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The Timing of Activity and Travel Planning Decisions

by

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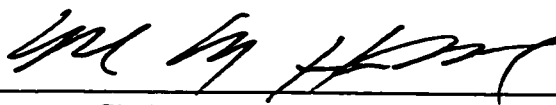
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Abstract

The Timing of Activity and Travel Planning Decisions

by

Christoffel Jacobus Venter

Doctor of Philosophy in Engineering - Civil Engineering

University of California, Berkeley

Professor Mark Hansen, Chair

This research focuses on the process of scheduling activities and travel, asking questions about the timing of scheduling decisions relative to each other and to their execution. The thesis is that *when* decisions regarding activity location, timing and travel mode are made bears importantly on resulting activity behavior. A theoretical model of activity scheduling is developed within the framework of control theory. Two aspects of scheduling most in need of exploration are identified, namely the characterization of regular patterns and activity disturbances, and the regulatory process of incorporating these into the schedule. These questions are explored using in-depth interviewing and statistical techniques. Regular or repetitive activity patterns are found to comprise about half of observed activities. They simplify the scheduling of other activities by providing a basic “skeleton” around which other activities are inserted. Concerning the decision

of how long before execution to schedule non-regular activities, wide variations are observed across individuals and activity types. Much of this variation is explained by variables related to the activity type, activity characteristics, travel, and personal characteristics of the decision maker, indicating systematic behavior in the choice of planning lead time. Among the most significant factors are the perceived importance and frequency of particular activities, and demographic indicators. People whose schedules are constrained by the needs of children, and people who are older, tend to plan their activities farther in advance than others. These findings are applied to a preliminary investigation of the user impacts of advance reservation policies in ADA paratransit systems. The planning behavior of disabled residents of the San Francisco Bay Area is estimated using data from a standard activity and travel survey. The findings show that a previous-day reservation policy is likely to constrain only about 20% of current activities, which are planned less than a day before execution. Most of these activities are likely to be plannable if need be. Exceptions occur for about 5% of activities — mostly urgent medical and shopping activities — which can not be planned long enough in advance to access next-day paratransit service. Severely disabled people without access to private automobiles are likely to be more severely affected by reservation requirements.

Carl G. Hansen 12/15/98

To my parents,
Herman and Magda Venter,
with love and gratitude.

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CHAPTER 1

INTRODUCTION

1. TRAVEL BEHAVIOR AND ACTIVITY PLANNING

The major goal of travel behavior research is to understand and model the processes by which people make decisions regarding activities and travel. These decisions, including whether, when, where, and with whom to participate in particular activities, and the choice of mode and route, are collectively known as activity scheduling decisions.

Traditionally the research focus has been on how these decisions are made, how they relate to demographic and environmental factors, and, to a lesser extent, how they interact with each other. A rich body of knowledge, increasingly useful for forecasting behavioral responses to a wide range of transportation and other policies, is already part of this tradition.

This study addresses an aspect of travel behavior that has not been in the mainstream of research and is less well understood, namely the timing of activity and travel related decisions during the planning process. The question of *when* decisions regarding activities and travel are made goes beyond the traditional question of *which* choices are made, to acknowledge the fact that they are part of a process with its own time dependent

peculiarities. In particular, studying the timing of scheduling decisions is motivated by three observations regarding the nature of the activity scheduling process:

- Activity scheduling occurs over time, with new decisions depending on previous decisions, and affecting future decisions still to be made. The timing of scheduling decisions relative to each other is thus an important source of *interdependency* within the process.
- There is reason to believe that the decision process itself is different for different types of activities. For instance, there is a qualitative difference between regularly repeated activity patterns and spontaneous, unplanned activities. The timing of scheduling decisions relative to their execution may thus affect the *decision processes* and *decision rules* used.
- The timing of decisions affect their outcome by determining the *choice sets* on which scheduling decisions are made. For example, the range of alternatives available for a mode choice decision may be smaller for short-notice or urgent activities than for activities with ample advance knowledge, especially in the absence of flexible modes such as the single-occupant automobile.

These observations suggest that an appreciation of timing effects in activity scheduling is important not only for achieving a fundamental understanding of activity behavior, but also for improving the ability of travel behavior models to capture true responses to policies and transportation system changes.

The purpose of this research is to further the state of knowledge about timing aspects of activity scheduling, by theoretical and empirical exploration of activity scheduling behavior. Although it has general applicability, the inquiry takes place within a specific policy context. Motivation for the study is provided by the question of the user impacts of advance reservation policies in paratransit systems for disabled people.

2. ADVANCE PLANNING AND THE DEMAND FOR ADA PARATRANSIT

Under the Americans with Disabilities Act (ADA) of 1990, transit operators in the United States provide flexibly-routed, flexibly-scheduled door-to-door paratransit service for people with physical disabilities within their service areas. The ADA effectively ended a decades-long debate about the need for specialized transport services versus accommodation of disabled travelers on mainstream services (see for instance Katzmann [1986]), by guaranteeing complementary paratransit service for all potential transit users who can not independently access or ride accessible transit vehicles [Thatcher and Gaffney, 1991].

Reasonably high service quality levels are specified in terms of criteria for service area,

hours and days of operation, fares, trip purpose restrictions, and capacity constraints¹. These criteria in effect guarantee that paratransit offers a service comparable to that enjoyed by users of fixed-route systems [Levine, 1997]. There is one exception, however: the criterion for the response time of paratransit systems, which specifies that operators must provide for previous-day reservation of trips, and are not obliged to offer response times of less than a day. This deviates from the fixed-route ideal, which does not impose any advance request restriction on users.

This specification of the response time criterion is partly a response, on the part of the Federal Transit Administration, to the fact that paratransit is an expensive proposition. Estimates of the combined capital and operating cost per paratransit trip are in the order of \$15 (1994) per trip [Stout and Webb, 1994]. Previous-day reservation policies provide operators with two cost-cutting opportunities. Firstly, operators secure more time in which to build efficient vehicle routes and maximize their vehicle productivity. Analytical and empirical evidence suggest that some savings can thus be realized, especially if shared-ride service is provided².

A second, and more significant, cost saving stems from the impact of advance reservation

¹ According to the ADA service criteria, paratransit service should be comparable to fixed-route services in terms of service area and hours and days of operation, charge no more than twice the regular transit fare, have no restrictions on trip purposes, and have no pattern of denying trip requests due to lack of capacity [Thatcher and Gaffney, 1991].

² For instance, the paratransit broker of Santa Clara County, California, estimates that advance reservation trips are 20% less expensive to serve than same-day trips [Santa Clara County, 1995].

requirements on use of the service. Empirical and anecdotal evidence indicate reductions of up to 50% in the demand for paratransit service as a result of 24-hour reservation restrictions [Lewis, 1989] in some systems. Reductions in demand translate into lower operating costs and lower financial deficits³. As a result, many paratransit providers in the ADA era have adopted previous-day reservation policies. For example, of 13 major ADA paratransit systems across the U.S. surveyed in 1994, only two offered same-day service [Crain and Associates, 1995]. Examples of systems which exceed the minimum response time requirement include San Francisco and Milwaukee, which have historically provided subsidized taxi services for disabled people. Cost advantages are achieved by continuing to provide immediate response service which is easily integrated with normal taxi operations [Koffman and Lewis, 1997].

It can thus be argued that advance reservation restrictions are potential demand management tools in paratransit systems. Yet, the impacts of such restrictions on the target population of the ADA are not well understood. The ADA acknowledges that advance reservation systems are likely to favor medical appointment trips, and that immediate response systems encourage more unplanned activity types [Thatcher and Gaffney, 1991]. Questions such as which types of activities are most affected, how users adjust their activity and travel behavior in response to the need for advance planning, and

³ Recent experience in the Bay Area has shown that advance reservation requirements may also increase costs if the number of cancellations is high [Eastern Contra Costa Transit Authority, 1992]. Some users reserve trips with a low probability of occurring, and later cancel the trips that are not needed. This degrades vehicle productivity since vehicle resources dedicated to the canceled trips can not be efficiently used for serving other trips.

to what extent are activities completely foregone, are not addressed. Even more importantly, the ADA eligible population includes people with a wide range of disabilities and needs. The impacts of reservation restrictions will thus vary across subgroups of the population. The question of how the response time criterion affects the least flexible users, which may also be those with the fewest mobility alternatives, is one worth asking.

This research sets out to answer some of these questions by examining the relationships between activity scheduling and activity/travel behavior, particularly with respect to the timing of scheduling decisions. The results are applied in the context of paratransit use, to assess the impacts of external restrictions on the timing of those decisions.

3. ACTIVITY PLANNING AND OTHER TRANSPORTATION POLICY ISSUES

While this exploration of activity scheduling is motivated by the question of ADA paratransit use, its focus on planning behavior is relevant to a number of other policy issues in the transportation arena. While not explicitly addressed here, some are worth mentioning:

Price discrimination in interurban travel — Pricing in interurban travel modes,

particularly air travel, typically extract premium fares for short-notice travel. The principle is one of recouping the marginal cost of operating redundant fleet resources from consumers who benefit most from them. The possibility exists of applying this principle in intracity travel contexts, for instance by providing discounts for advance reservation or regular taxi and shuttle service which can be provided more efficiently.

Understanding travel behavior issues such as trip chaining — The chaining of activities into multiple-stop trip chains is an abiding topic of travel behavior research. A better understanding of interdependencies between activities planned earlier and activities inserted later into a chain, as well as rescheduling effects, will further improve analysts' ability to model the impacts of policies on travel patterns.

Travel demand management — TDM strategies attempt to persuade people to give up the flexibility of the single-occupant automobile, in favor of transit and carpool modes. For many tripmakers this requires increased planning of their activities and travel. A better understanding of the how and why of activity planning may suggest ways in which people can be compensated for this loss of flexibility.

Use of Advanced Traveler Information Systems — The success of ATIS depends on timely provision of the correct level of information to travelers. How new information is acquired and incorporated into activity plans during the planning process, on different time horizons, needs to be understood for systems to be appropriately designed.

4. OBJECTIVES AND SCOPE OF STUDY

The objectives of this study can be summarized as follows:

- To explore behavioral issues around the timing of activity and travel decisions relative to their execution, including the extent of the range of behaviors, motivations for, and factors influencing the choice of timing of scheduling decisions. These factors include personal characteristics such as physical disabilities.
- To explore ways of capturing the time-dependent aspects of the activity scheduling process in a behavioral modeling framework, for enrichment of current activity scheduling models.
- To investigate the potential user impacts of previous-day advance reservation restrictions in ADA paratransit systems, by applying the results from the foregoing analyses of behavior to a population of disabled people.

The research is exploratory; the objective is not to develop a comprehensive model of behavior but to provide new insights into the process and implications of activity scheduling behavior. The approach is both theoretical and empirical. Theoretical development is undertaken to establish a conceptual framework and to identify research questions more closely. Empirical analyses are then performed to explore these questions in the context of actual behavior.

The scope of the study is limited to activity and travel behavior in intraurban, day-to-day situations. Planning for infrequent, interurban travel is not specifically addressed, although the concepts developed here may also be applicable in that context.

5. ORGANIZATION OF THE DISSERTATION

The dissertation is organized into six further chapters. Chapter 2 contains a review of the relevant literature on activity-based approaches to travel demand analysis, previous approaches to the modeling of activity scheduling, research into the travel patterns of disabled people, and the demand effects of advance reservation policies. The discussion establishes the background for this study within the context of activity-based research, and points to gaps in the current knowledge about the timing aspects of activity planning.

In the next chapter a theoretical and conceptual framework is developed for thinking about the activity planning process, which specifically includes explicit modeling of the timing of scheduling decisions. An innovative approach is followed, employing concepts from control theory to identify relevant components, inputs and outputs to the process. In the course of the discussion, several concepts are defined that are developed and quantified further in subsequent chapters. These include concepts of the planning horizons and planning lead times of activities.

Chapter 4 takes a qualitative investigative approach to the study of activity and travel planning behavior. It describes a series of in-depth interviews that were conducted with ten disabled and non-disabled people, aimed at exploring the motivations behind and the mechanisms for the day-to-day planning of activities and travel. Factors are identified that determine the timing of scheduling decisions, and the reasons for observed differences between the planning behavior of disabled people and non-disabled people are explored.

The qualitative interviews set the stage for a broader empirical analysis of observed planning behavior, described in Chapter 5. From the interviews, a number of behavioral hypotheses are developed of the factors influencing people's decisions regarding the timing of activity planning decisions. In particular, the decision between planning activities a day or more in advance of execution, and scheduling them on the same day as execution, is investigated. Both simple hypothesis tests and multivariate discriminant analysis are used to test these hypotheses, based on data collected during a 1980 activity and travel survey. The analysis provides a quantitative understanding of which types of activities tend to be scheduled further in advance or executed on very short notice, the apparent reasons for doing so, and differences in planning behavior associated with demographic characteristics.

An application of these empirical results to the question of user impacts of advance reservation policies in ADA paratransit systems, is described in Chapter 6. Observed

activities and travel for a population of disabled tripmakers in the San Francisco Bay Area are investigated, with an aim to inferring the likely planning behavior underlying the observed patterns. Although an exhaustive treatment of the question is precluded by a shortage of behavioral data, we are able to make preliminary comments on the number and types of activities that are likely to be most influenced by planning restrictions, as well as the differential impacts across user groups. An estimate is also obtained of the likely impact of previous-day reservation policies on potential paratransit usage.

The final chapter summarizes the findings of this study regarding the timing aspects of planning behavior, and draws policy conclusions regarding the impacts of advance reservation policies in transportation systems. The likely equity and effectiveness impacts of such policies on potential paratransit users are summarized. These conclusions point to some interesting results regarding paratransit operation policies that warrant further investigation. A number of recommendations regarding future research are included.

CHAPTER 2

LITERATURE REVIEW

1. INTRODUCTION

An overview of the relevant literature is presented with two goals in mind: to describe the general conceptual environment within which previous research on activity planning has been conducted; and to identify more specifically the needs and shortcomings to be addressed by this research.

Four main sections are included. The first provides a brief overview of the human activity approach to travel analysis. Strengths and weaknesses of the approach are pointed out. Secondly, previous work on activity scheduling — both empirical and theoretical — is examined with a view toward describing the state of current thinking on activity planning as a behavioral process. Promising methodological approaches are identified. The third main section explores the policy context of this research, by discussing previous work on the travel behavior of disabled people and the impacts of reservation restrictions on paratransit use. The final section offers some concluding remarks.

2. ACTIVITY-BASED APPROACHES TO TRAVEL ANALYSIS

Activity-based approaches to travel analysis treat travel in the context of household activity participation. Seen as the outcome of the growing incorporation of social science theories and methodologies in transportation planning [Fox, 1995; Pas, 1990], development of these approaches followed an increasing disenchantment with previous trip-based paradigms [Fox, 1995]. Activity-based analysis is increasingly accepted within the academic community as a valuable approach to the study of travel demand and travel behavior, and it already constitutes a substantial body of knowledge [Ettema and Timmermans, 1997b].

Jones et al [1990] summarized the features that set activity approaches apart from earlier approaches to travel demand analysis. Some of the most important features include:

- Travel is treated as a derived demand: the need to travel is generally derived from the need to participate in activities;
- Sequences or patterns of behavior are of interest, rather than single, discrete trips;
- The emphasis is on decision making in a household context, taking explicit account of linkages and interactions among household members; and
- Spatial, temporal, and interpersonal constraints are explicitly considered.

The conceptual basis for activity approaches was laid by Hägerstrand and the Swedish

school of time geographers, with their analysis of patterns of human activities [Hägerstrand, 1970]. Two significant aspects of their work included the concept of a human being's continuous existence in time and space; and that space has temporal expression in the time it takes to move from one location to another [Jones et al, 1983].

Overviews of subsequent work in the area [e.g. Jones et al, 1983; Axhausen and Gärling, 1992; Fox, 1995; Ettema and Timmermans, 1997b] show that, within this common philosophical approach, a wide range of conceptual models have been developed. Theoretical and behavioral work has drawn from a diversity of other disciplines, including economics, psychology and urban planning. Nevertheless, dissemination of activity-based techniques to the practice of transportation planning and policy analysis has been slow in coming [Wachs, 1996]. Questions on the user impacts of transport-related policies, such as a reduction or increase in transportation services, altering rail and bus route systems, and wheelchair access, have most often been studied with the aid of activity simulation models [Fox, 1995]. These models typically combine detailed data of the activity and transportation environment with models of individual and household behavior. A good example is Lenntorp's PESASP model [Jones et al, 1983], which was used to identify the constraints governing access and travel between activity locations, given observed sets of activity programmes. The model illustrated the way in which altering constraints such as bus frequencies affects the range of activity choices available to people.

Recently microsimulation models have been growing in comprehensiveness and complexity. Improvements such as generating synthetic populations, endogenizing long-term adjustment and demographic change, and incorporating dynamic networks, have been proposed to increase the applicability of these models for forecasting and policy analysis purposes [Miller and Salvini, 1997; Pendyala, 1997; Kitamura et al, 1996]. These developments also exemplify two of the problems with the activity approach, namely the amount and detail of data required, and the complex modeling demands [Ettema and Timmermans, 1997a].

3. EMPIRICAL STUDIES OF ACTIVITY SCHEDULING

3.1 Qualitative approaches

A key focus of activity-based approaches is how individuals and households make decisions about activities and travel. Decisions such as whether, where, when, and with whom to engage in activities are part of the process known as activity scheduling. A few studies have taken a qualitative approach towards understanding this process. In a study of the extent to which people have control over planning of their schedules, Cullen and Godson [1975] asked their subjects to record their activities and indicate whether each activity was fixed in time and space. They found that people's flexibility in scheduling activities depended on either the activity itself (e.g., routine or high priority activities

such as working and domestic duties were relatively inflexible), or on its relationship to other inflexible activities (e.g. cooking food was inflexible if the subsequent meal was inflexible). Regular or routine activities were found to act as “pegs” around which more flexible activities were scheduled, and people tended to balance the amount of flexible and rigidly scheduled activities in their day.

Hayes-Roth and Hayes-Roth [1979] conducted a “think aloud” experiment in a simulated setting to investigate how people dealt with the problem of developing plans for future activities. People were found to plan “opportunistically”, with decisions at any point in time influencing other decisions about plans made earlier or later in time. Subjects distinguished between primary and secondary activities, scheduling primary activities first and adding secondary activities later. More recently, Ettema et al [1993b] investigated the steps taken by individuals when performing a scheduling task by means of an interactive computer experiment. Steps such as adding, deleting, or modifying the order and location of activities were recorded. They found, in contrast to Hayes-Roth and Hayes-Roth, that subjects use straight-forward scheduling rules and make scheduling decisions more or less in the order of execution.

It is clear from the above that current understanding of activity scheduling processes is still very limited. Partly in response to this, Doherty and Miller [1997] devised a computerized method for tracking the actual evolution of household schedules over the course of a week, as additions, deletions, and modifications to the schedule occur. Data

thus gathered may be invaluable for furthering understanding not only of the fundamental process of activity scheduling, but also of household-related questions such as the allocation of vehicles and the trading of activities by household members.

3.2 Discrete choice modeling approaches

Quantitative studies of individual aspects of activity scheduling has been quite common. These include models of the choice of activity participation and duration (e.g. Damm and Lerman [1981]), activity location (e.g. Kitamura and Kermanshah [1984]; Kitamura et al [1998]), trip chaining (e.g. Kitamura [1984]), and complete activity patterns (e.g. Ben-Akiva and Bowman [1996]). In general, these models have provided valuable insights into the factors affecting individual decisions; yet, they have been criticized on behavioral grounds. They typically rely on the principle of utility maximization, which has been questioned for its behavioral soundness (e.g. Kahneman and Tversky [1979]). It is argued that discrete choice models have limited usefulness for developing theoretical understanding of behavior since they do not specify *how* utility is maximized [Gärling et al, 1993]. Also, by focusing on individual scheduling decisions, an understanding of how these decisions affect each other is often lost.

Discrete choice models have tended to focus on decisions executed over the course of a day or less. As such, they have been deficient in the modeling of two realities of activity

scheduling. The first is that, as Axhausen and Gärling [1992] pointed out, people often schedule their activities with a time horizon longer than a day. Attempts at modeling decisions taken over longer time periods have included the shopping participation model of Hirsch et al [1986] that considered a planning horizon of a whole week, and studies on time use across multiple days (e.g. Pas [1988]). Dependence of activity decisions on *past* activities is occasionally incorporated through a frequency variable (e.g. Recker et al [1985]). However, no effective way has been devised for dealing with the fact that most scheduling decisions are actually conditional on previous decisions regarding recurrent activity patterns.

The second shortcoming of discrete choice approaches, from the point of view of capturing the process of activity scheduling, is their inability to reflect short-term behavior — the type of actions that occur when activity and travel decisions are interwoven with their execution [Golledge et al, 1991]. They generally fail to consider updating or revision of the schedule as new information becomes available, partly because of the complexity of the error structures that would be needed to accurately represent such situations using discrete choice models.

4. THEORETICAL MODELS OF ACTIVITY SCHEDULING

Theoretical approaches to activity scheduling attempt to model in more detail the

behavioral components of the process and don't rely exclusively on the assumption of utility maximization. Known as Computational-Process Models (CPMs), this broad class of models often explicitly incorporates aspects such as information acquisition and storage, memory retrieval, evaluation of options, and conflict resolution [Gärling et al, 1993]. CPMs usually rely on computer simulation as an implementation tool.

The small number of models developed simulate complete activity schedules, given the set of possible activities to be participated in and personal and environmental constraints. Earlier models include CARLA [Jones et al, 1983], STARCHILD [Root and Recker, 1983], and SCHEDULER [Gärling et al, 1989]. Recent microsimulation models for planning and policy evaluation such as AMOS [Kitamura et al, 1996] and SMART [Stopher et al, 1996] employ advanced computational techniques to reflect some of the behavioral aspects of activity scheduling.

STARCHILD, although technically a utility-based model, incorporate many behavioral components of activity scheduling into a single framework [Root and Recker, 1983].

