day** after receiving the diary materials.* For example, if you received them on a Friday, then fill out the diary with the activities from the following Monday. But if you forget to do so, record the activities from the following working day. Please keep track of your activities as close as possible to the time at which they occur.

- *The diary should read like a continuous series of activities with no gaps in time.* The list below shows examples of types of activities. But do not worry about fancy names: just write what you were doing at any given time. Record the time at which the activity began, and the time at which it ended. Be as precise as possible. As the diary should be continuous, the end time of one activity should be the start time of the next.

- *Be sure to record the major ways in which you spent your time **at home**.* Record all activities performed at home which last **30 minutes** or more. But remember that your diary should not have any gaps in time.

- *Trips should also be recorded as activities.* For example, your commute from home to work should be recorded as a separate activity. Record all trips, even walking trips (for example from the parking lot to your office). If your trip includes one or more stops before reaching your final destination, then record each stop on a separate line.

EXAMPLES OF ACTIVITIES:

Activities at Home	Activities Outside Home
Childrearing	Church/Religious
Cooking/Preparing Meals	Cultural or Athletic Events
Eating Meals	Driving for Pleasure
Exercise	Eating Meals
House Cleaning	Exercise/Fitness
Hobbies	Food or Grocery Shopping
Laundry/Ironing	Medical/Health Care
Personal Business (bills, mail, etc.)	Personal Services: banking, barber, beauty shop, dry cleaning, etc.
Personal Hygiene	School Events: PTA meetings, little league, etc.
Reading/Listening to Radio	Trips
Resting/Relaxing	Visiting Friends or Family
Sleeping	Volunteer Work
Watching TV or a Video	Work
Working/Telecommuting	

Turn over this page to see a sample completed diary.

SAMPLE DIARY:

1. MORNING DIARY

No.	ACTIVITY	Time	
		Start:	End:
1	*Personal hygiene*	*6:15*	*6:45*
2	*Prepare and eat breakfast*	*6:45*	*7:20*
3	*Leave home to go to work*	*7:20*	*7:45*
4	*Stop to drop daughter at school*	*7:45*	*7:50*
5	*Continue driving to work & arrive at parking lot*	*7:50*	*8:05*
6	*Walk from parking lot to my office*	*8:05*	*8:15*

2. Evening Diary:

No.	ACTIVITY	Time	
		Start:	End:
1	*Leave work to go to the gym*	*5:10*	*5:20*
2	*Workout and shower*	*5:20*	*6:35*
3	*Leave from gym towards home*	*6:35*	*6:50*
4	*Stop at Safeway for groceries*	*6:50*	*7:20*
5	*Drive from the store to home*	*7:20*	*7:45*
6	*Put groceries away, talk to husband and daughter*	*7:45*	*8:00*
7	*Eat dinner with family*	*8:00*	*8:30*
8	*Clean the kitchen*	*8:30*	*9:00*
9	*Watch T.V*	*9:00*	*10:00*
10	*Get ready to go to bed, Read in bed*	*10:00*	*10:45*

MORNING DIARY

Day:_____ (date)

No.	ACTIVITY	Time	
		Start:	End:
	You get up at:		
	(Your last activity should be arriving at work)		

EVENING DIARY

Day: _____ (date)

No.	ACTIVITY	Time	
		Start:	End:
	You leave from work at:		
	(Your last activity should be going to bed)		

A2.4 INTERVIEW FORMS

Interview Question Guide

The purpose of this interview is to explore the scheduling characteristics of some of the activities listed in your diary. Among other questions, I'm going to ask you to rate the level of discretion you have to reschedule or cancel these activities. For this purpose, I'd like to use the following scale (show card).

Let's start by defining how "regular" the activities in your diary are.

Part I: Activity Diary

Of all (non-personal hygiene) activities in your diary:

1. Which ones do you perform every weekday?
2. Which ones do you perform regularly on _____ (day of the week)?
3. Which ones do you perform every week, not necessarily on the same day of the week?