Two stages of activity scheduling are conceptualized: a pre-travel stage, during which a day's activities are planned, and a travel stage, during which revisions, additions and deletions to the day's schedule resulting from unforeseen events can occur. However it is only pre-travel stage tasks that are modeled in detail. The flexibility of a future schedule for allowing unplanned activities was empirically found to contribute to the utility of the schedule [Recker et al, 1985]. The question of when pre-travel stage decisions occur is

not directly addressed. Attempts to integrate STARCHILD into a microsimulation model for travel demand forecasting are currently underway [McNally, 1996].

SCHEDULER [Gärling et al, 1989], in a more detailed treatment of cognitive processes, assumes that scheduling may continue as the schedule is being executed, to reflect preferred flexibility, insufficient information, or spontaneous activity participation. It is also assumed that different planning horizons exist, and that different scheduling processes are valid in each. However, only the short-term horizon of a day or shorter was worked out in detail. The role of regular activities (appointments, obligations) in determining activity choices is also acknowledged. Empirical verification of the concepts was attempted [Golledge et al, 1991], but dependencies between consecutive activity choices were not incorporated.

Ettema et al [1993] created a simulation model of the scheduling process that reflects the (assumed) sequential nature of scheduling by allowing insertion, deletion and substitution of activities into and out of the activity schedule. The strict time-order sequence in which scheduling actions is modeled may not capture well the more “opportunistic” nature of scheduling found by some empirical studies [Hayes-Roth and Hayes-Roth, 1979].

AMOS (Activity Mobility Simulator) is a recent prototypical CPM simulating daily activity and travel patterns for short-term transportation planning and policy analysis [Pendyala et al, 1997]. Its behavioral content stems from its implementation of a neural

network model to simulate the adaptation and learning process that people exhibit when faced with a change in the travel environment. The incorporation of satisficing instead of optimizing behavior is an encouraging improvement over utility maximizing models. Although the model is theoretically able to incorporate time dependence across days, such as activities planned over periods of longer than a day, this capability is not yet operationalized. Integration of AMOS within a broader simulation environment is ongoing [Kitamura et al, 1996].

Stopher et al [1996] also recently proposed a simulation model called SMART (Simulation Model for Activities, Resources and Travel) that integrates household activity choices and travel with land use and traffic models using several desirable behavioral concepts. These include the degree of fixedness (in terms of location and frequency) of desired activities, the priority of activities, acknowledgement of the importance of habitual travel, and flexibility of the schedule.

Pointedly, though, these concepts are offered as hypotheses still to be tested, rather than as fully understood behavioral phenomena. Ultimately, the new generation of travel demand models will be only as useful for planning and policy analysis as our knowledge of behavioral processes is accurate. This suggests that the current need in travel behavior research, and in activity scheduling research in particular, is more for focused empirical work than for theoretical model development.

5. TRAVEL BEHAVIOR OF DISABLED PEOPLE

Since the early 1970s most studies on the travel behavior of disabled people were aimed at: (i) defining the transportation disabled as a user group, (ii) measuring the amount and type of travel that occurs, and (iii) identifying possible barriers to travel. Groups that have been studied include the elderly, the “mobility limited”, the functionally disabled, and the mentally disabled. Although these groups do not overlap perfectly with the target group defined by the ADA, some general trends are apparent regarding the trip making behavior of disabled travelers.

National studies have suggested that persons with transportation disabilities have **trip rates** on average 75% to 50% lower than those of the general population [Grey Advertising, 1978]. Reasons that have been cited for this include the lower access that disabled people have to services, facilities, and the work force; lower incomes; and the physical discomfort of travel [Bailey et al, 1983; McKnight et al, 1978; Markovitz, 1970]. Many transportation disabled people are elderly, and it is well-known that tripmaking generally declines with age [Altshuler, 1979]. Lower trip rates have been seen as evidence of insufficient transportation supply, and some analysts have inferred the existence of considerable latent demand for transportation among the disabled [Markovitz, 1970; Kane, 1989]. It has been argued however that this treatment of latent demand is very simplistic, ignoring differences in lifestyle choices and preferences between comparison groups [Rosenbloom et al, 1980].

Demand models have shown the trip generation of disabled users to be affected by similar factors as with the general public, such as household size, age, income, and automobile availability [Wachs, 1979; Bailey et al, 1983]. Additional factors such as the type of disability have also been found to be significant [Michaels, 1974].

The **trip purposes** of disabled travelers tend to differ from those of the general population, although this result seems to be location specific. Disabled people in general make fewer work trips and more medical trips [McKnight et al, 1978]. Most frequent trip purposes are shopping, personal business and recreation, which together account for almost two-thirds of all trips [Grey Advertising, 1978]. Interestingly, where latent demand for transportation was observed among elderly and disabled people, it was mostly within these three categories. In other words, even in the absence of convenient transportation services, people tend to satisfy their “basic need” for work and medical attention [Bochner et al, 1978].

Examining the **modal use** of disabled travelers, it is clear that the automobile is as important to disabled travelers as to the general population. In some cities with paratransit programs 40% to 65% of all trips are made by automobile, although the majority of these are as non-drivers [Rosenbloom et al, 1980]. Where accessible fixed route service is available, the disabled traveler uses it more frequently than the non-disabled [McKnight et al, 1978]. The mode share of fixed route transit may increase as more and more wheelchair-lift equipped buses are deployed in transit fleets.

The usage of specialized transportation services, such as paratransit and subsidized taxi, depends on a range of eligibility and service variables, which has tended to vary greatly between communities. Pre-ADA studies have often found that only a small proportion of the eligible population actually used these systems [Rosenbloom et al, 1980].

Furthermore, most paratransit users tend to avoid becoming dependent on paratransit, by regularly using other modes as well. This trend was more prevalent among non-disabled than among disabled paratransit users [Rosenbloom et al, 1980]. Evidence of the growth in paratransit ridership in the post-ADA era suggests that this mode is rapidly growing in importance among the ADA eligible population [Rosenbloom, 1994; Crain and Associates, 1995].

6. IMPACTS OF RESERVATION POLICIES ON PARATRANSIT USERS

No studies have looked in-depth at the effects of reservation policies on the demand for paratransit or dial-a-ride systems. However, cross-sectional studies that included lead time as an explanatory variables in demand models have found evidence that this effect is significant. In a nationwide study of 53 specialized transportation systems, Lewis [1989] found lead time to have a very significant impact on ridership levels. Controlling for other factors, systems with a 24 hour advance reservation requirement had per capita trip rates 48% lower than immediate response systems. Similar trends have been reported in Swedish paratransit services for elderly and disabled people [Stahl, 1991].

Louviere et al [1979] used conjoint techniques to demonstrate that general population (non-disabled) users prefer on-demand service to services with advance reservation requirements. This result was substantiated by Benjamin [1984] for disabled users of paratransit. Respondents' stated likelihood of using paratransit increased with decreasing reservation lead time.

Other studies by paratransit providers to investigate the elasticity of demand with respect to service attributes also found evidence of the importance of reservation lead time. In a study by the Santa Clara County Transportation Agency, a 19% increase in the trip rates of active paratransit users was estimated in response to a list of service improvements which included a four-hour maximum response time to all trip requests [Crain and Associates, 1995]. The same consultants also estimated that, changing the current immediate response taxi service in San Francisco to previous-day reservation system, and increasing some fares, would result in a significant reduction in demand [Crain and Associates, 1995]. Unfortunately it is impossible to separate out the effects of the response time from the effects of other factors.

Reservation lead time has been found to influence not only the trip rates of paratransit users, but also their trip purposes. Thatcher et al [1991] notes that congested systems with advance reservation requirements tend to carry more medical trips, as these can be scheduled in advance. Congested systems with a large number of immediate requests often have large variations in reliability, causing medical and work trips to be driven

away from the system. Social and recreational trips — in Rosenbloom’s words “the only trips unimportant enough to trust to the system” — dominate [Rosenbloom, 1980; p.255].

7. CONCLUSIONS

The overview of activity-based approaches highlighted some of their strengths and weaknesses. A common strength of these approaches is their emphasis on activity participation and behavioral processes. It is this emphasis that makes the activity-based paradigm an appropriate conceptual framework for investigating the activity impacts of reservation policies in transportation systems. As far as methodology is concerned, the use of full-scale policy-oriented simulation models for this study is precluded by their enormous data needs and operational complexity. Instead, a smaller scale model applying the basic principles of these models to specific policy questions, can be used to arrive at relevant results consistent with the activity-based paradigm. In this regard, a useful approach is suggested by earlier simulation models in the “constraint”-focused tradition [Ettema and Timmermans, 1997b], such as PESASP [Jones et al, 1983]. The focus of these models is on identifying ways in which activity and travel behavior is constrained by environmental and policy effects (such as bus schedules), and to use theoretical and empirical models of behavior to evaluate likely responses to relaxing or tightening those constraints.

As for the behavioral process of activity scheduling, this discussion pointed to some of

the gaps in current knowledge. Axhausen and Gärling's [1992, p.335] statement that "the details of this process, how information on the environment and the transport system is acquired and used, how utilities and priorities are assigned to activities, and which heuristics and decision rules are used, are largely unknown" is still substantially valid. Aspects of scheduling behavior in need of further investigation include the role of regular or repetitive activities, how people respond to urgent or short-notice needs, and how the timing of scheduling decisions is affected by personal and activity-related factors. No operational models adequately reflect the fact that scheduling decisions are made over time, and that this imposes time-dependent constraints on the evolution of schedules over time. The development of a conceptual framework within which time dependence is easily incorporated would contribute to further theoretical and empirical study.

In light of these uncertainties about some of the fundamental aspects of activity behavior, an exploratory approach or "naturalistic observations" [Axhausen and Gärling, 1992] of actual scheduling behavior and the motivations behind it would perhaps be an appropriate starting point. Initial work in this study employed this method to explore the scheduling behavior of disabled and non-disabled people (Chapter 4).

Lastly, it is clear that the question of the user impacts of reservation policies, both in terms of the effects on individuals' activity and travel behavior, and in terms of systemwide impacts on paratransit usage, has not been adequately addressed before. To contribute to an understanding of this issue is one of the main aims of this research.

CHAPTER 3

A THEORETICAL FRAMEWORK FOR ACTIVITY SCHEDULING

1. INTRODUCTION

The review of activity-based approaches to travel analysis showed that, despite the wide body of literature in this area, no existing model provides an entirely satisfactory framework for examining the central questions of this study. Investigation of the user impacts of restrictive reservation policies in transportation systems requires explicit consideration of the timing of activity and travel decisions, in order to account for the relationships between the timing of decisions and the outcome of those decisions.

Previous approaches generally failed to capture the continuous nature of the activity planning process, in which plans for future activities and travel are constantly evolving as a result of new decisions. As a result, both long-term scheduling issues such as the impact of routine or repetitive patterns, and short-term behavior such as schedule revision, are inadequately represented.

This chapter develops a theoretical framework that explicitly captures the time-dependent nature of the scheduling process. It draws on concepts from electrical engineering to conceptualize the scheduling process as a regulation or control process. The objective of

the process is to obtain an activity program that is both feasible and personally optimal, by continually adjusting the future schedule in response to the arrival of disturbances. Measures are developed for describing the planning horizons and chosen lead times of activities. Together, these concepts provide a conceptual framework against which subsequent empirical sections of this study are pinned. Development of the framework into a comprehensive operational model is not within the scope of this research; rather, its application is illustrated using a simple graphic example.

Three sections are included in this chapter. The first provides the background to control theory, showing that it has provided a convenient framework for analyzing many kinds of time-dependent systems. The major components and information flows in a control system are explained. The second section applies these concepts to the activity scheduling problem and highlights some of the benefits and disadvantages of doing so. Lastly follows an example application to illustrate the comparative benefits of the new formulation, and to give more flesh to the core concepts.

2. BACKGROUND: CONTROL THEORY

Control theory deals with systems that produce fixed results in a variable environment [Marken, 1990]. It can be used to describe any system that responds to its environment in such a way that some definable goal is reached.

Control theory evolved from the study of engineering systems such as robots and electrical systems. The thermostat controlling the temperature in a room is often used as the archetypical example of a control system. Control theory's reputation for flexibility and usefulness has led to applications in other areas such as psychology, economics, and management [Auslander et al, 1974].

Control theory conceptualizes systems in terms of the transmission and the processing of information. Three types of information — reference input, disturbance, and feedback — and three processes — regulation, transformation, and execution — are of concern [Auslander et al, 1974; Ashby, 1961]. Figure 3.1 shows the basic processes (in boxes) and information flows. Information about the system's goal (such as the target temperature of a thermostat) is introduced through the *reference input*. Other information introduced from the environment, usually stochastic in nature, also affect the performance of the system; these are called *disturbances*. In the thermostat example, a cold draft entering a room is considered a disturbance. In the absence of any regulation, the disturbance may prevent the system from reaching its goal. It is the task of a well-designed *regulator* to choose the correct response in order to counteract the effect of the disturbance. The *transformer* enacts the regulatory command received from the regulator; the furnace in a temperature-controlled room has the function of a transformer. The ultimate outcome of the system is determined in the *execution* process, where the controlled response (from the transformer) and the uncontrolled signal (from the disturbance) interact. Information about the system outcome may be fed back to the

regulator as a *feedback* signal. A good regulator will use such information about the performance of the system as a result of earlier regulatory decisions, to choose future control actions. The current temperature of the room is an appropriate feedback signal in the thermostat example.

It is useful here to consider the concept of *variety*. As described by Ashby [1961], variety is introduced into the system through the disturbance signal — over time the disturbance takes on numerous (random) values. In order to keep the output of the system within some desirable range, we need to prevent the same variety from transmitting through the system, by regulation. In the thermostat example, variety needs to be reduced from the large range of temperatures the external environment can have, to the much narrower range of temperatures desirable for the room.

3. ACTIVITY PLANNING AS A REGULATION AND CONTROL PROCESS

3.1 Components and information flows

The activity planning process can be conceptualized as a regulation and control process. The process of formulating an individual's activity schedule is depicted as a continuous system with feedback. Two types of information enter the system: deterministic or reference input (c) and random or disturbance input (d). Deterministic input is

information that is generally constant or slow-changing. It may include information on the activity and travel environment (such as the locations of home and work), fixed constraints on travel (such as automobile availability), and regular activity patterns, as well as personal goals that are to be achieved through engaging in activities.

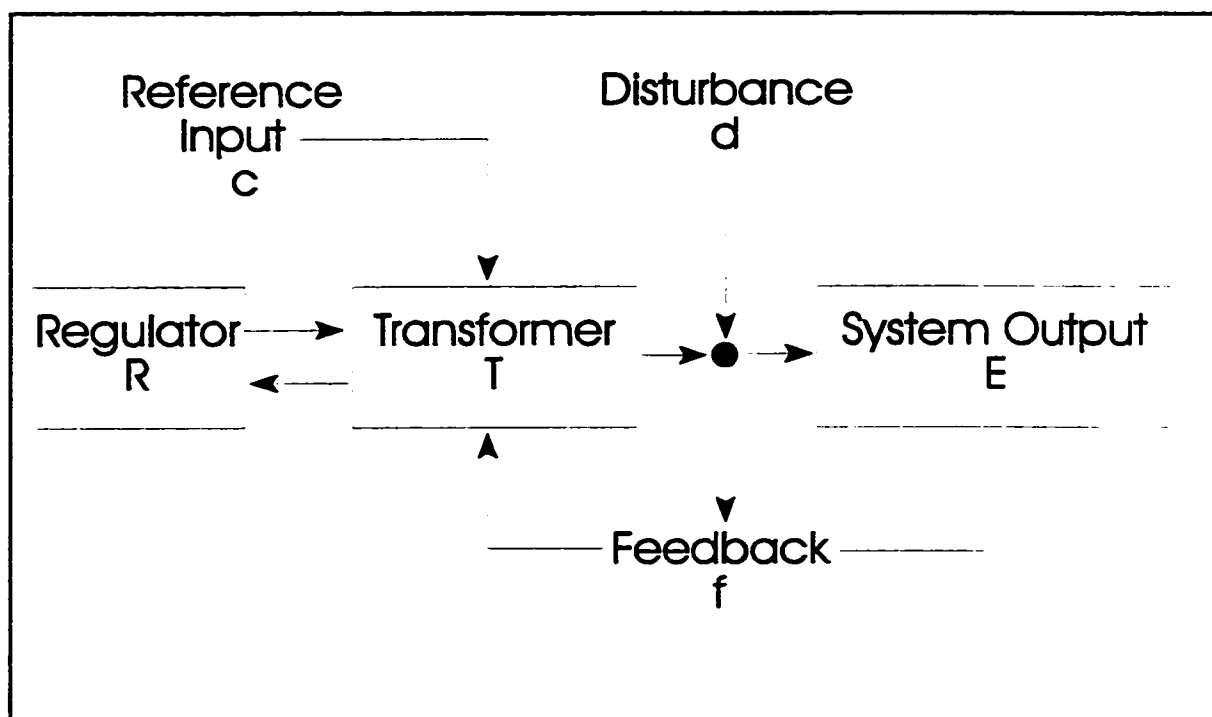


Figure 3.1 Block diagram of activity scheduling as a control system

Disturbances introduce variety into the system in the form of unforeseen needs, opportunities and constraints. These represent alternative ways of spending some future period of time, that may conflict with previously scheduled activities. Regulation is needed to resolve this conflict while still assuring the reaching of personal goals.

The regulator (R) is the decision making component in the system; its function is to make all interrelated decisions regarding activity participation, timing, location, and travel between activities. In the transformer (T) the decisions and inputs are combined into a feasible activity schedule, which represents a cognitive "map" of the future in space and time. The transformer may be thought of as the memory of the system, since it also keeps track of activities that need further regulation due to unresolved conflicts or insufficient information. The distinction between the regulator and the transformer is convenient, since it allows us to separate the system's decision making processes from its purely "accounting" type processes.

The planned activity/travel schedule is the main output of the control system. The schedule evolves as it is continuously modified by the regulator in response to inputs c, d and f.

The activity schedule is executed by the executor (E), which functions as the "real-time" component of the system. New information that arise during execution of the schedule, such as an unexpected early ending to a scheduled activity, is returned to the transformer via the feedback loop (f). The transformer then invokes the regulator, which decides whether and how to incorporate this new information in a revised activity schedule for the immediate future.

3.2 Conceptual and practical implications of the control theory approach to activity scheduling

As a conceptual framework for modeling activity scheduling behavior, the control theory approach has several promising properties:

(i) Control theory offers a comprehensive framework within which many previously investigated concepts can be incorporated. The pattern generation and activity program choice models developed for STARCHILD's "pre-travel" phase [Root and Recker, 1983] describe some of the tasks of the transformer and regulator respectively. The heuristics of Ettema et al [1993a] modeling updating of the existing schedule may provide a starting point for describing the regulator's response to feedback. The suggestions of Golledge et al [1991] regarding cognitive filters on information and imperfect memory could be applied to the transformer and all inputs entering the system (c and d).

(ii) Because of its continuous nature, the control system can capture the time-dependent aspects of scheduling behavior. Interaction between regular activity patterns (introduced through the reference input) and unforeseen opportunities (introduced as disturbances) can be modeled explicitly. Not only can we model which participation, timing and location decisions are made, but also when these decisions are made. It thus becomes possible, in theory at least, to investigate the relationships between the timing of decisions and the activity/travel behavior that results. The control theory framework is

also flexible enough to be applied to various decision making units, either at the level of the individual or at that of the household. By conceiving of the individual's activity scheduling process as a control system embedded within a larger control system representing decisions of the household, interactions and trade-offs between household members may be captured. Longer term dynamics can be captured by an upper level control system, which models slower changing decisions such as residential location and car ownership, and feeds this information to the reference input of each household member's control system.

(iii) Methods from the application of control theory to other fields can be used to investigate the scheduling behavior we are interested in. An example is the concept of the speed of the regulator, which has been used to describe how fast the regulator responds to disturbances [Ashby, 1961]. In physical systems the speed of the regulator is affected by how quickly the disturbance is detected, and by the rate at which the regulator can access appropriate responses. In the activity scheduling context there are obvious parallels to the speed at which scheduling conflicts are detected and to the rate at which an individual can reschedule affected activities.

At this point the control theory approach also has the following limitations as a conceptual framework:

(i) While it provides a convenient conceptual model of the scheduling process, it

does not address one of the central needs in this field, namely a lack of knowledge about how many aspects of activity scheduling actually work. The framework is only as useful as the underlying behavioral models are accurate.

(ii) The theory doesn't seem to offer any clear guidance on how to characterize the disturbances. In physical applications disturbances are typically characterized as random variables, with known distributions and parameters [Tou, 1964]. While this approach captures the random nature of the disturbance, it is not clear that this is the best way to describe the process by which new needs for and constraints on activities arise.

4. OPERATIONALIZING THE MODEL: AN EXAMPLE

Without attempting to specify a comprehensive activity scheduling model, a few suggestions are made towards operationalizing the control theory framework. The ability of the framework to capture some of the behavioral issues critical to a realistic representation of activity planning is illustrated with an example.

4.1 The time-dependent state of the system

Since the control system describes the evolution of activity schedules over time, inputs

and outputs are denoted with a time specification. Discrete time periods may be used for simplicity. In the following example, discrete 24-hour periods will be considered. In time period t , let $s_j(t)$ represent the activity schedule for some day j in the future. This schedule $s_j(t)$ incorporates all relevant scheduling actions taken in previous time periods $[0;t]$, where period zero is an arbitrary starting point for the scheduling exercise.

4.2 Characterization of inputs to scheduling

Regular activity patterns represent repetitive behavior with daily, weekly and maybe monthly cycles. Information about a specific pattern is introduced to the control system through the reference input c_j for day j . For example, consider a simple home-work-home pattern for hypothetical day 7. According to the pattern, regular working hours are from 8am to 5pm, while the 5pm to 9pm period is considered discretionary time in which to engage in out-of-home activities.

Disturbance m , detected in time period t_n , is denoted as $d_m(t_n)$. If the disturbance is a demand for a new activity, it may be characterized by the activity type, available times and locations, expected duration, and the target execution day(s). Let t_e and t_l be the earliest and latest times that execution of the activity can start; together, they define the allowable time window for executing the activity (see Figure 3.2). The elapsed time between t_n and t_l is the maximum time available within which to schedule execution of

the activity. We will refer to this time period as the planning horizon, denoted T_{PH} . The planning horizon indicates how much time the regulator has to respond to the new demand if it is to be executed satisfactorily. In the extreme case of urgent needs, $t_n = t_l$, and the disturbance has to be regulated immediately.