For each (non-personal hygiene activity) in the diary:

For all regular weekly activities:

4. How much does the schedule for _____ vary from one day to the next?
   - How much does the start time for this activity change from one day to the next?
   - How much does the duration of this activity change from one day to the next?
5. On a scale from 1 to 5, where 1 is little or no discretion, how much discretion do you have to do _____ at another time of the day?
   - If reply 1 or 2, suppose you had a week's notice to reschedule the activity.
6. On a scale from 1 to 5, where 1 is little or no discretion, how much discretion do you have to cancel/forgo _____ ?
   If reply 1 or 2, suppose you had a week's notice to cancel the activity.
   Could somebody else in your household do it in your place? Is that sustainable?
7. How willing would you be to do _____ at another time of day?
8. How willing would you be to cancel/forgo _____ ?

Interview Form. Subject ID: _____ Date: _____

Activity	Frequency	Schedule	Schedule Variability	Discretionarity / Willingness		
				Reschd.	Interval	Cancel

Part II: Scheduling Behavior

9. Please examine the options listed on this card, and tell me which one you think best describes your work scheduling flexibility. Show Card 1.

CARD 1

A	B
Your job gives you little choice to decide your work schedule	Your job lets you choose the times at which you start and end your work day.

10. If B chosen:
Please rate the importance of each of the following motivations, in terms of deciding your work hours. Show Card 2

CARD 2

Please rate how important each of the factors below is in deciding your work hours. Use the following scale:

Not Important				Very Important
1	2	3	4	5

Motivation	**Rating**
Family responsibilities before and/or after work.	
Personal activities before and/or after work.	
Avoiding morning and/or evening peak hours.	
Other. Please specify:	

A2.5 CONSENT FORM

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

TELEPHONE. (510) 642-5672
FAX. (510) 643-8919

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
TRANSPORTATION ENGINEERING
215 MCLAUGHLIN HALL
BERKELEY, CA 94720-1712

Dear Sir / Madam,

My name is Rosella Picado, and I am a graduate student at the University of California at Berkeley. I am currently working on a study concerning people's schedules and their work travel habits, and I have chosen to study in detail the Berkeley campus community.

You were recently contact over the telephone to participate in this studey. Participation entails that you do the following: (a) answer the enclosed Transportation and Activity Scheduling Questionnaire, (b) complete the enclosed Morning and Evening Activity Diaries, and (c) meet with me to talk about the scheduling of your work and non-work activities.

The questionnaire asks questions about the timing, duration, and purpose of your typical daily activities (including both work and non-work activities), and also about the characteristics of your commute to and from campus. Filling out the questionnaire should take no more than 15 minutes. In turn, the interview will be based on your activity diary, and will explore in some detail your preferences for scheduling work and non-work activities, as well as any scheduling constraints you normally face. This interview should last approximately 20 minutes.

There are no foreseeable risks to you from participating in this research. There is no direct benefit to you, however we hope that the research will benefit society by helping transportation professionals understand the impact that travel has on people's work and family schedules. Participation will entail no costs to you, other than your time.

Your response to this survey will be confidential. Your name or any other identifying information will not be used on any reports or other research products. Upon completion of my study, I may save the survey data for use in future research by myself or others. However, the same confidentiality guarantees given here will apply to future storage and use of the materials.

Your participation in this research is voluntary. You are free to refuse to take part at any time. However, if you do agree to take part in this study, please sign the enclosed consent form, and keep one copy of it for your records. The other copy will be collected during our meeting.

Should you have any questions regarding this study or the survey itself, please feel free to call me, Rosella Picado, at (510) 643-6927, or my faculty adviser, Prof. Mark M. Hansen, at (510) 642-2880.

Please sign above the line if you agree to participate in this study *Date*

R Picado M

Rosella Picado
Graduate Student / Civil and Environmental Engineering

C.P.H.S.
98-8-44
EXPIRES:
8/27/99
AMB

APPENDIX 3
FACULTY AND STAFF
HOUSING AND TRANSPORTATION SURVEY.
SURVEY INSTRUMENT.