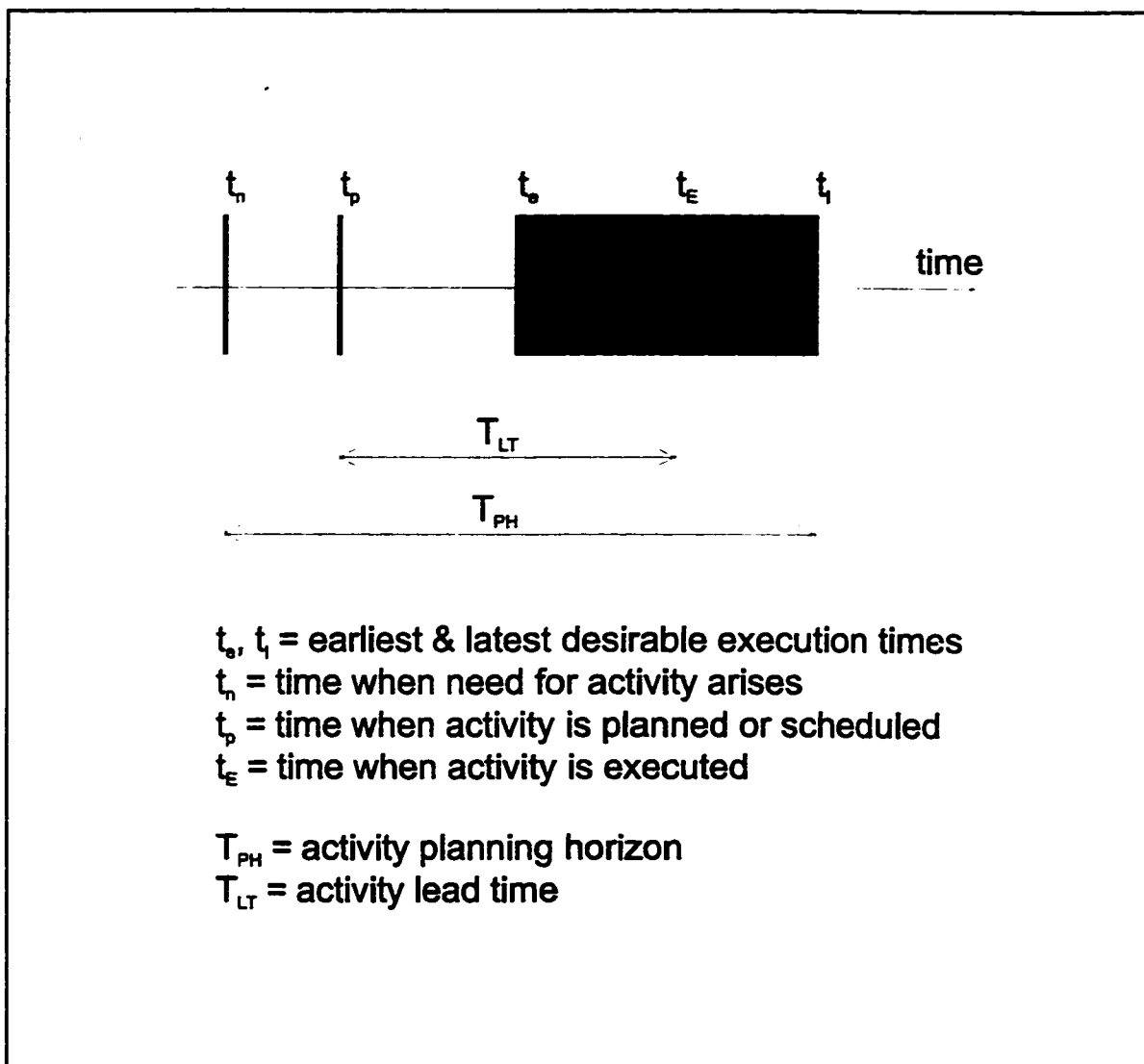


Figure 3.2 Definition of events and intervals for a single hypothetical activity

While it is not yet clear how the characteristics of a disturbance are to be modeled, we will for now simply take them as given. Figure 3.3 shows an example of a disturbance that is detected in time period $t = 1$. The new activity, a personal business engagement, has to be executed at location L1 on day 7, between 9am and 9pm. We assume that the expected duration of one hour is exogenously determined. Absent any other constraints, the control system has six days to incorporate the new demand into the schedule for day 7.

DISTURBANCE 1	
TYPE OF DISTURBANCE:	New activity
ACTIVITY TYPE:	Personal Business
POSSIBLE LOCATION(S):	L1
TARGET DAY:	Day 7
TIME WINDOW(S):	9:00 to 21:00
DURATION:	1 hour
MINIMUM LEAD TIME:	4 days (must be scheduled by Day 3)

Figure 3.3 Example: Disturbance entering control system on Day 1

4.3 The task of the transformer

As stated earlier, the transformer is responsible for “accounting” type functions of the control system. In each time period t , the transformer receives reference inputs c_j , disturbances $d_m(t)$, and feedback signals. The transformer compares these with schedules

constructed in the previous time period, $s_j(t-1)$, for all future days $j \in \{t, t+1, t+2, \dots\}$. If a disturbance introduces an alternative time use for some of these schedules, a conflict is detected and the regulator is invoked to solve it.

To illustrate these tasks we trace the processing of the example schedule by the transformer. At time $t=0$ the transformer builds an activity schedule for day 7 based on the reference input for that day. This schedule, $s_{\lambda}(t=0)$, represents the expected time-space path of the individual if no other activity demands arose (see Figure 3.4(a)). At time $t=1$ a disturbance arrives with target date day 7 (Figure 3.3). The transformer compares the disturbance to the schedule $s_{\lambda}(t=0)$, and determines that the individual is not currently scheduled to participate in the new activity on day 7. Thus, a conflict between the planned behavior and the desired behavior of the individual is identified — a situation clearly in need of regulation.

4.4 Regulation of demands for activities

The regulator decides where and when to include a new activity demand (or other disturbance) in the existing schedule. People do not always respond to new opportunities immediately, but often postpone the scheduling of a new activity until more information about that and other activities can be obtained. In each time period the regulator thus has the option to postpone scheduling decisions until the next period. The postponement

PLANNED ACTIVITY SCHEDULE S7(0)
FOR DAY 7
CURRENT DAY = 0

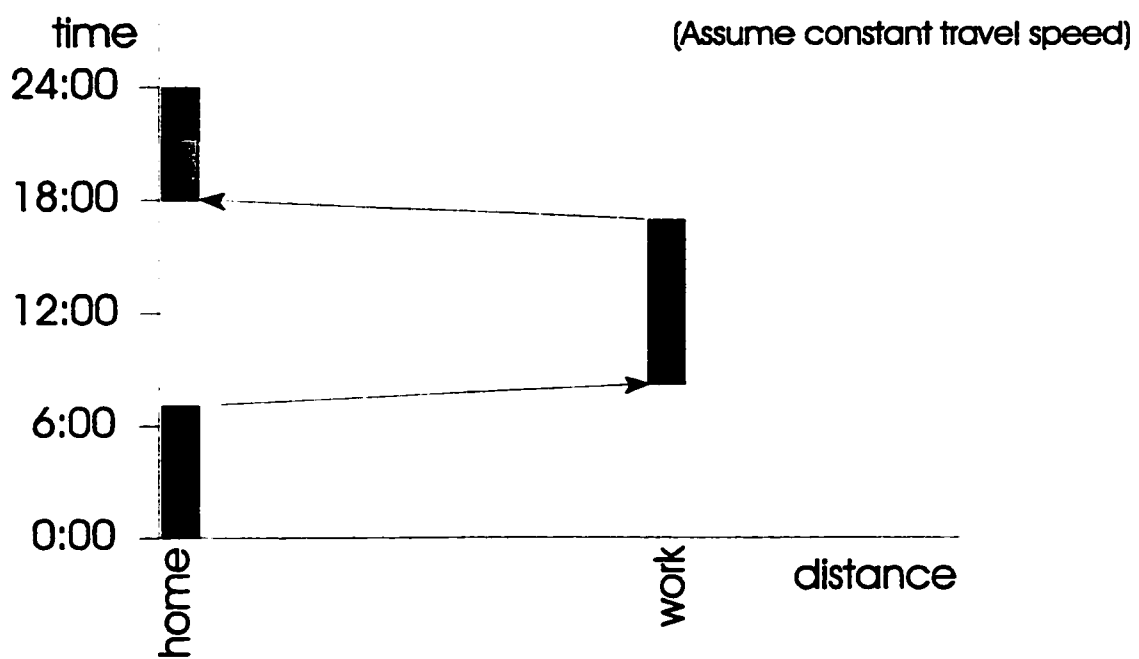


Figure 3.4(a) Output of hypothetical control system on Day 0, after scheduling of regular activities

decision is likely affected by factors such as an individual's valuation of flexibility, his/her aversity to risk, and the benefits of getting more information. In addition, the timing of scheduling decisions is often constrained by activity-specific factors. Some activities can be scheduled arbitrarily close to execution, while others require a certain minimum lead time to be met. Activities that require appointments, reservations, or significant coordination with other individuals may have to be scheduled some time in advance. In other cases, such as paratransit systems with advance reservation policies, the transportation system imposes constraints on the timing of activity scheduling decisions.

To illustrate regulation in our example, assume that the new activity demand has a minimum lead time of four days. This is a reasonable assumption, as personal business activities often require appointments to be made several days in advance. Without describing the regulatory process in detail, we will assume that the regulator postpones scheduling of the activity as long as possible in order to retain maximum flexibility in the schedule. Scheduling is thus postponed on days 1 and 2; on day 3 the activity has to be scheduled to comply with the minimum lead time. Since the location of the activity is already fixed, the regulator has only to choose an appropriate activity start time. Assume that scheduling decisions are based on principles akin to those of Recker and McNally's [1985] STARCHILD model, which maximizes the utility of the complete activity program based (among other factors) on the time spent traveling and waiting out-of-home, and also on the potential of engagement in future (unknown) activities. This last

feature allows us to some extent to capture the effect of desired flexibility.

An optimal timing for the activity is shortly after work, as shown in Figure 3.4(b), as it imposes no waiting time outside of home. It also maximizes the accessibility to other opportunities that may arise, such as activities 2, 3 and 4 in the figure. Hypothetical availability windows for these activities, shown in dashed lines, fall within the time-space prism after execution of activity 1.

These regulatory decisions allow us to define another important time period in general terms. Let t_E refer to the planned execution time of an activity, in this case 5:15pm on Day 7. The time at which scheduling of the activity occur is denoted by t_p — in this case Day 3. The elapsed time between t_p and t_E reflects how close to the execution of the activity it was scheduled. We will in future refer to this as the activity lead time and denote it as T_{LT} (see Figure 3.2). Note that, for all activities, $T_{LT} \leq T_{PH}$.

4.5 Ability to predict suboptimal activity schedules

The regulation process described above captures not only *how* new activity demands are incorporated into the schedule, but also *when* this happens. To illustrate the impact of this formulation on the predicted activity schedule, we will consider a second disturbance acting on the schedule for day 7, $d_2(6)$, detected on day 6. Assume this disturbance takes

place at location L2, that it can be accessed any time up to 9pm, and that its minimum lead time is such that it has to be regulated immediately. The important point is that activity 2 has to be included in a schedule already structured around previously scheduled activities, namely home, work, and activity 1. The ability to do so depends in part on the degree to which rescheduling or modification of previously scheduled activities is possible. If no rescheduling is possible (as is likely with several types of activities, including personal business appointments) activity 2 can only be accessed after activity 1, as shown in Figure 3.4(c). However, activity 2's location is such that some backtracking is necessary. The only permissible scheduling decision thus results in an overall activity program that is not optimal in a travel sense.

Existing activity scheduling models that ignore time dependence in the scheduling process will produce different results using the same information. By assuming that all relevant scheduling decisions are made simultaneously, the problem is in effect defined without the constraints imposed by minimum lead times. If the control system was allowed to regulate both disturbances 1 and 2 simultaneously, the travel-optimal solution would be to execute activity 2 before activity 1, so as to eliminate extra travel. This will not correspond to actual behavior under these circumstances.

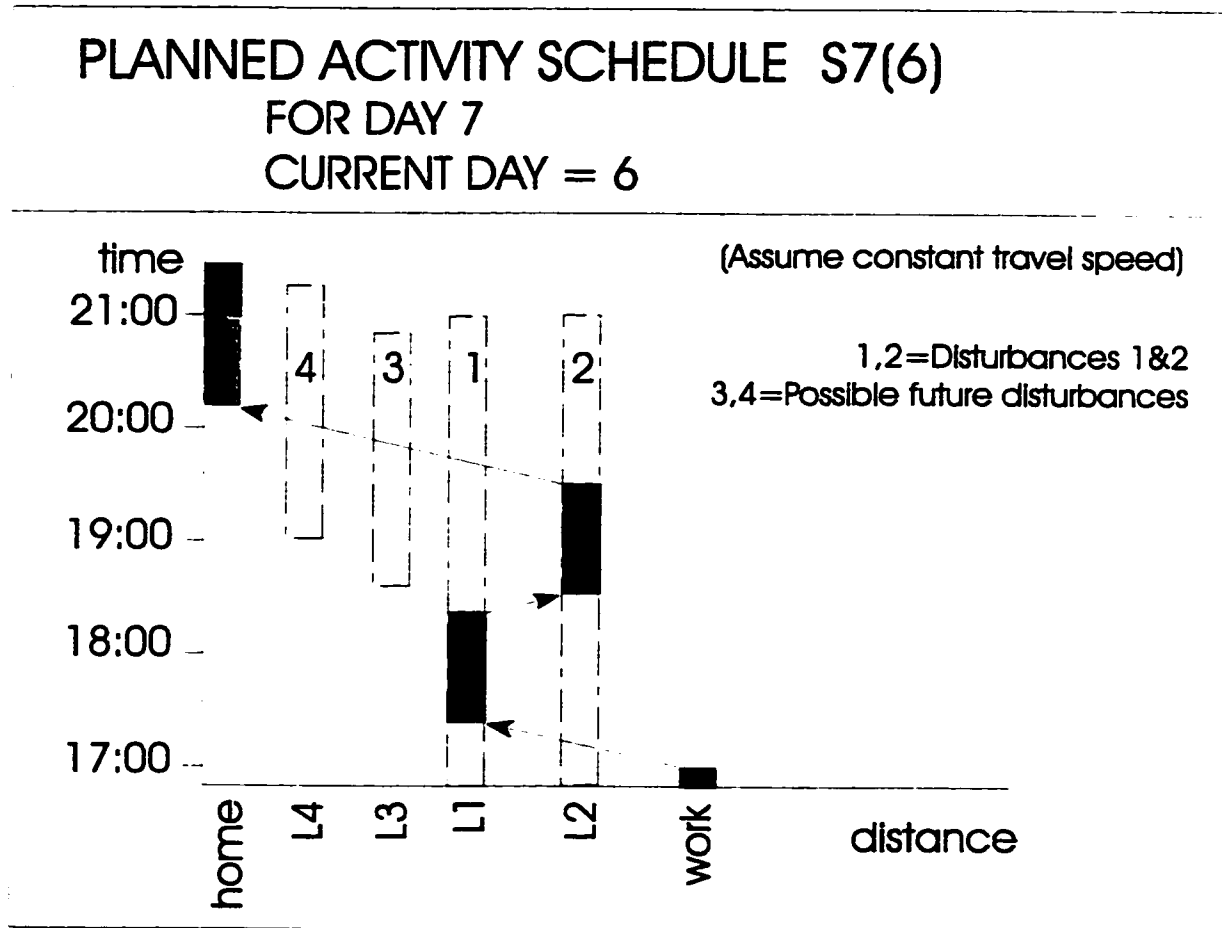


Figure 3.4(c) Output of hypothetical control system on Day 6, after scheduling of disturbance 2

5. CONCLUSIONS

This chapter developed a conceptual framework for the activity scheduling process that explicitly captures the evolution of schedules over time. Concepts from control theory are used to identify distinct information flows, distinguishing between reference inputs (such as regular patterns), disturbances (such as new activity needs and constraints), and outputs (final activity schedules) of the scheduling process. Regulation is conceived as the process by which decisions are made regarding the incorporation of these inputs into the future activity schedule.

The basic framework can theoretically be expanded to model the entire scheduling and activity participation process. However, our inability to specify their behavioral content in more detail points to specific issues that need further exploration. These revolve around two key aspects of the control system: the characterization of inputs, and the specification of the regulation process. Uncertainty exists about how, why, and how often disturbances (such as the need for new activities) arise, and which of their many attributes are critical to scheduling behavior. Very little is known about aspects such as planning horizons and minimum lead times that are critical to how disturbances are treated in the scheduling process. The characterization of reference input in the form of regular activity patterns is another area in need of study.

Questions that arise regarding the regulation process include how regulation differs for

different kinds of disturbances and different types of people — for instance, whether people with lower mobility are prone to regulate new activity needs further in advance. Related questions are concerned with how people decide whether to regulate a disturbance (i.e. schedule an activity for future execution) or to postpone regulation; and what penalties are imposed by being forced to regulate earlier or later. Some of these issues are explored in greater depth in subsequent chapters.

CHAPTER 4

EXPLORATORY INTERVIEWS

1. INTRODUCTION

This chapter describes a qualitative exploration of some of the behavioral aspects of activity and travel planning. We focus on questions that emerged from the theoretical framework developed in the previous chapter. In short, these questions revolve around the characterization of regular activity patterns and new activity demands, the variation of planning horizons across disturbances of different types, and the decision of when to regulate disturbances by inserting them into the activity schedule. Variations in this process across individuals are also relevant for our study of the policy impacts of reservation policies.

In-depth interviews were conducted with ten disabled and non-disabled people, with the goal of exploring the mechanisms of activity planning and the motivations for the behavior. Differences between the planning behavior of disabled and non-disabled respondents are also examined. The results from this investigation provide guidance for a broader empirical analysis described in Chapters 5 and 6.

The next section describes the objectives and scope of the interviews, followed by a brief description of the method and the results. The findings of the interviews are then discussed and summarized in a final section.

2. OBJECTIVES AND SCOPE

The study set out to explore the activity planning behavior of both disabled and non-disabled people in the context of their daily activities and travel. Major objectives included:

- To explore the amount of advance planning that people undertake before participating in daily activities. (How long in advance do people make decisions such as whether, when, and where to participate in activities?).
- To investigate systematic differences between activities with long planning lead times and activities with shorter planning lead times. (Are some types of activities consistently found to be planned longer in advance than others?)
- To investigate the effects of personal or household factors, particularly being physically disabled, on people's tendency to plan in advance. (Does not owning an automobile, or having children in the home, cause greater need for advance planning? Are disabled people inherently more likely to plan their activities?)

A further objective is motivated by the study's secondary focus on paratransit reservation policies:

- To investigate the potential impacts of advance reservation policies in paratransit systems on the activity and travel patterns of disabled tripmakers.

In the interest of keeping the respondent burden manageable, the scope of the inquiry was limited in two respects. The interviews and analysis focused only on out-of-home activities, ignoring questions around the substitutability of in-home and out-of-home activities. Only intra-regional travel (within the metropolitan San Francisco Bay Area) was considered, as the planning processes for long-distance travel may differ substantially from those for local travel.

3. METHOD

3.1 Format of the interviews

A qualitative and open-ended format was selected for the exploratory interviews. This approach was deemed more appropriate than a quantitative one, as the objective was to obtain insight into the "life world" of a few interviewees [Kvale, 1996], rather than to infer results that can be generalized to a whole population. Qualitative techniques,

although very common in social science research, are only slowly being used more in transportation-related research. Most transportation applications have been in the areas of travel behavior research and policy evaluation studies [Handy, 1997]. Some previous studies of activity planning behavior have made successful use of small-sample qualitative approaches. Hayes-Roth and Hayes-Roth [1979] used think-aloud experiments to investigate the planning behavior of five subjects faced with the problem of scheduling a number of errands to be performed in a simulated environment. Cullen and Godson [1975] used a more structured activity diary and questionnaire approach in their study of activity patterns and underlying planning behavior.

For the current study, interviews were conducted one at a time and in person by the author (with the exception of one interviewee who preferred being interviewed by phone). Focus groups, another popular method of exploring individuals' responses to policies [Krueger, 1994], was not deemed appropriate for this study, as we desired in-depth exploration of individual cases rather than a group response.

A list of open-ended questions was prepared to guide the interview. However, the interviewer was free to deviate from the list in order to pursue unexpected responses. A copy of the interview guide is attached in Appendix A.

At the start of the interview, interviewees were informed of the general goals of the study. This was followed by questions about typical travel patterns and modes used by the

interviewee, to establish a general sense of the individual's travel and activity behavior. The main part of the interview was based on an open-ended activity diary, in which the respondent was asked to recall out-of-home activities and travel for the previous two days. The respondent was encouraged to remember all trips, including walking and serve-passenger trips. The interview days were chosen such that both weekdays and weekends were covered.

The subject was then asked to identify all activities that are repeated regularly every day, week or month, at the same time and location. For the remaining activities, the respondent was asked a series of questions about the planning actions undertaken prior to participation in each activity. These included questions about when the decisions about activity participation, location, timing, and travel mode were made. Lastly followed a more general discussion of the respondent's planning process.

3.2 Sampling issues

The sampling procedure targeted two populations: East Bay residents who are disabled and either current or potential users of ADA paratransit; and East Bay residents who are not physically disabled. The Americans with Disabilities Act (ADA) classifies as ADA-eligible all residents who have a disability that can prevent them from using regular (fixed-route) transit, at least some of the time.

Randomness of the sample was not a major concern, as the data was not intended for statistical analysis. Potential interviewees were identified using a snowball sampling technique, where respondents were asked to suggest other interviewees. For the sake of effective interviewing, subjects were pre-screened to exclude people with cognitive disabilities seriously affecting their ability to communicate. A sample size of 10 was obtained; five of these are disabled and five non-disabled. Only one refusal was encountered.

3.3 Description of sample

The distribution of demographic and personal characteristics in the sample is shown in Table 4.1. The five disabled interviewees included two visually disabled persons and three wheelchair users, one of whom could transfer to a car seat and drive herself.