UNIVERSITY OF CALIFORNIA AT BERKELEY

FACULTY AND STAFF
HOUSING AND TRANSPORTATION SURVEY

FEBRUARY 1996

1. What is your faculty or staff position? (Select only the highest level title you hold.)
   - ___ Professor/Assoc. Professor
   - ___ Assistant Professor
   - ___ Lecturer
   - ___ Other Faculty/Academic
   - ___ MAP/Exec
   - ___ A&PS
   - ___ Staff Classified/Represented
   - ___ International/American Visiting Scholar
   - ___ Don't know: My title is _____
   - ___ Other_____ (Please describe)

2. Is your primary work location:
   - ___ On Central Campus
   - ___ At Peripheral Site Near Campus
   - ___ At LBNL
   - ___ At Hill Area Location
   - ___ At 6701 San Pablo
   - ___ At 2000 Carleton
   - ___ At RFS
   - ___ Other_____ (write in location)

3. Number of years employed at Berkeley? (Exclude student positions): _____

4. Gender: Male____ Female _____

5. What is your age in years?
   - ___ Under 25 ___ 25-34 ___ 35-44
   - ___ 45-54 ___ 55-64 ___ 65+

6. Household Composition:
   - ___ Self Only
   - ___ Self w/Spouse/Partner
   - ___ Self w/Spouse/Partner/Child(ren)
   - ___ Self w/Roommate/s
   - ___ Self w/Child(ren)

7. Total number of adults living in your household: _____

8. Total number of children (under 18) living in your household: _____

9. How many persons contribute to household income: _____

10. Your combined gross annual household income:
    - ___ less than $18,000
    - ___ $18,000-$24,999
    - ___ $25,000-$34,999
    - ___ $35,000-$44,999
    - ___ $45,000-$54,999
    - ___ $55,000-$69,999
    - ___ $70,000-$84,999
    - ___ $85,000-$99,999
    - ___ $100,000-$114,999
    - ___ $115,000-$129,999
    - ___ $130,000-$144,999
    - ___ $145,000+

11. Number of others in household employed by UC:
    Full time:_____ Part time_____

12. Your housing status: ___ Own ___ Rent

13. Housing size: ___ Studio ___ 1BR ___ 2BR ___ 3+BR ___ Room in house

14. Housing type you live in :
    - ___ mobile home or trailer
    - ___ apartment
    - ___ detached single family home
    - ___ townhouse (or similar attached housing)
    - ___ other

15. a). What is your estimated combined household monthly housing cost (excluding utilities and parking):
(Owners: Include mortgage (P&I), insurance, property taxes; Renters: include rent only; Condo owners: include all owners' costs plus condo fees)
    - ___ less than $300
    - ___ $300-$499
    - ___ $500-$749
    - ___ $750-$999
    - ___ $1,000-$1,249
    - ___ $1,250-$1,499
    - ___ $1,500-$1,999
    - ___ $2,000-$2,499
    - ___ $2,500-$2,999
    - ___ $3,000-$3,499
    - ___ $3,500-$3999
    - ___ $4,000+

    b). What is your monthly household parking cost at your place of residence, if any: $_____

    c). What are your average household monthly utility costs (PG&E, water, & refuse) $_____

16. Location of residence:
    - ___ Albany
    - ___ Berkeley
    - ___ Kensington
    - ___ Emeryville
    - ___ El Cerrito
    - ___ Orinda & east
    - ___ San Francisco & south
    - ___ Other
    - ___ Piedmont
    - ___ Richmond
    - ___ Oakland
    - ___ Alameda
    - ___ Marin County & north
    - ___ San Leandro & south
    - ___ San Pablo & north

17. Your current home zip code: _____

18. Distance in miles from residence to primary work location?
    - ___ less than .5 mile
    - ___ 0.5-0.9 miles
    - ___ 1-2.9 miles
    - ___ 3-4.9 miles
    - ___ 5-9.9 miles
    - ___ 10-19.9 miles
    - ___ 20-29.9 miles
    - ___ 30-39.9 miles
    - ___ 40-49.9 miles
    - ___ 50+ miles