Although all five disabled people had used paratransit at some point in the past, only interviewees A and E were somewhat frequent paratransit users. The sample included men and women, workers and non-workers, automobile owners and non-auto-owners, single people, married people without children in the home, married parents, and a single parent. All the married and single parents had children below driving age. All interviewees with automobiles had unrestricted access to their vehicles, except J who shared one car with her husband. All interviewees were residents of three East Bay cities: Berkeley, El Cerrito, and Oakland.

INTER- VIEWEE	PHYSICAL- LY DISABLED?		SEX		AGE			WORKING?		MARITAL AND HOUSEHOLD STATUS				OWN AND DRIVE AN AUTOMOBILE	
	Y	N	M	F	20 to 30	31 to 50	51 and over	Y	N	SINGLE	MAR- RIED	NO CHILD- REN	CHILDREN IN HOME	Y	N
A	●			●		●		●		●		●			●
B	●		●	●		●		●	●		●				●
C	●		●	●	●			●	●	●		●			●
D	●			●			●	●	●		●			●	
E	●				●			●	●	●		●			●
F		●		●	●				●			●		●	
G		●		●		●			●		●		●	●	
H		●				●				●				●	
J		●		●		●					●		●	●	
K		●	●			●				●			●	●	

Table 4.1: Personal characteristics of interview sample

4. RESULTS OF EXPLORATORY INTERVIEWS

The activities, travel, and planning behavior reported by each interviewee are summarized in Table 4.2. This section provides a brief description of the responses. Subsequent analyses are based on these results; the reader may refer back to these summaries as the need arises.

A total of 49 out-of-home activities were recorded. The daily average number of activities was 2.1 for disabled interviewees, and 2.8 for non-disabled interviewees. In addition to activities in the diaries, eleven other activities with interesting planning histories were described by the interviewees. Dominant activity types included work, shopping, personal business, and social activities.

4.1 Activity patterns of disabled interviewees

Interviewee A recorded five activities, two of which were work activities identified by the interviewee as regular activities. Another work activity, which was identified as non-regular, was scheduled with a client one week in advance. The mode choice decision — perceived as a choice between paratransit and bus (with transfers) — was consciously postponed until the day before the trip, to take advantage of weather forecasts for the next day. Interviewee A preferred traveling by bus, but considered door-to-door paratransit

INTER-VIEWEE	DIS-ABLED?	ACTIVITY TYPE	# OF ACTI-VITIES	REGULAR OR NON-REGULAR	TRAVEL MODE (# of travel companions)	PLANNING LEAD TIME			COMMENTS
						Location	Timing	Mode	
A	Yes	Work	2	Regular (weekly)	Bus (0)	Regular	Regular	Regular	Appointment with client Hairdresser appointmt Park
		Work	1	Non-regular	Paratransit (0)	7days	Regular	1day	
		Pers.Business	1	Non-regular	Bus (0)	2days	2days	2days	
		Recreation	1	Non-regular	Car pasngr (1)	Same day	Same d.	Same d.	
B	Yes	ShopGrocery	1	Non-regular	Walk (1)	Same day	Same d.	Same d.	Spontaneous Coordinated w/ driver
		Church	1	Non-regular	Car pasngr (1)	Fixed	Fixed	5days	
C	Yes	Education	1	Non-regular	Rail & bus (0)	Fixed	2days	2days	Exhibit Lecture Swimming pool
		Education	1	Non-regular	Rail & bus (0)	Fixed	Fixed	3days	
		Recreation	1	Non-regular	Bus & walk(0)	Same day	Same d.	Same d.	
D	Yes	Social	1	Regular (weekly)	Car driver (0)	Regular	Regular	Regular	Chained to social activ. Spontaneous Spontaneous
		Pers.Business	3	Non-regular	Scooter (0)	1day	1day	1day	
		ShopGrocery	1	Non-regular	Scooter (0)	Same day	Same d.	Same d.	
		Pers.Business	1	Non-regular	Car driver (0)	1day	1day	1day	
		Social	1	Non-regular	Scooter (0)	Same day	Same d.	Same d.	
E	Yes	Medical	1	Non-regular	Paratransit (0)	Fixed	7days	5days	Paratransit reservation Lecture Coordinated w/ driver
		Pers.Business	1	Non-regular	Bus (0)	Same day	Same d.	Same d.	
		Education	1	Regular (weekly)	Bus & walk(0)	Regular	Regular	Regular	
		ShopClothes	1	Non-regular	Car pasngr (1)	1day	1day	1day	
F	No	Work	1	Regular (daily)	Bus (0)	Regular	Regular	Regular	Spontaneous; chained Chained to work activity Coordinated w/ friend Party; spontaneous
		ShopClothes	1	Non-regular	Walk (0)	Same day	Same d.	Same d.	
		Recreation	1	Regular (weekly)	Walk (1)	Regular	Regular	Regular	
		Social	1	Non-regular	Walk (1)	2days	2days	2days	
		ShopGrocery	1	Non-regular	Walk (1)	Same day	Same d.	Same d.	
		Social	1	Non-regular	Walk (1)	Fixed	Same d.	Same d.	

Table 4.2 Summary of activity diaries and planning lead times: exploratory interviews

INTER-VIEWEE	DIS-ABLED?	ACTIVITY TYPE	# OF ACTIVI-TIES	REGULAR OR NON-REGULAR	TRAVEL MODE (# of travel companions)	PLANNING LEAD TIME			COMMENTS
						Location	Timing	Mode	
G	No	Pers.Business	1	Non-regular	Car driver (1)	Same day	Same d.	Same d.	Post Office; chained Pay bills; chained Spontaneous
		Pers.Business	1	Non-regular	Car driver (1)	Fixed	Same d.	Same d.	
		ShopGrocery	1	Non-regular	Walk (1)	Same day	Same d.	Same d.	
		ShopApplnce	1	Non-regular	Car pasngr (3)	Same day	Same d.	Same d.	
H	No	Work	1	Regular (daily)	Bike & Rail(0)	Regular	Regular	Regular	Chained to work trip Coordinated w/ friend Coordinated w/ friend Coordinated w/ driver
		Pers.Business	1	Non-regular	Bike (0)	Fixed	Same d.	Same d.	
		Social	1	Non-regular	Bike (0)	1day	1day	1day	
		ShopGrocery	1	Non-regular	Walk (1)	Same day	Same d.	Same d.	
		Pers.Business	1	Non-regular	Car pasngr (1)	Fixed	7days	7days	
J	No	Serve Pasngr	2	Regular (daily)	Car pasngr (3)	Regular	Regular	Regular	Drop & pick-up children Coordinated w/ friend Urgent need of child
		Work	1	Regular (daily)	Car pasngr (1)	Regular	Regular	Regular	
		Lunch	1	Non-regular	Walk (1)	1day	1day	1day	
		Serve Pasngr	1	Non-regular	Car driver (2)	Same day	Same d.	Same d.	
K	No	Serve Pasngr	2	Regular (daily)	Car driver (1)	Regular	Regular	Regular	Drop & pick-up children Chained to work activity Coordinated w/ child Chained to recreation
		Work	2	Regular (daily)	Car driver (0)	Regular	Regular	Regular	
		Lunch	2	Regular (daily)	Car driver (1)	Regular	Regular	Regular	
		Recreation	1	Non-regular	Car driver (1)	2days	2days	2days	
		ShopGrocery	1	Non-regular	Car driver (1)	1day	1day	1day	

Table 4.2(continued) Summary of activity diaries and planning lead times: exploratory interviews

the better option in light of a forecast for rainy weather. A visit to the hairdresser was planned two days before when an appointment was made. A recreational visit to the park was made spontaneously with a friend.

Interviewee B recorded only two activities, both of which she considered non-regular.

One was a grocery shopping trip to a neighborhood mall, taken on the spur of the moment. She recalled frequently making such trips for shopping, recreational or social reasons: “It is like going to my livingroom”. The other was a church service — usually a regular activity — that in this case required conscious planning because the regular access mode (being driven by her husband) was unavailable. Scheduling of the trip occurred five days in advance when a friend was asked to drive her.

Interviewee C attended two non-regular educational activities, respectively in San Francisco and Marin County, and scheduled two and three days before execution. In each case the travel mode was a combination of train, bus and walking. A third activity, a recreational swimming activity, was considered two days in advance, but the final decision to go was only taken an hour before. The interviewee remarked that she “only do(es) it when I feel I have the energy”.

Interviewee D used a regular weekly social engagement as an opportunity to access two personal business activities (bank and post office) and one shopping activity. The business activities were planned the previous day, while the shopping activity was

executed on the spur of the moment. Another business trip to the bank was also planned a day in advance, and a social visit was spontaneously chained to it.

Interviewee E recorded one regular educational activity and three non-regular activities.

He described a routine medical visit which was scheduled a week in advance. A reservation for paratransit service was made two days later — the interviewee felt he needed to give the operator five days' warning because of capacity constraints. A personal business activity was accessed by bus and planned only on the day of the activity, when the need for the activity arose. A non-regular shopping activity was planned a day in advance because of the need to coordinate the trip with a friend providing transportation.

4.2 Activity patterns of non-disabled interviewees

Interviewee F recorded two regular activities — work, and a recreational activity chained to the work activity. A shopping activity — urgent because of the need to buy clothes for the recreational activity — was chained onto the work activity at very short notice. One social activity was scheduled and coordinated with a companion two days in advance, while another social activity — an event that required no advance commitment — was scheduled only an hour before going.

Interviewee G had no regular activities and a very flexible schedule. She identified the need for two personal business activities on the day before, but postponed choosing the time until the day of execution. The reason she gave was to coordinate her time of travel with the schedule of a teenage daughter, who was less flexible than Interviewee G. A grocery shopping trip later that day was planned with three hours' notice when she coordinated the trip with another person's schedule.

Interviewee H chained three additional activities to the regular trip back from work. These activities included a social visit (coordinated with a friend the previous day), a grocery shopping activity (coordinated with the same friend on the morning of the activity), and a visit to the library (made on the spur of the moment when he realized he had time to spare in his schedule). Interviewee H also described another personal business activity planned and coordinated with a friend a week in advance, to ensure that the friend could drive him there.

Interviewee J identified a work activity and two serve-passenger activities (dropping and fetching children from school) as regular daily activities. A non-regular restaurant activity was planned the day before, when it was scheduled together with a companion. Another serve-passenger activity to serve an urgent need of a child was executed with less than an hour's advance planning.

Interviewee K regularly undertook a daily work activity, to which regular serve-passenger

(dropping and fetching a child from school) and lunch activities were chained. A recreational activity accompanied by the child was planned two days in advance, and a food shopping activity planned the day before was chained to the recreational trip.

5. DISCUSSION OF RESULTS

5.1 Regular activity patterns

In the interviews, “regular” activities were functionally defined as activities that occur at the same time and place every day or week. Interviewees were asked to identify the regular activities included in their activity diaries. Regular activity patterns seemed to play an important role. Sixteen of the 49 reported activities were considered regular. These included some work, educational, social, and recreational activities (regular sports participation), and activities to serve children (dropping off and picking up children at school). While most work activities were regular, no one activity type exclusively occurred regularly. Interviewees that were employed and interviewees with children tended to have more regular activities than other interviewees. Also, regular activities were more prevalent during weekdays than during weekends. Disabled people in the sample seemed to have fewer regular patterns — only a quarter of regular activities were made by disabled interviewees — which reflected their lower employment level.

These results generally fit with earlier work on the prevalence of regular patterns in daily activities and travel. For instance, Huff and Hanson [1990] showed empirically that routine movement is a major component of daily travel. More interesting is the role that regular activities seemed to play in the scheduling process. Regular activities were known long in advance: interviewees agreed that they could have named the time, location and mode of most regular activities more than a week in advance. Patterns of regular activities thus provided a “skeleton” around which non-regular activities were organized as the need arose, much like the “pegs” that Cullen and Godson [1975] found regular activities to be. For example, interviewee G (a non-worker) suggested that her regular trip to fetch her children from school used to provide structure around which the rest of her day had been planned. Regular patterns thus simplify the scheduling process by defining obvious time windows where non-regular activities can be inserted, thereby substantially reducing the range of feasible scheduling options for other activities. In addition, regular patterns seemed to provide opportunities for unplanned behavior, for instance the personal business and shopping trips that interviewees H and F spontaneously chained to their regular trips from work.

5.2 Non-regular activities

For the purpose of this study, we considered activities that interviewees did not identify as occurring at regular places and times and accessed with the same mode, as non-regular.

This distinction, although simplistic, was sufficient as it allowed identification of activities for which one or more conscious scheduling decisions were made. However, the distinction between regular and non-regular activities becomes less clear when longer term activity behavior is considered. Patterns form over time and exactly when a conscious decision changes into habitual behavior is not clear at all. This research did not attempt to probe the mechanisms of routine behavior in depth.

The interviews showed that even in the short term, the boundary between regular and non-regular behavior may shift. Some activities were usually regular, executed with recurring frequencies, locations, timings, and access modes; except for occasional episodes when external factors forced a deviation from the regular pattern. In such cases the activity became temporarily non-regular, in the sense of it requiring more intentional scheduling actions. An example is the need for a new mode choice that interviewee B encountered when her usual ride to a weekly church event was unavailable¹. Exceptions such as this exemplify some of the subtleties involved in activity scheduling behavior.

Non-regular activities varied greatly with regard to type, duration, location, timing, mode use, and amount of advance planning undertaken. There was considerable variation in the order and timing of planning decisions, and the reasons for that. Sixteen activities (out of

¹ Technically this can also be thought of as a change in *trip planning* rather than *activity scheduling*. However, this distinction is not made in this research. We acknowledge the interdependencies among location, timing, and mode choice by defining activity planning to include all of these decision processes.

49) were planned on the same day as execution, with five of them executed spontaneously (without any advance planning). Seven other activities had some or all planning actions taken one day before execution, and the rest were planned between two and seven days in advance. Most of the following discussion will be devoted to exploring this variation in planning behavior.

5.3 Activity attributes

The interviews gathered information on a number of attributes for each activity, including activity type, location, start and end time, companions, and travel mode. Interviewees were also asked for information on when the major scheduling decisions — choice of location, timing, and travel mode — were made.

Many of the observed activities had location and timing attributes that were fixed *a priori*. The relevant attributes were accepted by the individual as given — no other options were considered. This applied to regular activities — of which the location, timing and mode were fixed by definition — as well as to some non-regular activities. Seven of the 33 non-regular activities had only the location fixed *a priori*. These included activities offered only at one location (e.g. C's educational exhibit; F's social event/party), and activities offered at multiple locations, but perceived in the short term to be fixed (e.g. E's routine medical visit; C's closest swimming pool; G's personal business

activity). In only two cases the location as well as the timing of the activity was fixed: B's church service, and C's lecture. There were no cases of activities that had to be executed at fixed times but not at fixed locations.

To the extent that the attributes of an activity were not fixed, people tended to choose the desired attributes within a short time period rather than spreading the decisions out over multiple days. For 31 of the 33 non-regular activities, interviewees decided the location, timing, and/or travel mode of an activity all on the same day. This seemed to be a response to the complexity of the scheduling process — choices regarding locations, timings, and travel modes influenced each other, causing complex interdependencies to develop. Despite these complexities, some of the interdependencies could be inferred from the interviewees' descriptions of their decision making processes. It was found that, for many non-regular activities, the order in which attributes were chosen was systematically related to the kind of activity. Two patterns were observed:

- (i) For activities offered at many possible locations, the mode choice tended to precede the choice of location and timing. Observed activities of this type included grocery shopping and visits to the hairdresser, bank, and post office. Many of these activities were executed as part of a trip chain. What these activities had in common was that the quality of service did not vary greatly over

the range of potential activity locations². People thus first chose the travel mode that minimized the perceived cost of accessing the activity, and then searched for a desirable location given the chosen mode.

- (ii) For activities offered at few locations or a single location, the choice of location and timing tended to precede the mode choice. Examples included occasional personal business activities, appliance shopping, and social activities. The location choice, if not fixed, seemed to be driven by factors of quality and price, with travel cost being a secondary consideration. The question of “how do I get there?” thus tended to be addressed only after desirable locations and timings had been identified.

Two interesting examples were found where the timing and mode choice decisions were not made on the same day, but where the mode choice was purposely delayed by several days until more information could be obtained. In the first case (for interviewee A), the decision to participate in a work-related activity was made a week in advance, but the mode choice decision was delayed until the day before execution in order to take advantage of forecast weather information for the next day. The choice of door-to-door paratransit over bus transport was prompted by a forecast for rainy weather. In the second case (for interviewee F), the location and starting time of a party was known, but

² Hairdressers may not usually be considered equivalent in terms of service quality. Interviewee A described a choice between two hairdressers perceived as offering similar quality, but where one could be accessed at considerably lower cost by chaining the activity to her work trip.

uncertainty existed about which modes would be available. The mode choice set only became clear shortly before the activity, when the decision was made to walk to the event.

5.4 Factors affecting the timing of planning decisions

A close look at the distribution of planning lead times across the 49 reported activities, as well as respondents' general descriptions of their planning processes, suggested that a number of factors systematically influenced the timing of planning decisions. These factors are related to activity-specific characteristics, transportation-related characteristics, and personal characteristics.

5.4.1 Factors related to activity characteristics

Five factors related to characteristics of the activity that was undertaken, seemed to affect individuals' tendency to plan ahead. Firstly, activities that required appointments or reservations tended to be planned ahead. Observed examples include a work-related appointment and visits to the hairdresser and a routine medical care provider.

Appointments for these were made between one and seven days in advance. Activities requiring appointments were evidently ones with a limited capacity which was allocated among competing patrons on the basis of reservations.

Secondly, activities that involved coordination with other people tended to be scheduled in advance by interviewees. All social, many recreational, and some shopping and personal business activities were executed in the company of a companion. The confirmation of such activities on the schedule tended to occur a day or more in advance. As can be expected, the amount of flexibility (in terms of busyness of the schedule, and the ability to respond to new opportunities) of both individuals influenced the amount of advance planning undertaken. To illustrate, interviewee H, who coordinated many social activities with a companion with a relatively low ability to accommodate new activities, planned all social activities one or two days in advance. Interviewee B, on the other hand, undertook numerous shopping and social activities with less than an hour's planning, assisted by the fact that both she and her non-working companion had extremely flexible schedules.

A further factor that seemed to explain the tendency to plan ahead was the importance of the activity to the well-being of the individual. While information on activity importance was not routinely sought, some interviewees volunteered this information. Activities with higher importance tended to be planned longer in advance, ostensibly to ensure that they were completed successfully. Observed examples included important personal business or shopping activities undertaken as part of trip chains, and planned a day or more ahead of time (interviewees D and K). Other activities with lower importance, such as lunch or discretionary shopping activities, were typically not planned long in advance but made in a more spontaneous fashion (interviewees D, F, and H).

Lastly, activities that were perceived as urgent had very short planning horizons; planning and execution of these activities were constrained to occur within a few hours of perceiving the need for the activity. Reported examples included urgent personal business activities (interviewee G), urgent shopping (that had to be accomplished in preparation for an imminent event: interviewee F), and urgent serve-passenger trips (what parents won't do for their children...). Recreational activities, while not typically thought of as "urgent", also tended to have short planning horizons. Half of all recreational activities were planned and executed on the same day. Respondents A and C, both disabled, stated that their enjoyment of such activities depended much on their state of mind and body — conditions not easily predicted. As interviewee C remarked about trips to the public swimming pool, "I only do it when I feel I have the energy".

5.4.2 Factors related to transportation

Transportation-related factors that tended to encourage advance planning included the need for reservations, the need to coordinate with other travelers, and travel cost. Accessing dial-a-ride or paratransit systems, which typically require advance reservation of rides, forced potential users to make location, timing, and mode choice decisions ahead of time. The perceived likelihood of service denial due to capacity constraints further affected planning times. For example: interviewee A, using a paratransit provider that guaranteed service with a one-day lead time, often reserved paratransit trips only one day in advance. Interviewee E, whose shuttle service made no such service guarantees but worked on a first-come-first-served basis, typically reserved trips 5 to 6 days in advance,

in order to increase the likelihood of receiving service.

Where travel to or from an activity was dependent on coordinating with other travelers, activities also tended to be planned in advance. Non-driving interviewees A, B, E, and H all described having to coordinate trips with friends or paid attendants who would drive them to the activity, 1 to 7 days ahead of execution.

The final transportation-related factor that seemed to affect people's tendency for advance planning was generalized travel cost. After the interviews the researcher categorized all reported trips into two groups based on the reported travel times: trips with high travel costs, and trips with low travel costs. High cost trips were those with travel times in excess of about twenty minutes, or with higher out-of-pocket costs such as paratransit fares. These trips were also grouped according to whether they were chained into multiple stop chains. The result is shown in Table 4.3.

The results suggest a few trends. Activities with low travel costs had the highest tendency towards short planning lead times. Travel costs were low because destinations were within walking or wheelchair distance of home. Activities in this group included many short-duration, high-frequency activities such as grocery shopping, lunch, and personal business activities. Destinations and travel conditions were familiar and activities were typically not constrained to occur within a narrow band of time. People seemed to insert such short trips into gaps in their schedules without much advance planning.

TRAVEL COST	CHAINED OR UNCHAINED	NUMBER OF ACTIVITIES	PLANNING LEAD TIME		
			same day	1-2 days	3-7 days
low	unchained	10	7	2	1
low	chained	11	6	5	-
high	chained	7	2	4	1
high	unchained	5	1	1	3
TOTAL NON-REGULAR ACTIVITIES		33	16	12	5

Table 4.3: Travel costs and advance planning for non-regular activities

Where low travel cost activities were inserted into trip chains, lead times of one or two days were observed more frequently. This suggests the existence of some relationship between trip chaining and advance planning. When planning trip chains in advance, respondents identified convenient places in the future activity and travel schedule to insert new activities with a minimum amount of additional travel. The motivation for this was summarized by interviewee G as “to save gas, to save use of the car, and to save time”. Advance planning thus provided the opportunity, through trip chaining, to reduce the overall amount of travel. However, chaining was also associated in some cases with spontaneous behavior, when proximity to an activity location prompted execution of unplanned activities. Examples included spontaneous shopping, social (interviewee D), and personal business activities (interviewee H).

Lastly, most activities with high travel costs tended to be planned between one and seven days in advance. High cost activities included some work-related, education, medical, shopping and personal business activities. Planning for these activities occurred longer in advance, evidently to increase the likelihood that the activity would be successfully completed. One might have expected to see chaining associated with the longest lead times, as the motivation to save travel time may increase with total travel expenditures, but this is not supported by the results.

5.4.3 Factors related to personal and household characteristics

Household factors — specifically the presence of children in the home — were found to be associated with specific planning behaviors, by causing a higher incidence of activities both with very long and very short lead times. All three respondents with children undertook significant coordination of their schedules with those of their children. For interviewees J and K, both working, this caused more rigorous planning of their schedules, in the form of regular patterns (dropping and picking up children from school), and advance planning of non-regular activities (for instance, interviewee K planned to visit a movie theater with his child two days in advance). However, interviewees G and J also reported more spontaneous behavior, both as a result of responding to urgent needs of children (for instance J's unplanned serve passenger activity to buy something needed by her child), and as a result of safeguarding more flexibility in their own activities in order to be able to respond to these unforeseen needs. Interviewee J, facing the mobility constraint of sharing use of one automobile with her husband, described a daily process

of negotiating changes in her own (and other family members') schedules to resolve conflicts among the schedules. Interviewee G, a non-worker with very few regular patterns, engaged in extremely flexible behavior by planning very few activities more than a day in advance to enable her to coordinate her movements with those of her children.

Apart from all the factors described above, personal tastes and preferences accounted for some of the variation in planning behavior. Interviewee A stated that she liked her day-to-day life to be planned and structured, and therefore tended to plan activities with longer planning lead times. Interviewees C, D, and F admitted to valuing a flexible and spontaneous lifestyle. Said C, "I can't plan my life in advance — I love flexibility". These stated preferences were not ostensibly related to the disability status of each respondent.

5.5 Inadequate planning time and foregone activities

In order to get at the question of what happens if the available time is insufficient to plan for an activity, respondents were asked to recount recent instances of activities that were desired but foregone for a planning-related reason.

Both disabled and non-disabled interviewees described such cases. Interviewee F

described a social activity that was foregone because the time available between hearing about it, and her desired arrival time at the activity, was not enough to coordinate transportation with others. Interviewee G declined an unexpected personal business activity requested by her spouse, because she had already committed herself to another activity involving a number of other people.

Less urgent activities were sometimes postponed to create adequate planning time. An example was provided by interviewee C who sometimes postponed weekend shopping trips because paratransit — the only mode by which to access certain shopping locations on weekends — was not available on short notice. In other cases urgent activities were not postponed but executed at higher cost because low cost alternatives all require longer planning horizons. Interviewee H described an urgent shopping trip that, had more planning time been available, could have been made with a lower overall travel time by chaining it to a work trip. The absence of adequate planning time therefore lead to increased transportation costs for this activity.

From these examples it was clear that, in general, “adequate” planning time varied with factors such as activity type, the fullness of the schedule, and the range of transportation modes available to an individual. Insufficient planning time caused a number of behavioral responses, varying from postponement or acceptance of a higher activity cost, to outright elimination of the activity.

5.6 Impacts of a physical disability on planning behavior

Disabled interviewees seemed to do more advance planning of non-regular activities than non-disabled interviewees. Six of the nine non-regular activities with lead times of two days or more were reported by disabled respondents. One reason for this was that disabled interviewees generally faced higher travel costs than non-disabled interviewees. Only one disabled person owned and operated a car, compared to four of the five non-disabled respondents. Alternative travel modes, including transit and paratransit, are generally more costly in terms of travel time and out-of-pocket cost. Advance planning thus provided a mechanism for ensuring the successful completion of these more costly trips.

Two disabled interviewees also described a more intense need for collecting extra information before choosing activity locations and travel modes. Interviewee C, who is visually impaired, described sometimes spending days gathering accessibility information by telephone and thinking it over, before deciding to travel to an unknown location. Interviewee A, who uses a wheelchair, also stated that “one of the biggest implications of having a disability is the need to plan ahead”.

Although it is impossible to ascertain from this small sample, it stands to reason that the need for advance planning among disabled people is also related to their activity needs. To the extent that disabled people engage more in appointment-type activities such as

medical visits, they would be expected to do more advance planning. On the other hand, to the extent that disabled people tend to be unconstrained by the schedules of children in the household, they would be expected to engage in less regular and also less urgent activity behavior. This is likely to be a significant effect in larger disabled populations, as these increasingly include elderly people [Altshuler, 1979].

5.7 Paratransit use

All five disabled interviewees were eligible for ADA paratransit service and used it at some time in the past, although only two of them were somewhat regular users. The need to reserve trips a day or more in advance was perceived as a distinct drawback of the service — a perception mentioned by all five interviewees. Interviewees saw the imposition of advance reservation requirements as limiting their personal flexibility, their ability to take full advantage of unforeseen opportunities. Even though most trips were planned long enough in advance to have allowed previous-day reservation, interviewees valued the possibility of having quick access to transportation.

Other attributes of the paratransit mode were also mentioned as deterrents to its use. These included longer travel times due to ridesharing, higher out-of-pocket costs, lower comfort, and lower reliability compared to the automobile or scheduled transit. Some disabled interviewees also preferred “rubbing shoulders” with the general population to

being isolated on a specialized service.

Paratransit trips that were described by interviewees A and E were to longer distance locations that could not easily be reached by scheduled accessible transit. In these cases, the fact that paratransit provided a door-to-door service without transfers proved attractive, especially given the expectation of rainy weather in the case of interviewee A. However, to closer locations these two interviewees preferred to travel by bus. These examples illustrate the principle of conditional eligibility for complementary paratransit service, which is based on the assumption that disabled people with multiple modal options would use mainline transit modes in all cases where that provides adequate accessibility to activity locations.

However, there is evidence that this philosophy imposes hardships on potential users. Three interviewees recounted instances where they were urgently in need of transportation, after being unexpectedly stranded somewhere, but where ADA paratransit could not be accessed because no advance reservation had been made. Two of these people had no recourse to taxi service as they were wheelchair bound. Interviewee A expressed a willingness to pay more for paratransit service with immediate response, pointing to the possibility of recovering the extra costs of such a service from those who benefit from it.

6. SUMMARY OF FINDINGS

In summary, the in-depth interviews of five disabled and five non-disabled people provided insight into not only the nature of activity planning behavior, but also the extent to which it conforms to a control theory-based description of the process³.

6.1 Systematic aspects of scheduling behavior

The investigation of disturbances and regulatory action during scheduling suggested that some aspects of scheduling behavior can be captured well within a rational descriptive framework, while other aspects exhibit idiosyncratic and unsystematic properties. Confirmation was found that reference input, in the form of regular activity patterns, encourage systematic planning behavior by providing a “skeleton” of activities around which further scheduling decisions are made. Scheduling of non-regular activities was described by a series of decisions regarding activity participation, location, timing, and travel mode. The timing of these decisions (where they weren’t fixed *a priori*) relative to each other often followed systematic patterns related to the type of activity and the density of activity locations. For activities offered at numerous competing locations, the location and timing decisions were typically conditional on mode choice. The opposite

³ A more comprehensive description of a theoretical framework for activity scheduling based on control theory concepts is provided in Chapter 3.

was found to be true for activities offered at a small number of locations, where the quality of the service varied among locations.

The timing of regulatory decisions relative to the execution of activities — or the decision of when to make scheduling decisions — appeared systematic in as much as it reflected individuals' perceptions of risk and travel cost. Two factors emerged that seemed to motivate the choice of lead times: people planned in order to reduce the risk of unsuccessful completion of an activity, and people planned in order to reduce the transportation costs of accessing an activity. The first motivation explained the tendency to schedule in advance activities involving coordination with other people, and activities that needed appointments or reservations.

The second motivation — that of reducing transportation costs — was evident from three distinct behaviors. Firstly, activities with low transportation costs were not usually planned long in advance, there being no significant cost-saving incentive to do so. Secondly, activities with high costs due to long distances or costly modes were typically planned longer in advance, in part to allow more time for identifying optimal locations and travel alternatives. Costly activities also tended to be more important to the well-being of the individual; the desire to ensure successful completion of the activity provided an incentive for advance planning. Thirdly, many activities executed as part of trip chains were planned to increase the ability of finding a suitable travel pattern into which they could be inserted.

6.2 Unsystematic aspects of scheduling behavior

At the same time, observed scheduling behavior also exhibited unsystematic aspects that fit into the control theory model less well. Firstly, some observations suggested that regular activity patterns are not as stable as implied by their definition as reference input. The boundary between regular patterns and activities in need of conscious scheduling may be constantly shifting. Secondly, despite the fact that common factors motivate advance planning of individual activities, the overall process is still somewhat idiosyncratic. Variations in personal tastes and opportunistic behavior sometimes cause planning decisions to proceed rather unsystematically. In this respect our findings reflect those of Hayes-Roth and Hayes-Roth [1979] which found planning to be opportunistic in nature. In light of this, a strategy often used to reduce the complexity of the planning process is packaging of the participation, location, timing and mode choice decisions related to a particular activity into a single decision making exercise (as opposed to drawing the decisions out over multiple days).

6.3 Variations due to household and personal factors

Household effects — particularly the presence of children — seemed to increase the amount of reference input as well as disturbances with very short planning horizons. The activity needs imposed by children in the home created more planned activities in terms

of regular serve-passenger trips, but also lead to more spontaneous behavior in terms of responding to urgent needs of children. Some interviewees purposely safeguarded extra flexibility in their schedules to accommodate short-notice activities.

Compared to non-disabled interviewees, the disabled interviewees tended to plan more of their activities in advance. This was more a result of differences in the types of disturbances (in terms of activity and travel needs) experienced by the two groups, than of differences in the regulatory processes per se. To the extent that disabled people engaged more in appointment activities (such as medical visits), and more frequently coordinated trips with other people (such as people who can provide transportation), disabled people engaged in more advance planning. Also, to the extent that disabled tripmakers faced higher unit travel costs, more planning was undertaken to reduce those costs as much as possible.

At the same time, the frequent need to coordinate travel with other people exposed disabled people to a larger set of potential disturbances. For example, in cases where disabled interviewees depended on others to be driven around, unforeseen disturbances in the drivers' schedules were propagated to the schedules of the disabled interviewees, causing a need for additional regulatory action.

Lastly, interviews with disabled tripmakers showed that the advance reservation policies of current ADA paratransit providers serve as a deterrent to using the system, even

though the number of affected trips may be small. The results suggested that advance reservation restrictions may most impact potential users with few modal alternatives, and those who need emergency service on short notice.

CHAPTER 5

EMPIRICAL ANALYSIS OF PLANNING BEHAVIOR

1. INTRODUCTION

Activity planning is motivated by people's desire to ensure that activities are successfully completed, and to reduce the cost of accessing them. The results from the exploratory interviews (Chapter 4) are examined within a more quantitative framework in this chapter. Disaggregate activity survey data with information on activity planning are examined to identify groups of activities with similar planning profiles. While these include regular activities known long in advance, and urgent activities with very little advance notice, the main focus is on activities with a broader range of possible planning behaviors. The goal is to determine the reasons why we observe these particular planning behaviors.

A number of hypotheses are formulated to explain the observed choice of planning lead time for each activity. The hypotheses are evaluated individually, using bivariate statistical techniques, and collectively, using a discriminant modeling approach.

Significant insights are obtained into the influence of activity, travel and personal characteristics on the planning behavior of individuals.

2. DATA

2.1 Data source

The data for this analysis was obtained from an activity and travel survey in the Windham Planning Region of Connecticut. The home interview survey of 600 households was conducted between November 1979 and May 1980. The objective of the original study by the University of Connecticut's Transportation Institute, was to evaluate the potential for real-time ridesharing in the region [Davis et al, 1981]. This activity database was chosen because it collected unique information on the amount of planning undertaken for each activity, which was crucial for this analysis. Additional information on the flexibility of activity patterns also proved to be very useful.

Important characteristics of the survey region include a relatively low population density and a high proportion of students in the population. The region is semi-rural with a population density of approximately 195 persons per square mile. Due to the presence of two major educational institutions in the area, about 20% of the sampled individuals were students, and 26% of all households were composed of students only. Also, at the time of the survey no public transit other than schoolbus service was provided.

2.2 Critique of survey

The sampling procedure was adequately designed to obtain a random sample of households. The sampling plan was based on a random draw of occupied housing units on a map. An earlier comparison of the sample with census records found it representative of the region's population [Davis et al, 1981].

A major limitation of the survey, however, was its selective recording of activities. Respondents were asked to record only activities that took place more than half a mile from the home, on the day prior to the interview. An unknown number of local activities and short-distance trips were therefore omitted from the database¹. Respondents were limited to those present (at home) at the time of the interview, and did therefore not include all family members. Reporting of the previous day's travel depended on memory only; while the level of accuracy thus obtained was probably adequate, it could have been improved by asking respondents in advance to keep a diary of activities and travel.

Activity purposes were not defined with consistent levels of detail in the survey. Some purposes were disaggregated finely (for instance, recreational activities were recorded in

¹ An estimate of the proportion of trips omitted is provided by the 1990 Nationwide Personal Transportation Survey, which indicated that 7.4% of home-based work trips in urbanized areas were shorter than ½ mile. The proportion for shopping, personal business and social trips will be slightly higher, as these are typically shorter than work trips [COMSIS, 1994].

four separate categories), while other categories combined activities that should have been indicated separately. Examples include routine shopping and personal business activities, which were recorded in a single category, and serve-passenger trips which were included in a miscellaneous “Other” category.

2.3 Description of sample

The distributions of the demographics, activity behavior, and travel behavior reported in the survey are described in detail by Davis et al [1981]. This section highlights the major characteristics of the sample.

2.3.1 Sample demographics

Almost all of the demographic indicators reflect the influence of the relatively large student population.

The sample of 1,652 individuals is evenly divided between men and women. About 40% of respondents were below 20 years of age; excluding students, the median age is 29 years. Household income is also skewed downwards; the median income is between \$10,000 and \$15,000 for the whole population and between \$15,000 and \$20,000 for non-student households only. Despite the relatively low incomes, automobile ownership was high, probably reflecting the semi-rural character of the area. Only 17% of households

had no automobile, most of which were student-only households. Sixty eight percent of households had 1 or 2 automobiles, and the remaining 15% owned three or more automobiles.

The survey asked whether a household includes any physically disabled persons who need special assistance in traveling to or from activities. About 4% of households responded positively. Unfortunately disabled individuals were not identified, so that their activity and travel behavior could not be analyzed separately from that of the general population.

2.3.2 Activity behavior

A total of 3,062 activities were reported, or 1,774 excluding return home². The average number of activities per person is 1.07 activities per day. This number underrepresents true activity participation, for reasons explained earlier. Of the sixteen activity types defined in the survey, work was the most common, followed closely by shopping and school-related activities (Table 5.1). The “Other” category includes mostly serve-passenger, miscellaneous personal business, and social/recreational activities. Since the survey was conducted on weekdays only, recreational and church activities are probably underrepresented.

² Since the “return home” trip is included in each journey, the remainder of the analysis does not include “return home” trips in the number of activities unless stated otherwise.

Information was collected regarding the frequency, perceived importance, and flexibility of each activity. Thirty-six percent of activities occurred daily — these were mostly work and school-related activities. Activities that tended to occur with a weekly or monthly frequency included recreation, shopping, and voluntary association activities.

ACTIVITY TYPE	Number	%
Work	470	26.5%
Theater, Movie	10	0.6%
Spectator Sports	8	0.5%
Participatory Sports	28	1.6%
Other Recreation	70	3.9%
Grocery Shopping, Banking	342	19.3%
Clothes, Appliance Shopping	26	1.5%
Other Shopping	25	1.4%
Church	13	0.7%
School	241	13.6%
After School Activity	23	1.3%
Voluntary Association	49	2.8%
Public Meeting	18	1.0%
Restaurant	69	3.9%
Medical/Dental/Legal	53	3.0%
Other	329	18.5%
TOTAL	1,774	100.0%

Table 5.1: Distribution of reported activities by activity type

The perceived importance of each activity was captured by the question “How important do you think this activity is for the well-being of your household?” Not surprisingly, most activities (79%) were deemed “Very Important” or “Important” to the well-being of the family. Only two activity types — recreation and restaurant activities — had a

majority of responses in the “Relatively Unimportant” or “Unimportant” categories. The flexibility in the timing of each activity was recorded by asking whether the activity could have occurred on a different day, and whether the activity had fixed start and end times. Most activities (69%) could not have been executed on another day, while 49% of all activities had fixed start and end times. Respondents seem to have been relatively constrained in the choice of timing of many of their activities.

2.3.3 Travel behavior

For every travel link between activities, the travel time, mode of travel, and the presence of other people in the vehicle was recorded. The average number of home-to-home journeys is 0.78 per person per day, while the average journey consisted of 2.4 links (including the trip home). Forty-two percent of activities were thus combined with other activities on the same journey to form trip chains. Activity types most frequently linked into chains are work, shopping, and “other” (probably serve-passenger) activities.

The mode use distribution reflects the virtual absence of public transportation in the region at the time of the survey. Eighty-eight percent of trips (including return home) were made by automobile; the 8% of trips by public transit were all by school bus. Only 3.5% of recorded trips were walking trips — a number probably underestimated by the omission of short-distance trips from the database. Almost half of all trips were undertaken in the company of other people from the same or another household.

3. OBSERVED PLANNING BEHAVIOR

The survey collected information on the amount of advance planning undertaken for each activity by asking “How long ahead of time did you know that this activity would occur?” Allowable responses included “No advance knowledge of activity”, “Less than one hour”, “One to two hours”, “Two to four hours”, “Same day but over four hours”, “24 to 48 hours”, “Over 48 hours and up to one week”, and “More than one week”. This information is useful for characterizing and investigating the planning behavior associated with each activity in the sample.

3.1 Advance knowledge of activities

Responses to the question on advance knowledge of activities show that respondents knew in advance about a majority of their activities. Only 25% of activities had less than one day’s advance notice; 22% of activities had between one and seven days’ notice; and 53% of activities had more than a week’s advance notice.

Figure 5.1(a) and (b) show the cumulative distribution of planning times for each activity type. Planning behavior clearly varies according to the type of activity. Work and school-related activities were generally known more than a week in advance, while

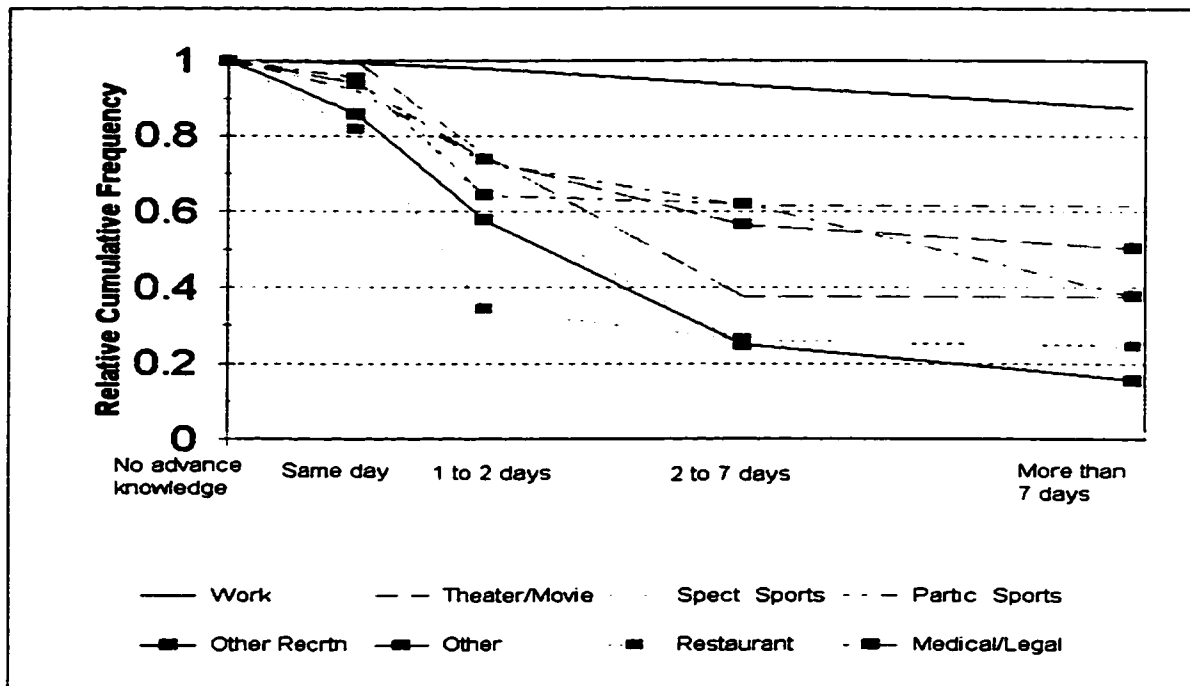


Figure 5.1(a) Distribution of reported activity lead times

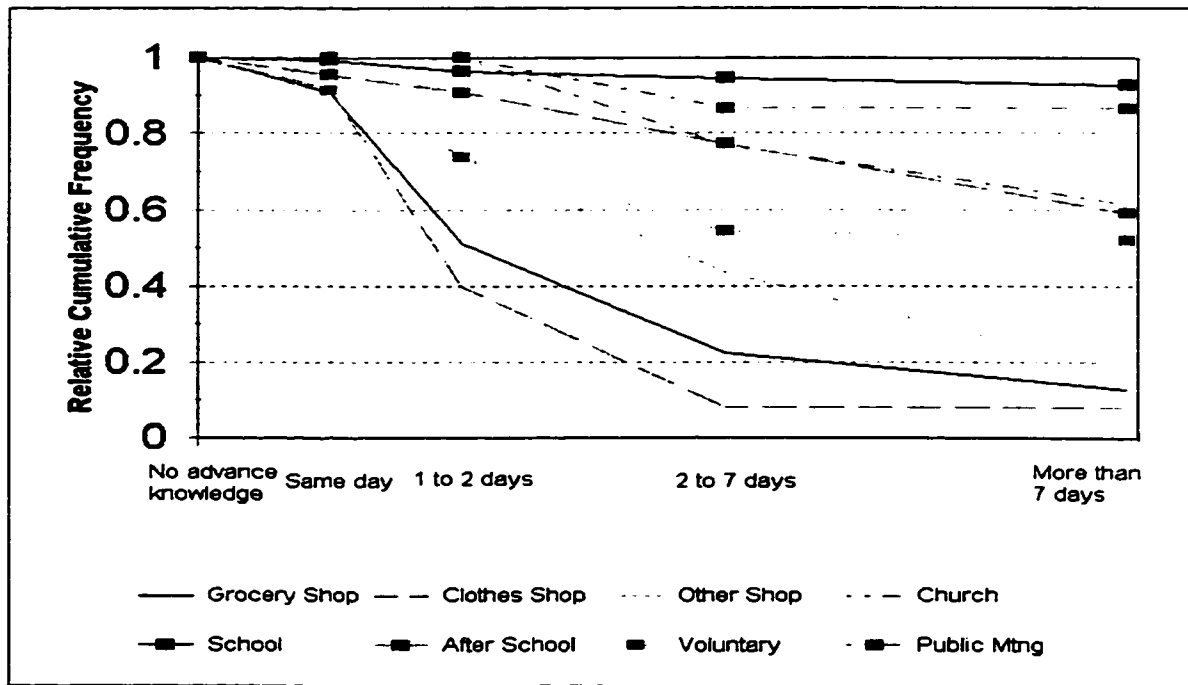


Figure 5.1(b) Distribution of reported activity lead times

medical/legal and community activities tended to have intermediate advance notice.