19. What time do you usually arrive at work: __:__ am pm

    What time do you usually leave: ___:___ am pm

20. a) Average one way travel time from your residence to your workplace: _____ (minutes)

    b) If you transport child/ren to child care, how much does this add to travel time: _____ (round trip in minutes)

21. No. of vehicles (car/van/truck) in household: _____

22. What is your primary mode of travel to work?
___ Walk
___ Wheelchair
___ Drive alone
___ Carpool/vanpool (2 or more persons)
___ Motorcycle, scooter, moped
___ Bicycle
___ Public transit

23. If your primary travel mode is public transit, check all systems you usually use:
___ AC Transit ___ S.F. Muni
___ Campus shuttle ___ BART
___ LBNL or RFS Bus ___ Other transit

24. a) Have you changed your travel mode to your work location in the last 12 months? ____ yes ____ no

b) If you changed your travel mode to work in the past 12 months, please identify the primary mode previously used:
___ Walked ___ Wheelchair
___ Public transit ___ Drove alone
___ Carpool (2+ persons) ___ Bicycle

c). If you changed your travel mode in the past 12 months, please identify the one major reason for your change:
___ Change in residential location
___ Change in job requirements
___ Change in child care
___ Increased parking fees
___ Restricted city parking
___ Change in flextime arrangements
___ Other _____

25. What factors would influence you to move to Berkeley, if you don't live there now? (Please rank from 1-8 in order of importance to you, with 1= most important.)
___ No factors, I like where I am
___ Improved public schools
___ Lower cost rental housing
___ Better quality rental housing
___ Lower cost for-sale housing
___ Lower property taxes
___ Improvements in safety/security
___ Better parking for shopping/entertainment
___ Other _____

Central Campus Access and Parking

Answer questions 26-35 only if your primary work location is on Central Campus or an off-campus site and you come to Central Campus during the course of your work.

26. How frequently do you come to Central Campus?
___ Daily ___ Weekly ___ Weekly+ ___ Monthly

27. If you come to campus regularly, which days of the week do you typically come? (circle all that apply)

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28. If your primary work location is an off-campus site, what are your modes of travel from your work site to campus? (If you take more than one mode, rank them in order of frequency from 1-10, with 1 the most frequent. If you use several with equal frequency, assign them the same number.)
___ Walk to campus
___ Drive alone
___ Carpool/vanpool (2 or more persons)
___ Motorcycle, scooter, moped
___ Bicycle
___ AC Transit
___ LBNL Shuttle
___ University vehicle
___ Campus shuttle(s)
___ Other transit: _____

29. Do you have a campus parking permit?
___ Yes, Central Campus Permit
___ Yes, Faculty/Staff
___ Yes, Other
___ No permit

30. If you drive to campus, where do you typically park? Where did you typically park last year? (Select one from each column):

	1995-96 (current)	1994-95 (last year)
UC structure /lot	_____	_____
On street meter	_____	_____
Other paid parking	_____	_____
Hill Area	_____	_____
On street unpaid	_____	_____
Other (describe below)	_____	_____

_____

31. If you drive to campus, is the parking location you specified in #30 your first choice? ____ Yes ____ No

32. If you currently park or would prefer to park in a UC structure or lot, please write the applicable parking lot code to
_____ Indicate your preferred campus parking location
_____ Indicate your normal /regular campus parking location
_____ Indicate your alternative parking location
_____ Indicate your normal/regular evening parking location
(Parking lot codes and map enclosed)

33. Once on campus, how do you get around? (Mark all that apply. If you use more than one mode, rank them in order of frequency from 1-7, with 1 the most frequent.)
___ Walk ___ Wheelchair
___ Car ___ Shuttle
___ Bicycle ___ Other
___ Motorcycle, scooter, moped

34. If you drive to campus, which university building or facility do you usually walk to after parking your car? _____
(write bldg. code #; bldg. code list & map enclosed)

35. If you drive to campus, what travel corridor do you usually use? (Check one)
___ I 80 (880/980) North ___ Highway 24
___ Highway 13 (Ashby) ___ I-580
___ I 80 south
___ None, local streets only

Thank You for Your Responses!