Shopping, theater/movie, and restaurant activities tended to occur with the least amount of advance warning.

3.2 Methodology for identifying regular and urgent activities

Exploratory interviews (Chapter 4) indicated that individuals often have some measure of freedom to select when scheduling decisions are made for future activities. Whether scheduling occurs long in advance or close to the time of execution is determined by both the individual's assessment of the need for advance scheduling, and by the amount of advance scheduling allowed or required by the circumstances. Two types of activities, in particular, impose severe constraints on when scheduling occurs: regular and urgent activities. Regular activities occur with fixed frequencies, timings, and locations; scheduling decisions are, by definition, not consciously repeated every time regular activities are executed. Urgent activities, on the other hand, are constrained to happen shortly after they become known, preventing an individual from planning long in advance for their execution. It is important to identify them, as these activities may be treated differently during the scheduling process.

Regular and urgent activities represent the opposite extremes of a continuum of planning scenarios. Conceptually, this continuum is defined using the theoretical concepts

developed in Chapter 3. For each activity, two time periods are pertinent: a **planning horizon** (T_{PH}), indicating the maximum time available in which to plan the activity, and a **planning lead time** (T_{LT}), indicating the actual amount of time between planning and executing the activity. The planning lead time is always equal to or shorter than the planning horizon.

3.2.1 Defining urgent and plannable activities

Conceptually, urgent activities can be identified with reference to the planning horizon.

Activities with very short horizons have to be planned and executed within that short period of time. For the purpose of this study an arbitrary but convenient cut-off value of one day is chosen, referring to a calendar day rather than to a 24 hour day. Activities with $T_{PH} \leq 1$ day are urgent activities — both scheduling and execution are constrained to happen on the same day. Activities with $T_{PH} > 1$ day are called plannable activities.

Since more time is available to plan and execute plannable activities, the decision maker has the option of planning such activities long in advance or closer to execution.

Among plannable activities, the activity lead time differentiates planned from unplanned activities. A cut-off value of one day also defines the boundary between these categories.

Activities with short lead times ($T_{LT} \leq 1$ day) are called unplanned — scheduling of the activity happens on the same day as execution — while activities with lead times of longer than a day ($T_{LT} > 1$ day) are called planned activities. These quantities are superimposed to categorize activities, as shown in Table 5.2. Urgent activities are those

with both $T_{PH} \leq 1$ day and $T_{LT} \leq 1$ day; these are by definition always unplanned.

Plannable activities ($T_{PH} > 1$ day) can be either planned or unplanned, depending on the lead time chosen by the individual.

			LEAD TIME		
			$T_{LT} \leq 1$ day	$T_{LT} > 1$ day	$T_{LT} \gg 1$ day
			Unplanned	Planned	
PLANNING HORIZON	$T_{PH} \leq 1$ day	Urgent	Urgent activities	---	---
	$T_{PH} > 1$ day	Plannable	Plannable, unplanned activities	Plannable, planned activities	---
	$T_{PH} \gg 1$ day				Regular activities

Table 5.2: Definition of regular, urgent, and plannable activities based on relationships between lead time and planning horizon

Although clear in concept, urgent activities are harder to identify in practice. We interpret respondents' answers to the question "How long ahead of time did you know that this activity would occur?" as the lead time of each activity. The specific reference to "this activity", and the position of the question in the survey after all other information about the activity had been collected, suggest that respondents likely referred to the scheduled activity when answering this question.

Unfortunately we do not have direct information on the planning horizon of each activity. However, respondents' answers to the question "Would it be possible for this activity to

have occurred on a different day?” provides other useful information. Unplanned activities for which the answer was “no” include two groups of activities: activities with planning horizons of a day or less — truly urgent activities — and activities known longer in advance but constrained to occur on this day. Activities in the latter group include event-type activities such as sports events, where the participation decision was not made until the day of execution although the event may have been known more than a day in advance. Although such activities are actually plannable and not urgent, they are inadvertently labeled as urgent activities in this analysis. Section 3.4 below briefly examines the impact of this error.

3.2.2 Defining regular activities

Conceptually, regular activities are defined as activities that occur with regular frequencies. By virtue of their repetitiveness, regular activities do not require conscious scheduling decisions to be made before each execution. Such activities have the property that both their planning horizons and their lead times are very long. However, according to the results of the exploratory interviews (Chapter 4), (and also pointed out by Huff and Hanson [1990]), identifying regular activities is more difficult in practice than in theory. The current dataset contains no information on long-term activity patterns, and respondents were not asked whether they consider activities to be regular (assuming such a question could be formulated clearly). Consequently, this study uses information on both the frequency and the planning lead time of activities to differentiate between regular and non-regular activities in the dataset (see Table 5.3).

PLANNING LEAD TIME	FREQUENCY OF ACTIVITY			
	Daily	Weekly	Monthly	Less than once a month
Less than or equal to one week	Non-regular	Non-regular	Non-regular	Non-regular
More than one week	Regular	Regular	Unknown — Assumed non-regular	Unknown — Assumed non-regular

Table 5.3: Use of data on advance knowledge and activity frequency to identify regular and non-regular activities

Activities that are known less than a week in advance have short lead times and are thus non-regular, regardless of the activity frequency. However, activities that are known more than a week in advance are ambiguous — they may be either regular activities or non-regular activities planned very long in advance. We attempt to address this by considering the reported frequency with which each activity is usually undertaken. Very frequent activities (e.g. daily work, weekly lesson) known long in advance are likely to be regular fixtures on the schedule and are designated as regular activities. Less frequent activities are assumed to be non-regular, although they can include both regular (e.g. monthly public meetings) and non-regular activities (e.g. occasional medical appointments scheduled two weeks in advance). This causes a number of regular activities to be classified as non-regular. The operational impact of this assumption is examined in Section 3.3.

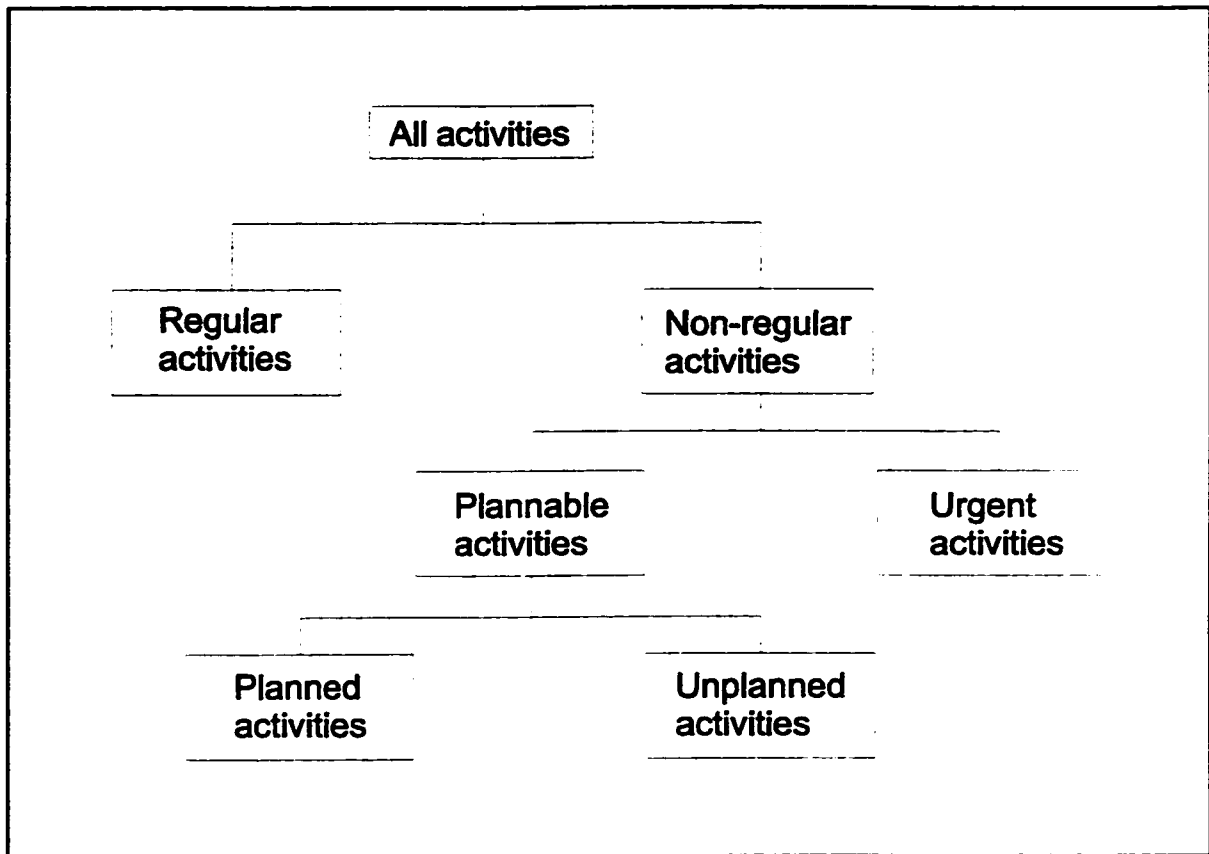


Figure 5.2 Categories of observed activities

3.2.3 Order of categorization

Using these definitions, the set of observed activities is categorized as shown diagrammatically in Figure 5.2. The method consists of three levels of differentiation. In the first step, all activities are divided into regular and non-regular activities, according to the length of the planning horizon and frequency information. Secondly, non-regular activities — those for which conscious scheduling decisions were made — are divided into urgent and plannable activities. Information on the lead time and planning horizon of each is used. Lastly, plannable activities are labeled as either planned or unplanned

according to the lead time chosen by the individual. The results of these categorizations are described below.

3.3 Regular activities

Using the method described above, 994 activities (or 56% of all activities excluding return home) were identified as regular activities. The distribution by activity type is shown in Table 5.4. Four groups of activities can be identified, according to the fraction of regular activities. Expectedly, work and school activities have the highest fraction of regular activities with 90% and 94% respectively. The second group, with between 50% and 64% regular activities, includes participatory sports, after school activities, church, and other activities. A third group, with between 20% and 31% of regular activities, includes most recreational, community, and grocery shopping activities. The last group, of which less than 10% of activities are regular, includes shopping for larger items and clothes.

Interestingly, while over half of reported activities are considered regular, these are dominated by only a few activity types. Non-regular activities, in contrast, span a large variety of activity types, including a majority of shopping, personal business, social, and

ACTIVITY TYPE	REGULAR ACTIVITIES	NON-REGULAR ACTIVITIES	TOTAL
	Number (%)	Number (%)	
School	227 (94%)	14 (6%)	241
Work	423 (90%)	47 (10%)	470
Participatory Sports	18 (64%)	10 (38%)	28
After School Activity	14 (61%)	9 (39%)	23
Church	7 (54%)	6 (46%)	13
Other	165 (50%)	164 (50%)	329
Voluntary Association	15 (31%)	34 (69%)	49
Medical/Dental/Legal	15 (28%)	38 (72%)	53
Public Meeting	5 (28%)	13 (72%)	18
Spectator Sports	2 (25%)	6 (75%)	8
Other Recreation	16 (23%)	54 (77%)	70
Restaurant	14 (20%)	55 (80%)	69
Theater, Movie	2 (20%)	8 (80%)	10
Grocery Shopping, Banking	68 (20%)	274 (80%)	342
Other Shopping	2 (8%)	23 (92%)	25
Clothes, Appliance Shopping	1 (4%)	25 (96%)	26
TOTAL	994 (56%)	780 (44%)	1774

Table 5.4: Regular and non-regular activities by activity type

recreational activities. Most of the work and school activities identified as non-regular have flexible activity timings and/or locations, and less than daily frequencies.

Conscious decisions are thus required for scheduling these activities. With the exception of 7 work activities with lead times shorter than a day, all the non-regular work activities are planned between one and seven days in advance.

By categorizing low-frequency, long-lead-time activities as non-regular, a number of

regular activities are incorrectly described as non-regular. Ninety seven (about 5% of all) activities had frequencies of once a month or less, and lead times of more than a week. These include 24 voluntary/community, 19 shopping, 10 medical, 9 restaurant, and 30 “other” activities. It is unknown how many of these activities are actually misclassified as non-regular.

3.4 Urgent activities

In this research urgent activities are identified as activities with lead times of shorter than or equal to one day, and which could not have been executed on another day. The distribution of urgent activities, obtained by applying this definition to the set of non-regular activities, is shown in Table 5.5.

Only 13% of non-regular, or 6% of all, activities were identified as urgent. Sports and recreation, school and after-school, and medical/dental/legal activities seem to have most urgent observations. However, some of these activities, notably spectator sports, school, after- school, and other recreation activities, were event-type activities with fixed start and end times (Table 5.5). These were not truly urgent but may have had longer planning horizons where the decision to participate was only taken on the day of the event.

A third of medical/dental/legal activities were urgent. Other urgent activities include

ACTIVITY TYPE	URGENT ACTIVITIES		PLANNABLE ACTIVITIES
	Total (%)	Events with fixed start/end times	Total (%)
Spectator Sports	3 (50%)	3	3 (50%)
School	5 (36%)	3	9 (64%)
Medical/Dental/Legal	12 (32%)	0	26 (68%)
After School Activity	2 (22%)	2	7 (78%)
Other	28 (17%)	0	136 (83%)
Other Recreation	8 (15%)	1	46 (85%)
Restaurant	7 (13%)	0	48 (87%)
Voluntary Association	4 (12%)	0	30 (88%)
Participatory Sports	1 (10%)	0	9 (90%)
Other Shopping	2 (9%)	1	21 (91%)
Work	4 (9%)	1	43 (91%)
Clothes, Appliance	2 (8%)	0	23 (92%)
Shopping	21 (8%)	0	253 (92%)
Grocery Shopping, Banking	0 (0%)	0	8 (100%)
Theater, Movie	0 (0%)	0	6 (100%)
Church	0 (0%)	0	13 (100%)
Public Meeting			
TOTAL	99 (13%)	11	684 (87%)

Table 5.5: Urgent and plannable non-regular activities by activity type

restaurant, voluntary association, shopping, and a few work activities. Less than 9% of all shopping activities were considered urgent.

Table 5.6 shows the relationship between urgency and the perceived importance of activities. While 64% of plannable activities were deemed “Very important” or “Important” to the well-being of the household, the corresponding number for urgent

activities is 77%. Evidently, many short-notice activities could not be postponed because their urgent execution was important to the individual. Urgent activities that were not considered important include some restaurant and shopping activities.

	URGENT ACTIVITIES	PLANNABLE ACTIVITIES
	Number (%)	Number (%)
Very Important and Important	68 (77%)	436 (64%)
Relatively Unimportant and Unimportant	20 (22%)	238 (35%)
Unknown	1 (1%)	10 (1%)
TOTAL	89 (100%)	684 (100%)

Table 5.6: Perceived importance of urgent and plannable activities

Note: Event-type urgent activities with fixed start times, such as sports events, are excluded from this table.

3.5 Plannable activities

The remaining 684 activities are plannable — individuals had some flexibility as to when each activity was planned and executed. It is expected that systematic factors existed that encouraged people to plan certain activities further in advance than others. The rest of the analysis presents an examination of these factors.

4. BIVARIATE ANALYSIS OF FACTORS AFFECTING PLANNING BEHAVIOR

4.1 Research hypotheses

In-depth exploratory interviews (Chapter 4) identified two major motivations for planning activities in advance: reduction of the risk of unsuccessful completion of activities, and reduction of the transportation costs of accessing activities. These motivations do not apply equally to all activities and to all people. For some activities, the potential benefit of advance planning is higher, and these are therefore more likely to be planned further in advance. Likewise, some people may in general benefit more from advance planning than others, and be more likely to engage in this type of behavior.

In this section an analysis is undertaken of the plannable activities in the dataset, to identify systematic activity and personal characteristics which are associated with the tendency to plan activities in advance. The characteristics are formulated as *a priori* hypotheses based on the insights of the earlier interviews, and designed to be testable with the present dataset. Hypotheses are divided into three categories: activity-related hypotheses, travel-related hypotheses, and hypotheses related to personal factors.

4.1.1 Activity-related hypotheses

Some activities require reservations or appointments prior to their execution. Successful participation in such activities therefore requires advance planning on the part of the

participating individual. Thus:

HYPOTHESIS A1:

Activities that require appointments or reservations are more likely to be planned in advance than activities that do not require appointments or reservations.

The second hypothesis recognizes that, in order to engage in activities with long durations, long uninterrupted blocks of time need to be available. It is hypothesized that such long blocks of time are more easily assigned longer in advance of activity execution:

HYPOTHESIS A2:

Activities with longer durations are more likely to be planned in advance than activities with shorter durations.

The more important an activity is to an individual, the worse are the consequences of unsuccessful completion of the activity, and the higher are the risks associated with non-completion. Thus:

HYPOTHESIS A3:

Activities that are considered more important to the well-being of the individual and their household, are more likely to be planned in advance

than activities that are less important.

Lastly, a relationship is hypothesized between planning behavior and the frequency with which an activity is repeated. The more frequently a particular activity is undertaken, the more familiar the individual is with potential destinations and timings to be chosen, and the lower is the risk of unsuccessful completion associated with this activity. Thus:

HYPOTHESIS A4:

Activities with higher frequencies are less likely to be planned in advance than activities with lower frequencies.

4.1.2 Travel-related hypotheses

Advance planning may reduce the travel cost of an activity by increasing the opportunity for identifying and accessing efficient travel modes, routes and timings. One of the mechanisms by which savings are realized is the combining of suitable activities into multiple-stop trip chains. This may be particularly the case in this low-density area, where larger travel distances may provide an added incentive for trip chaining. It is therefore hypothesized that more advance planning is associated with chained activities than with unchained activities. Also, the potential benefit to be derived from advance planning increases in absolute terms with the travel cost of the activity:

HYPOTHESIS T1:

Activities that involve greater travel times are more likely to be planned in advance than activities that involve less travel.

HYPOTHESIS T2:

Activities that are executed as part of a trip chain are more likely to be planned in advance than activities that are unchained.

Where activities are executed together with a companion, advance planning is expectedly needed to ensure coordination of schedules. Unfortunately no information is available on whether activities were executed together with companions. However, we do have data on the presence of companions during travel to and from activities, and we expect the same planning incentives to apply to travel. The hypothesis is subsequently formulated as a travel-related hypothesis:

HYPOTHESIS T3:

Trips (excluding transit trips and serve-passenger trips) that are made in the company of other people, are more likely to be planned than trips that are made alone.

Transit trips are excluded because fellow passengers do not necessarily qualify as companions. The presence of companions on serve-passenger trips is related to the

purpose of the serve-passenger activity, and is therefore not a transportation-related factor.

4.1.3 Hypotheses related to personal characteristics

It is hypothesized that people who are employed generally have busier schedules and are more likely to engage in advance planning of non-regular activities, in order to ensure successful completion of all activities:

HYPOTHESIS P1:

Activities made by people that are employed are more likely to be planned than activities made by people that are unemployed.

Some tendencies to undertake advance planning may be related to life-cycle variables such as age and the presence of children in the home. Specifically, older people and parents with children may be more risk averse, have less flexibility or desire to respond to unplanned needs, and therefore tend to plan more activities in advance than other people:

HYPOTHESIS P2:

Activities made by older people are more likely to be planned in advance than activities made by younger people.

HYPOTHESIS P3:

Activities made by adults with children in the home are more likely to be planned in advance than activities made by adults with no children.

Lastly, the relatively ubiquitous access offered by the automobile may encourage greater flexibility in planning behavior:

HYPOTHESIS P4:

Activities made by people with unrestricted access to an automobile are less likely to be planned in advance than activities made by people with restricted or no access to an automobile.

4.2 Data preparation

After removal of all regular and urgent activities from the Windham Region dataset, 684 non-regular, plannable observations remain. These observations include all activity types except "Return home". In order to focus on the planning behavior of adult decision makers, a further 140 observations reported by children (under 17 years) were excluded. The remaining dataset consists of 544 activities made by 265 individuals.

Planning behavior is indicated by identifying each activity as either planned or

unplanned, depending on advance knowledge of the activity. Unplanned activities are those scheduled on the same day as execution, and planned activities are scheduled a day or more before execution.

For the sake of simplicity the sixteen activity types identified in the survey are reduced to eight activity classes. Theater/movie, spectator sports, participatory sports, and other recreation activities are grouped together under “Recreational Activities”, while “Shopping” includes all grocery and small item shopping, clothes and appliance shopping, and other shopping activities. The “School” class includes school and after-school activities, while “Community Activities” includes church, voluntary association, and public meeting activities. The remaining classes correspond to the original activity types, namely “Work”, “Restaurant”, “Medical/Dental/Legal” and “Other” activities.

4.3 Activity-related hypotheses

4.3.1 Appointments and reservations

In the survey, three activity types were assumed to be candidates for appointments or reservations: participatory sports, restaurant, and medical/dental/legal activities. The question “Did you make a reservation or appointment? If so, for what time?” was asked for only these activity types. The answer to this question was “yes” in about a third of the cases (Table 5.7). From the table it is clear that a majority of appointment activities

(77%) were planned, while a majority of non-appointment activities (74%) were unplanned.

	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
Activities with appointments	17 (77%)	5 (23%)	22 (100%)
Activities without appointments	12 (26%)	34 (74%)	46 (100%)

Table 5.7: The need for appointments and reservations, for participatory sports, restaurant, and medical/dental/legal activities

Hypothesis A1 is tested using a χ^2 test, on the null hypothesis of equal proportions of planned observations for appointment and non-appointment activities. The χ^2 value of 29.89 is very significant (compared to a critical value of 3.84 at a 5% significance level), indicating that Hypothesis A1 can be accepted. There is thus strong evidence that activities for which reservations or appointments are required, are more likely to be planned than otherwise.

4.3.2 Activity duration

Figure 5.3 shows the cumulative duration distribution of planned and unplanned activities in the dataset. Activity durations are skewed to the left: approximately 60% of non-regular, plannable activities have durations of less than one hour. The distributions of

planned and unplanned activities seem similar for such short durations. However, for longer durations the curves diverge, indicating that activities with longer durations tended to be more planned than unplanned. Note that only 8% of unplanned activities were longer than 3 hours in duration, while 18% of planned activities were this long. This provides some support for Hypothesis A2.

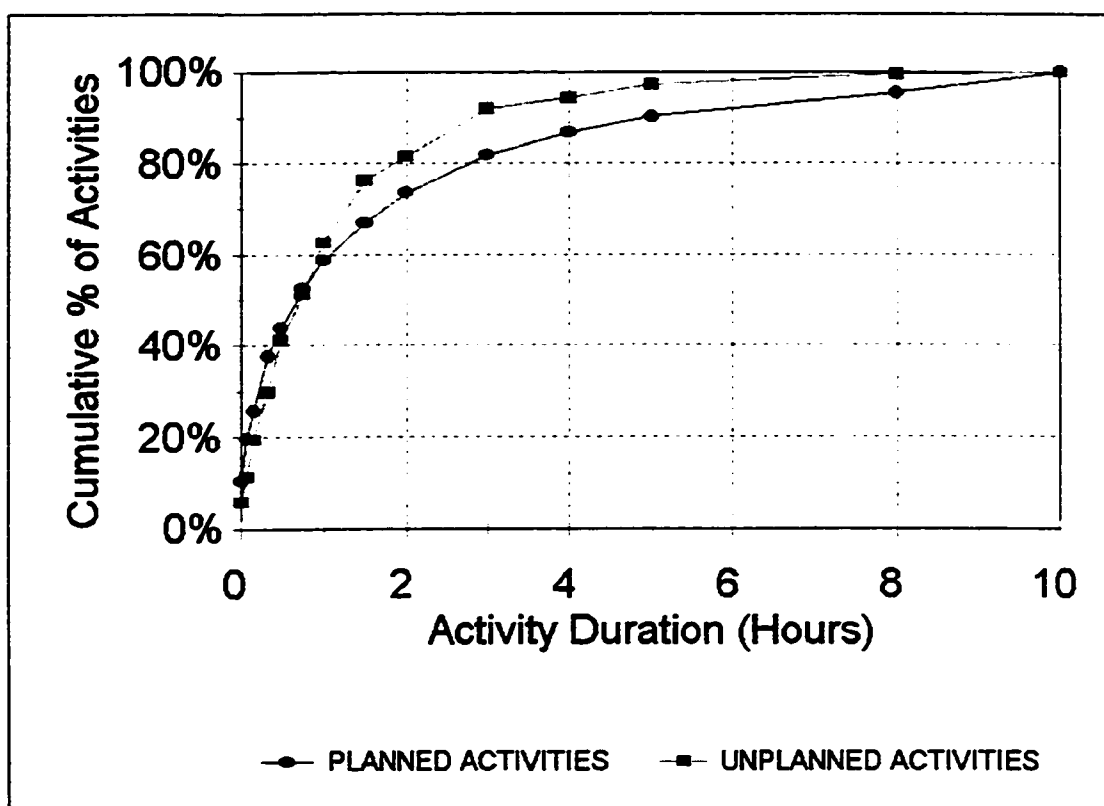


Figure 5.3: Cumulative distribution of activity durations

The duration distributions of planned and unplanned activities are shown in Table 5.8. A χ^2 test of this data, on the null hypothesis that the distributions are statistically similar, produces a χ^2 value of 25.14, which is statistically significant at $\alpha=5\%$. Planned activities seem to dominate unplanned activities not only in the long duration category,

ACTIVITY DURATION	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES
	Number (%)	Number (%)
0 - 10 minutes	84 (26%)	41 (19%)
11 - 60 minutes	108 (33%)	91 (43%)
1 - 3 hours	75 (23%)	62 (29%)
> 3 hours	59 (18%)	17 (8%)
TOTAL	326 (100%)	211 (100%)

Table 5.8: Distribution of planned and unplanned activities by activity duration

but also in the very short duration category. The percentage of planned activities with durations shorter than 10 minutes is 26%, as opposed to only 19% of unplanned activities. This surprising result suggests a more complex relationship between activity duration and planning behavior than that hypothesized.

Some of the complexity of this relationship is related to heterogeneity of the sample. Duration distributions are strongly related to the type of activity. This is evident from the variation in the median duration and duration variance for each of the eight activity classes shown in Table 5.9.

To test whether Hypothesis A2 applies to individual activity classes, the observations in each class were divided into two groups: those with duration shorter than the median duration for that class, and those with duration longer than the median. The fraction of

ACTIVITY TYPE	# OF OBS.	DURATION (hrs)		FRACTION PLANNED		U STATISTIC
		Median	Variance	< Median	≥ Median	
Work	43	5.33	10.41	1.00	0.86	1.77*
Recreation	50	1.71	2.81	0.40	0.64	-1.69*
Shopping	223	0.50	0.58	0.60	0.46	2.22**
School	11	0.75	6.54	1.00	0.86	0.92
Community	38	1.08	2.13	0.79	0.79	0.00
Restaurant	43	1.00	2.32	0.30	0.30	-0.03
Medical/Legal	18	0.92	0.31	1.00	0.80	1.41
Other	111	0.67	6.43	0.67	0.66	0.13

Table 5.9: Activity duration statistics by activity type

* = Significant at $\alpha=10\%$ (Two-tailed test)

**= Significant at $\alpha=5\%$ (Two-tailed test)

$$U = \frac{\sqrt{N}(f_1 - f_2)}{\sqrt{(f_1 + f_2)(1 - (f_1 + f_2)/2)}}$$

N = # of observations per group

f_1 = fraction for group 1

f_2 = fraction for group 2

$U_{\alpha=5\%} = 1.96$

$U_{\alpha=10\%} = 1.64$

planned activities was calculated for each group within each class (shown in Table 5.9).

The statistical significance of differences in these fractions was tested by calculating a normally distributed test statistic, U, as defined in the table. Two-tailed tests showed that only three activity classes exhibit strong relationships between duration and the tendency to plan ahead.

Recreational activities exhibit the hypothesized relationship between duration and advance planning. Work and shopping activities, however, show the opposite trend: longer duration activities are less likely to be planned than shorter duration activities. This result may be partly an artifact of the survey process, which recorded activities as

separate observations even if they formed part of a sequence of similar activities. For example, a work activity which is interrupted by another activity such as a lunch trip was recorded as two shorter duration work activities, even though it may be considered as a single work activity during the scheduling process. In this case, the data does not reflect the underlying nature of activity scheduling behavior.

This suspicion was tested for shopping activities by combining all uninterrupted sequences of shopping activities into single observations, and recalculating the fraction of planned observations for the two groups of observations. The fractions were reduced to 0.49 for shorter-than-median observations, and 0.41 for longer-than-median observations. The corresponding test statistic of 1.18 is no longer statistically significant, indicating that no significant relationship between duration and planning behavior is evident. This suggests that we do not have enough evidence to conclude that an inverse behavioral relationship exists between activity duration and the tendency to plan some activities ahead.

To summarize, the relationship between activity duration and advance planning is complex and likely varies by the type of activity. Hypothesis A2 appears to hold for a small fraction of activities with very long durations (on the order of 3 hours or more), which tended to be more likely to be planned than shorter activities. These activities tended to be mostly work and recreational activities.

4.3.3 Importance of activities

The survey collected subjective information on the importance of each activity to the respondent and his/her household. Table 5.10 tabulates the percentage of observations in each activity class that were deemed to be “Important” or “Very Important”. Percentages vary between 25% for restaurant activities to almost 100% for work and school activities, revealing a strong relationship with activity purpose, as can be expected. However, the variation within activity classes is also evident.

ACTIVITY TYPE	NUMBER OF OBSERVATIONS	% CONSIDERED “IMPORANT” OR “VERY IMPORTANT”
Work	43	93%
Recreation	52	40%
Shopping	223	67%
School	11	90%
Community	38	58%
Restaurant	44	25%
Medical/Legal	18	83%
Other	113	66%
TOTAL	542	63%

Table 5.10: Distribution of activity importance by activity type

A four-way table was constructed comparing the number of planned and unplanned activities that were considered “Important” and “Very Important”, with those considered “Relatively Unimportant” and “Unimportant” (Table 5.11). Seventy-five percent of important activities were planned ahead, while only 36% of unimportant activities were

planned. The corresponding χ^2 test statistic for the null hypothesis of equal distributions is 229.5, which is significant at the 1% significance level. There is a very strong statistical relationship between the subjective importance of an activity and the likelihood of planning that activity a day or more in advance.

IMPORTANCE OF ACTIVITY TO WELL- BEING OF THE HOUSEHOLD	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
Important/ Very Important	257 (75%)	87 (25%)	344 (100%)
Relatively Unimportant/ Unimportant	68 (36%)	123 (64%)	191 (100%)
Unknown	2	7	9

Table 5.11: Distribution of planned and unplanned activities by importance of activity

4.3.4 Activity frequency

Table 5.12 shows the distribution of observed activities according to the frequency with which the activity was undertaken. About half of all non-regular, plannable activities were undertaken with a frequency of once a week or more. Of activities in this group, 55% were planned in advance. The corresponding percentage for less frequent activities is 67%. The difference in distributions is statistically significant at the 1% significance level (the χ^2 value of 17.55 exceeds the critical value of 6.64, on the null hypothesis of equal distributions).

FREQUENCY OF ACTIVITY	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
Daily or weekly	149 (55%)	124 (45%)	273 (100%)
Monthly or less than once a month	177 (67%)	89 (33%)	266 (100%)
Unknown	1	4	5

Table 5.12: Distribution of planned and unplanned activities by activity frequency

It is concluded that activities with a lower frequency are significantly more likely to be planned in advance than activities with a higher frequency.

4.4 Travel-related hypotheses

4.4.1 Travel time

Hypothesis T1 states that the tendency to plan activities ahead is related to the time it takes to access the activity from the home location. The emphasis is on travel time because the survey collected information on travel times rather than travel distances.

For each activity, a direct home-based travel time was calculated. For unchained activities, this travel time is simply the round-trip journey time reported by the respondent. For chained activities which were accessed from other activities rather than

directly from the home, the home-based travel time was approximated by the average round-trip travel time for all other trips reported between the home location zone and the activity destination zone. This method averaged out time-of-day differences in travel times, but this is unlikely to be a significant effect since congestion was virtually absent in this region at the time of the survey.

ROUND-TRIP TRAVEL TIME FROM HOME	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
0 - 40 minutes	213 (56%)	168 (44%)	381 (100%)
41 - 80 minutes	73 (66%)	37 (34%)	110 (100%)
> 81 minutes	38 (86%)	6 (14%)	44 (100%)
TOTAL	324 (61%)	211 (39%)	535 (100%)

Table 5.13: Distribution of planned and unplanned activities by home-based travel time

Table 5.13 shows the distribution of home-based travel times for planned and unplanned activities, for three travel time categories. The increasing likelihood of planning an activity as the home-based travel time increases, is apparent from the table. Eighty-six percent of activities with travel times over 80 minutes were planned, while only 56% of activities with travel times under 40 minutes were planned. A χ^2 test of the hypothesis of equal travel time distributions between planned and unplanned activities, produces a χ^2 value of 22.72, which exceeds the critical value of 9.21 at a 1% significance level. The statistical evidence in support of Hypothesis T1 is strong.

This result reflects to some extent the distribution of activity locations over space. Potential activity locations are not distributed with uniform density for all activity types; observed travel times are expected to be correlated with the type of activity. Figure 5.4 illustrates this for four of the activity groups. Shopping and recreational activities, for instance, tended to occur closer to the home than work and medical/dental/legal activities. While about half of medical activities occurred within 40 minutes' round-trip travel time from the home, almost 80% of shopping activities were within 40 minutes from the home. The extent to which travel time effects on planning behavior is correlated to the type of activity is explored later in a multivariate context.

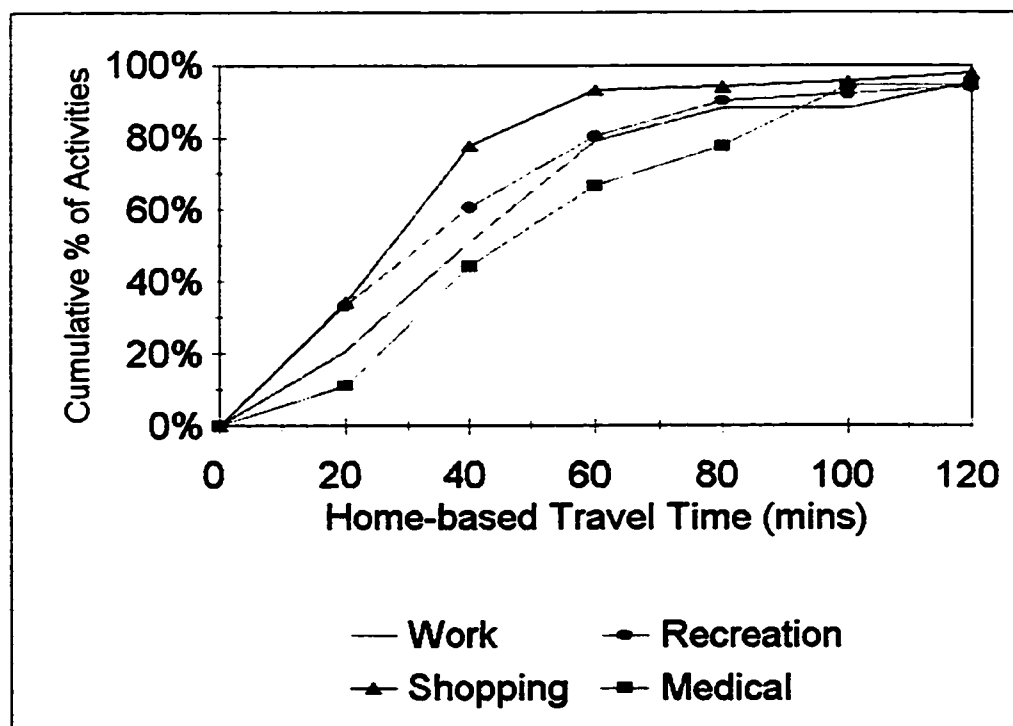


Figure 5.4: Cumulative distribution of home-based travel time for 4 activity types

4.4.2 Trip chaining

Table 5.14 shows that there is a positive relationship between advance planning and trip chaining. The percentage of planned activities is 57% for unchained activities, and 64% for chained activities. The χ^2 value, for the null hypothesis that there is no relationship between planning and chaining, is 4.69, which exceeds the critical value of 3.84 at the 5% significance level. This indicates that advance planning is indeed associated with a higher tendency to combine activities together into chains.

	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
Chained activities	182 (64%)	104 (36%)	286 (100%)
Unchained activities	142 (57%)	107 (43%)	249 (100%)

Table 5.14: Distribution of planned and unplanned activities by trip chaining

Table 5.15 further illustrates this finding by displaying the percentage of planned activities, disaggregated by home-based travel time. For both chained and unchained activities, the fraction of planned activities increases with increasing travel time, reconfirming Hypothesis T1. In addition, the tendency of chained activities to be more planned is evident for activities at closer locations.

The question now arises whether the quality of trip chains improves with the length of the planning horizon. One could speculate that, the longer the planning horizon that is

ROUND-TRIP TRAVEL TIME FROM HOME	UNCHAINED ACTIVITIES			CHAINED ACTIVITIES			
	Total	# planned	% planned	Total	# planned	% planned	Average savings (mins)
0 - 40 minutes	183	93	51%	206	123	60%	14.69
41 - 80 minutes	48	31	65%	62	42	68%	42.69
> 81 minutes	21	18	86%	23	20	87%	80.74
TOTAL							26.07

Table 5.15: Distribution of chained and unchained activities by home-based travel time

considered, the more potential trips are available onto which to chain, and the more likely it is that a very efficient trip chain will be formed. A measure of the quality of trip chains was obtained by estimating the savings in travel time that is obtained from chaining the activity to another, as compared to the hypothetical travel time if the activity was accessed by means of a separate home-based trip. The estimation makes the strong assumption that chained activities would be visited at the same locations, regardless of whether chaining occurs or not. This assumption is likely to overestimate the travel time savings provided by chaining, since some activities that are conveniently located on a trip chain, will be accessed at different locations closer to the home if no chaining occurred.

The savings through trip chaining averages 26.07 minutes for all chained trips. As shown in Table 5.15, the savings increases with overall travel time. Table 5.16 compares the savings between planned and unplanned chained activities, for each travel time category.

Although higher savings are evident for planned trip chains in the intermediate travel time category, there is not enough evidence to suggest that planned trip chains are consistently more efficient than unplanned trip chains.

ROUND-TRIP TRAVEL TIME FROM HOME	PLANNED CHAINED ACTIVITIES		UNPLANNED CHAINED ACTIVITIES		t statistic (H_0 = equal mean savings for planned & unplanned groups)
	Number	Average savings (mins)	Number	Average savings (mins)	
0 - 40 minutes	120	14.72	81	14.65	0.044
41 - 80 minutes	42	45.00	20	37.85	1.764**
> 81 minutes	20	78.35	3	96.67	—***

Table 5.16: Average savings due to chaining, for planned and unplanned chained activities

** = Significant at $\alpha=5\%$ (Two-tailed test)

*** = Sample size too small for t-test

In summary, advance planning seems to be associated with trip chaining, suggesting that planning is indeed used as a mechanism for reducing overall travel by combining activities into trip chains. However, the quality of resulting chains do not seem to be affected by the amount of advance planning undertaken³.

³ Another interesting question is how the primary and secondary activities in a trip chain differ in terms of activity types, lead times, and travel time savings. A preliminary analysis of these issues failed to produce any systematic and significant results.

4.4.3 Travel companions

For each recorded trip, the survey gathered information on the number of people from the same or from other households on the trip. Although different planning behaviors may be associated with whether or not companions are from the respondent's household, sample sizes are not adequate to permit analysis of this effect. Instead, all trips where the respondent was accompanied by any other person(s), excluding other passengers in public transit vehicles, are considered trips with companions.

ACTIVITY TYPE	NUMBER	PERCENT PLANNED		χ^2 value
		With companion(s)	Without companion(s)	
Work	43	100%	92%	— *
Recreation	52	53%	50%	0.09
Shopping	223	49%	57%	2.16
School	11	87%	100%	0.43
Community	38	95%	56%	56.67**
Restaurant	44	29%	29%	0.00
Medical/Legal	18	83%	83%	0.00
Other	113	70%	60%	2.34
TOTAL	542	59%	61%	0.51

Table 5.17: Percentage of planned activities with and without companions, by activity type

* = Sample size too small

** = Significant at $\alpha=5\%$

Table 5.17 shows that, for all activities, there does not seem to be a significant tendency to plan accompanied trips more in advance than unaccompanied trips. The χ^2 value, for

the null hypothesis that no significant relationship exists between planning and the presence of companions, is 0.51, which is smaller than the critical value of 3.84 ($\alpha=5\%$).

In order to examine the effect of activity type on this relationship, Table 5.17 disaggregates the data by activity category. Only one category displays a statistically significant relationship between planning and companions, namely Community Activities. Trips to Community Activities are significantly more likely to be planned when other travelers are present, with the χ^2 value for this activity group being 56.67. Although the numbers for shopping activities are not significant at the 5% significance level, there is a slight indication that the presence of companions may be associated with a decreased propensity to plan. This points to the possibility that in some activities of a social nature, the unanticipated presence of potential companions actually encourages spontaneous behavior.

In summary, Hypothesis T3 does not seem to hold in general, although there is evidence that the need to coordinate some types of trips with travel companions — notably trips to community activities — encourages advance planning.

4.5 Hypotheses related to personal characteristics

As with activity and travel-related factors, the effects of personal characteristics on

planning behavior are analyzed on the basis of activities rather than of individuals.

Naturally, individuals with higher activity participation are overrepresented in the dataset.

If significant correlation exists between the level of activity participation and planning behavior, then the true statistical relationship between individual-specific variables and planning behavior may be obscured.

NUMBER OF ACTIVITIES PER PERSON	NUMBER OF PERSONS	NUMBER OF ACTIVITIES		
		Planned (%)	Unplanned (%)	Total (%)
1	243	140 (58%)	103 (42%)	243 (100%)
2	53	65 (61%)	41 (39%)	106 (100%)
3	25	43 (57%)	32 (43%)	75 (100%)
4	14	38 (68%)	18 (32%)	56 (100%)
5	5	14 (56%)	11 (44%)	25 (100%)
6	4	21 (87%)	3 (13%)	24 (100%)
7	1	4 (57%)	3 (43%)	7 (100%)
TOTAL	345	325	211	536

Table 5.18: Distribution of number of activities per person in the dataset

The correspondence between individuals' activity participation and the tendency to plan activities ahead is shown in Table 5.18. The percentage of planned activities is disaggregated by the number of activities from the same person in the dataset. Although some more active people seem to plan more of their activities ahead, no clear correspondence exists between the number of activities per person and the tendency to plan ahead. An insignificant χ^2 value of 10.898, on the null hypothesis of no relationship

between activity participation and fraction of planned activities, supports this conclusion (critical $\chi^2=11.07$ at $\alpha=5\%$). We conclude that, for our purposes, statistically accurate conclusions can be drawn from an activity-based analysis of personal characteristics.

4.5.1 Employment status

Table 5.19 displays the number of planned and unplanned activities, disaggregated by the employment status of the individual. The table shows that 58% of activities made by unemployed people were planned, while the corresponding percentage for employed persons is 63%. There is no strong evidence that being employed is associated with a higher tendency to plan activities in advance, as indicated by a χ^2 value of 3.575 which is only significant at the 10% confidence level (critical value = 2.706).

EMPLOYMENT STATUS OF ACTIVITY MAKER	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
Unemployed	153 (58%)	112 (42%)	265 (100%)
Employed	171 (63%)	99 (37%)	270 (100%)

Table 5.19: Distribution of planned and unplanned activities by employment status of activity maker

Hypothesis P1 is not accepted for this sample, indicating that no significant relationship exists between people's employment status and their tendency to plan activities in advance. This result corroborates that of Table 5.18, which showed that people that

execute more plannable, non-regular activities are not significantly more likely to plan those activities in advance, compared to less active people.

4.5.2 Age

Table 5.20 shows the distribution of planned and unplanned observations, by the age of the activity maker. In general the hypothesized relationship between age and planning behavior seems to hold: activities made by people in the lowest age group (17 to 30 years) were least likely to be planned, with the proportion of planned activities increasing with the age of the activity maker. The χ^2 value of 51.918 (significant at $\alpha=1\%$) supports this conclusion. The relationship is not monotonic however; people in the highest age group (over 60 years) again plan fewer of their activities in advance than people in preceding age groups. This suggests that planning behavior is affected not only by age but also by whether retirement age (around 60) has been reached. The absence of tight work schedules and family obligations may encourage retired people to plan fewer of

AGE (years)	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
17 - 30	91 (46%)	105 (54%)	196 (100%)
31 - 50	143 (68%)	68 (32%)	211 (100%)
51 - 60	43 (78%)	12 (22%)	55 (100%)
More than 60	47 (64%)	26 (36%)	73 (100%)

Table 5.20: Distribution of planned and unplanned activities by age of activity maker

their plannable activities in advance. Age effects are therefore likely correlated with other life-cycle variables such as employment status and household composition.

4.5.3 Children in the home

Households were classified according to the presence or absence of children of age 16 and under, in the home. As shown in Table 5.21, the percentage of planned activities is significantly higher for adults with children than for adults without children. The significant χ^2 value of 23.535 exceeds the critical value of 6.635 at the 1% significance level. The presence of children in the home therefore seems to provide an incentive for people to plan more of their activities in advance. Hypothesis P3 is accepted.

PRESENCE OF CHILDREN IN THE HOME	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
No children	156 (54%)	131 (46%)	287 (100%)
Children are present	168 (68%)	80 (32%)	248 (100%)

Table 5.21: Distribution of planned and unplanned activities by presence of children

4.5.4 Automobile access

The number of automobiles per licensed driver in each household indicates the average level of access that household members had to an automobile. Table 5.22 shows the number of planned and unplanned activities for four categories of automobile ownership.

NUMBER OF VEHICLES PER DRIVER IN HOUSEHOLD	PLANNED ACTIVITIES	UNPLANNED ACTIVITIES	TOTAL
	Number (%)	Number (%)	Number (%)
No vehicles	12 (43%)	16 (57%)	28 (100%)
0.1 to 0.9	75 (57%)	57 (43%)	132 (100%)
1.0	177 (61%)	111 (39%)	288 (100%)
> 1.0	60 (69%)	27 (31%)	87 (100%)

Table 5.22: Distribution of planned and unplanned activities by automobile availability

The percentage of activities that were planned increases monotonically with the number of autos per driver in the household, from 43% for people with no automobiles to 69% for people with abundant access to automobiles. The χ^2 value of 13.825, exceeding the critical value of 7.815 at $\alpha=5\%$, indicates significant differences in the vehicle access distributions for planned and unplanned activities.

This result contradicts Hypothesis P4, which stated that automobile ownership is associated with an increase in flexibility and a decrease in advance planning. This surprising conclusion suggests that other factors confound the relationship between automobile ownership and planning behavior. High automobile access may be associated with busier schedules or being employed, but since these factors were earlier found not to be associated with an increased tendency to plan ahead, the reason for the observed tendency of people with unrestricted auto access to engage in more advance planning remains unclear.

4.6 Summary of results

The analysis of the relationships between individual activity and personal characteristics, and the planning behavior observed in the sample, indicates that there are systematic patterns to people's planning behavior. Activity characteristics which were found to encourage advance planning include the need to have reservations or appointments, very long activity durations, perceived importance of an activity to a household's well-being, and low frequencies of participation in that activity. High travel costs to access activities also encourage advance planning, as does the perceived opportunity to combine activities into multiple-stop trip chains.

Factors related to personal characteristics were also found to be associated with specific planning behaviors. Older people of pre-retirement age, people with children in the household, and people with high access to private automobiles were found to be more likely to plan activities in advance. These results suggest that people adjust their planning behavior to suit their personal circumstances in systematic ways.

Many of the activity and travel related factors appear to be correlated with the types of activities that were observed. Interactions between activity types, activity characteristics, and planning behavior are investigated in the next section.

5. MULTIVARIATE ANALYSIS OF FACTORS AFFECTING PLANNING BEHAVIOR

5.1 Modeling approach

5.1.1 Discriminant analysis

Discriminant analysis was used to assess the contributions of activity characteristics, personal characteristics, and activity type variables to the observed planning behavior, taking into account correlation among the variables. Conceptually, the technique provides a measure of association between the variables and observed behavior, without couching it in the language of choice, as does discrete choice techniques. It thus provides a sense of the relative importance of each characteristic in determining planning behavior.

Discriminant analysis is a multivariate technique for classifying objects into mutually exclusive groups on the basis of a set of observations. Discriminant analysis is useful for both analysis and classification purposes. In analysis (as it is used here), the technique is used to gain insight into the dimensions along which the groups differ. In classification (as it is used in Chapter 6), a decision rule is used to classify objects from unknown origin into one of the groups with minimum error. Full treatments of the theoretical background, assumptions, and mathematical derivations can be found in numerous statistical texts [e.g. Stopher & Meyburg, 1979; Lachenbruch, 1975; Dillon and Goldstein, 1984]. A summary of the main points is provided in Appendix B of this dissertation.

5.1.2 Definition of variables

The dataset of observed activities was assumed to consist of two subpopulations: planned activities and unplanned activities. This somewhat arbitrary partitioning of the data imposed a synthetic dichotomy on behavior, as individuals were conceptually able to use a continuum of activity lead times. However, the use of a one-day lead time to categorize behavior fits exactly with the question of previous-day advance reservation which motivated this research. Moreover, encouraging results from the bivariate analysis suggest that important insights into behavior can be obtained by categorizing activities as planned or unplanned.

As with the bivariate tests, only non-regular, plannable activities were included in the analysis. A total of 535 observations with complete data vectors were used, consisting of 211 unplanned and 324 planned activities.

Independent variables represent the factors which were expected to influence whether or not an activity is planned in advance. Following from the hypotheses evaluated earlier, they were divided into four groups: Variables describing activity type, activity-related factors, travel-related factors, and personal characteristics. The variables are summarized in Table 5.23.

5.1.3 Activity type variables

Observations were categorized into eight major activity types: Work, Recreation,

VARIABLE NAME	DESCRIPTION
<u>Activity type variables</u> TYPE-WORK TYPE-RECREATE TYPE-SHOP TYPE-SCHOOL TYPE-COMMUNITY TYPE-DINE TYPE-MEDICAL	Dummy variable describing the type of activity.
<u>Activity-related variables</u> IMPORTANCE DURATION FREQUENCY	Indicates if activity was considered important by respondent Logarithm of activity duration Indicates frequency of participating in this activity
<u>Travel-related variables</u> COMPANION TRAVELTIME-HOME CHAINED	Indicates whether companion was present on this trip Logarithm of direct round-trip travel time between home and this activity Indicates if activity was part of a trip chain
<u>Personal characteristics</u> EMPLOYED AGE CHILDREN VEH/DRIVER	Indicates if person was employed Age of respondent Indicates if respondent had children (<16) in the home Number of vehicles per licensed driver in the household

Table 5.23:Independent variables examined in discriminant model

Shopping, School, Community Activities, Restaurant, Medical/Dental/Legal, and Other activities. Seven dummy variables corresponding to the first seven activity types were created. Since all observations belong to one of the eight activity types, the number of variables is one fewer than the number of activity types.

5.1.4 Activity-related variables

Three variables describing the activity were included. These are:

- IMPORTANCE:** A dummy variable with the value 1 if the activity was identified as “Important” or “Very Important” by the respondent, and 0 otherwise.
- DURATION:** The logarithm of the activity duration (in minutes). The logarithmic variable has an approximately normal distribution, as required by the discriminant model.
- FREQUENCY:** A dummy variable with the value 1 if this activity was executed with a frequency of less than once a week, and 0 otherwise.

5.1.5 Travel-related variables

These variables relate to the trip by which the observed activity was accessed. They include:

- COMPANION:** A dummy variable with the value 1 if one or more companions accompanied the respondent on this trip. Trips by public vehicle (such as school bus) are considered not accompanied.
- TRAVELTIME-HOME:** The logarithmic transformation of the travel time to access this activity directly from home. The logarithm normalizes the travel time distribution, which is skewed to the left.
- CHAINED:** A dummy variable capturing the effect of trip chaining on planning behavior. It took the value 1 if this trip was part of a trip chain.

5.1.6 Personal characteristics

The personal characteristics which were thought to influence individuals’ planning behavior are:

- EMPLOYED:** A dummy variable with the value 1 if this person was employed, 0 otherwise.
- AGE:** The age of the respondent in years.
- CHILDREN:** A dummy variable with the value 1 if one or more children under the age of 17 were present in the respondent’s household.

VEH/DRIVER: Automobile availability, expressed as the number of vehicles per licensed driver in the household.

5.2 Results

5.2.1 Adherence to assumptions

The linear discriminant model rests on two important assumptions: that the distribution of the variables are multivariate normal, and that the variance-covariance matrices of the variables are the same for both populations. Normality of all the factors was assured by evaluating the distributions of all continuous factors and performing appropriate transformations where necessary.

The second assumption of the model is violated by the data. Except for a few outlier cells, factor variance-covariance values are on average 1.5 times larger for planned activities than for unplanned activities, indicating that the factor values are more dispersed in the population of planned activities. Previous work has shown that, in inference, heteroscedasticity can cause the results of significance tests on the discriminant results to be overly optimistic, especially for small and unequal sample sizes of the two groups [Dillon and Goldstein, 1984]. The present sample sizes are large enough to make this violation less of a concern, as long as the statistical tests have very significant results.

5.2.2 Estimated model

Model estimation proceeded in two steps. First, all the above variables were included in the estimation of a discriminant function. Partial F-statistics were calculated for each coefficient and used to identify the variables which make a significant contribution to the discriminant function. A second and final model containing only the significant variables was then estimated. All activity type variables were retained in the final model because activity type is thought to capture underlying differences between activities not captured by the other variables. Statistical tests were performed on this final model only.

Table 5.24 shows the estimated coefficients of the first model. Positive coefficient values indicate a positive association between a variable and the tendency to plan activities more than a day in advance. The coefficient estimates for the activity type variables can be interpreted as an indication of the tendency to plan activities of each type in advance, relative to "Other" activities. All else being equal, recreational, shopping, restaurant, and medical activities were least likely to be planned. Evidently, people preferred to execute these activities on short notice even if they had the option of postponing them. Work, school, and community activities were more likely to be planned. All other variables have the expected signs except DURATION, VEH/DRIVER, and CHILDREN, indicating that shorter durations, higher automobile ownership, and the presence of children in the home, are associated with a higher tendency to plan activities in advance. However none of these except the CHILDREN variable are statistically significant.

VARIABLE	FULL MODEL		FINAL MODEL	
	Estimated Coefficient	Partial F (p value)	Estimated Coefficient	Partial F (p value)
TYPE-WORK	1.073**	8.89 (0.00)	1.064**	10.24 (0.00)
TYPE-RECREATE	-0.005	0.00 (0.99)	-0.061	0.04 (0.84)
TYPE-SHOP	-0.397*	3.55 (0.06)	-0.407*	3.79 (0.05)
TYPE-SCHOOL	0.782	1.85 (0.17)	0.913	2.63 (0.11)
TYPE-COMMUNITY	0.607*	3.16 (0.08)	0.571*	2.83 (0.09)
TYPE-DINE	-0.786**	5.65 (0.02)	-0.814**	6.18 (0.01)
TYPE-MEDICAL	-0.054	0.01 (0.91)	-0.092	0.04 (0.84)
IMPORTANCE	1.424**	42.33 (0.00)	1.448**	67.09 (0.00)
DURATION	-0.036	0.45 (0.50)	--	--
FREQUENCY	0.856**	25.52 (0.00)	0.868**	27.60 (0.00)
COMPANION	0.046	0.08 (0.78)	--	--
TRAVELTIME-HOME	0.244**	4.82 (0.03)	0.224**	4.43 (0.04)
CHAINED	0.024	0.13 (0.72)	--	--
EMPLOYED	0.201	1.50 (0.22)	--	--
AGE	0.019**	11.41 (0.00)	0.019**	12.46 (0.00)
CHILDREN	0.474**	8.21 (0.00)	0.499**	9.24 (0.00)
VEH/DRIVER	0.241	1.68 (0.19)	--	--

Table 5.24: Estimation results of full and final models

* = Significant at $\alpha=10\%$

**= Significant at $\alpha=5\%$

The two activity-related variables in the final model, IMPORTANCE and FREQUENCY, are very significant, suggesting that these were the two most important factors affecting planning behavior. Only one travel-related factor had a significant independent affect on planning behavior, namely the direct travel time to activities (which is a substitute for distance from the home). Activities further away from the home were significantly more likely to be planned, regardless of other activity attributes. The independent effects of

companions and trip chaining are not significant.

The significant partial F-values for the AGE and CHILDREN variables suggest that, all else being equal, these two personal characteristics affected the tendency to plan activities in advance. Older people and people with children were both more likely to plan their activities. The fact that the VEH/DRIVER variable is not significant indicates that, after taking account of its correlation with other factors, automobile ownership did not independently affect planning behavior.

5.2.3 Statistical tests

The means of the calculated discriminant scores for the unplanned and planned populations are 2.285 and 3.425 respectively, with a Mahalanobis' Distance of 1.140. When using the discriminant scores to classify observations, the boundary between the populations is 2.735 (equation 2 in Appendix B). Reclassification of the original data using this boundary value produces the results shown in Table 5.25. Sixty-six percent of unplanned and 78% of planned activities are reclassified correctly by this function, producing an overall success rate of 74%. Using random classification, the success rates for unplanned and planned activities are 39.3% and 60.5%, respectively, and the overall success rate 52.1%. The model thus performs significantly better than a random classification, especially with regard to the identification of unplanned activities.

Using equation 3 (Appendix B), the calculated F-value for the discriminant function is

		PREDICTED BEHAVIOR		% PREDICTED CORRECTLY
		Unplanned	Planned	
ACTUAL BEHAVIOR	Unplanned	141	70	66.8%
	Planned	69	255	78.7%
TOTAL:				74.0%

Table 5.25: Reclassification results of final discriminant model

11.89, which exceeds the critical value $F_{(0.01,(12,522))}=2.22$. Thus, the model successfully discriminates between the two populations. The explanatory power of the individual groups of variables is assessed using the Q statistic of equation 4 (Appendix B); the results are given in Table 5.26. Activity-related variables make the strongest contribution to the discrimination, with a significance level of 0.1%. This is followed by activity type variables and personal characteristic variables with significance levels of

VARIABLE GROUP	Q VALUE [#]	CRITICAL F (p value)
Activity-related variable	26.18***	7.01 (0.001)
Activity type variables	3.35**	2.94 (0.005)
Personal characteristic variable	4.85*	4.65 (0.010)
Travel-related variables	2.55	2.72 (0.100)

Table 5.26: Tests for contribution of groups of variables to final model

- [#] Q value from equation 5.4, of final discriminant model relative to a restricted model excluding the indicated variable set.
- * Significant at $\alpha=1\%$
- ** Significant at $\alpha=0.5\%$
- *** Significant at $\alpha=0.1\%$

0.5% and 1% respectively. The travel-related variable (including only the travel time from home) is the weakest of the four groups and only marginally significant according to this statistic.

5.3 Discussion

The results from the discriminant analysis suggest that planned and unplanned activities differ significantly along a number of dimensions. Behaviorally this implies that, when faced with the need to schedule a future activity, an individual's decision regarding when to schedule it is significantly affected by the activity's characteristics. Furthermore, the personal context of the individual, reflected by a number of demographic variables, also helps determine how an individual responds to the scheduling task.

Two most important activity characteristics are the perceived importance of the activity to the well-being of the household, and the frequency with which the activity is undertaken. Higher importance and lower frequencies are both associated with an increased tendency to plan activities in advance. Other unmeasured activity characteristics related to the type of activity are captured by a simple set of activity categories, which explains another significant portion of planning behavior. Shopping and restaurant activities display a strong tendency towards short-notice execution, while non-regular work and community activities show the opposite trend. Recreation, school, medical/legal, and "other"

activities do not have very significant correlations with planning behavior. These results have the interesting implication that, although people's planning behavior is to some extent explained by the types of activities they plan, the meaning of these activities in the context of the household's priorities are more important determinants of how the activities are treated during the planning process.

Travel-related factors also affect activity scheduling: longer travel distances encourage advance planning, independent of other activity characteristics. Other factors that in the bivariate analysis were found to explain planning behavior, such as the presence of travel companions and trip chaining, are in fact sufficiently correlated with other activity attributes so as to have no independent effect on planning behavior.

6. CONCLUSIONS

This analysis of the activity behavior of a sample of people reveals systematic patterns of planning for activities and travel. Activities vary as to the amount of conscious planning undertaken before their execution. Approximately half of all activities appear to be regular activities, implying that they are known long in advance and occur with predictable frequency. While school and work activities dominate this group, a range of other activity types is also executed on a regular basis. An interesting implication is that regular activity patterns can not adequately be captured by simplistic designations of

work and school activities as “mandatory activities”, as is often done in activity scheduling studies. Regular patterns seem to include a much richer variety of activity types than these, including sports and recreation, social visits, community activities, and some grocery shopping. Although each of these other activities are typically repeated with low frequencies (weekly or monthly), together they comprise a full third of regular activity making.

Another group of activities for which planning behavior is constrained is defined as “urgent” activities — activities that have to be scheduled and executed on the same day. In the observed dataset, less than 6% of all activities were urgent. These were overwhelmingly considered by survey respondents as important to the well-being of the household, and mostly include activity types such as small-item shopping, medical/dental/legal, and “other” (presumably serve-passenger) activities.

The remaining activities — about 38% of observed activities — are more flexible because scheduling decisions can be made either on the same day or longer in advance of execution of the activity. Several factors were found to encourage people to schedule activities a day or more in advance, instead of delaying planning in favor of short-notice execution. Activities that require advance reservations, are considered more important, have very long durations, are executed with lower frequency, are undertaken further away from the home, and are chained together, were found to be more likely to be planned in advance. Some of these factors tend to be correlated with activity type, so that some of

the variation in planning behavior can be explained in reference activity type variables. Shopping and restaurant activities display a strong tendency towards short-notice execution, while non-regular work and community activities have a high tendency to be planned in advance.

Finally, people's planning behavior was also found to be associated with some personal indicators. All else being equal, older people (especially before retirement age) and people with children in the home are more likely to plan their activities in advance.

The results of this analysis start to present a picture of which activities and which people are more likely to be affected by externally imposed restrictions on planning behavior. An example of such a restriction is the one-day advance reservation requirement for use of some public transit modes such as paratransit service. Urgent activities, while a small fraction of all activities, are affected most severely. Because these are perceived to be important activities, their disruption is likely to have negative consequences for the household. Depending on how limited the choice sets of potential locations, potential timings, and potential modes for these activities are, significant additional costs may be incurred in order to access them by other modes.

Activities that were not planned ahead, but that could have been planned because they had longer planning horizons, would be affected less severely by restrictive reservation policies. In this dataset, this group included mostly shopping, eating out or recreational

activities, all of which respondents considered less important to the well-being of the household. These activities also tended to be relatively close to the home, and since they were undertaken with greater frequencies, individuals responding to planning restrictions are more likely to be familiar with potential locations and timings for rescheduling these activities.

A more exhaustive investigation of the potential effects of enforced planning restrictions on potential paratransit users is presented in the next chapter.

CHAPTER 6

APPLICATION: THE USER IMPACTS OF PARATRANSIT RESERVATION POLICIES

1. INTRODUCTION

Many paratransit systems serving disabled people in the United States require users to request service at least a day before travel. Such reservation policies restrict use of the system to trips which are planned a day or more in advance. The impacts of these policies on potential users vary from adjustments in planning behavior in order to plan some activities earlier, to adjustments in activity behavior in terms of finding alternative modes or locations. In extreme cases, short-notice activities that can not be planned in advance may be foregone due to a lack of transportation options. The severity of these impacts can be expected to vary across a user population together with their activity types, planning behavior, and travel alternatives. This analysis attempts to assess the magnitude of these impacts, in terms of the number and types of activities affected across subgroups of potential users.

The analysis focuses on the population of disabled people in the San Francisco Bay Area and is based on their activity and travel behavior observed at a time when almost no

advance reservation paratransit service was offered. This data is examined in the light of earlier analyses regarding systematic activity planning behavior (Chapter 5), to estimate the planning behavior that gave rise to these observed activities. These results, together with observed travel, in turn allow us to identify activities that would be most affected by externally imposed planning restrictions.

The chapter is organized as follows: firstly, a description is given of the analysis approach and the method used. This is followed by a description of the data, and issues around transferring modeling results from another population to the Bay Area. Finally, the analysis results are presented and discussed, and policy conclusions are drawn.

2. ANALYSIS APPROACH

Earlier analysis showed that advance planning for activities occurs in response to a multitude of factors, some of which are related to the transportation systems used to access activities, and some of which are related to activity-specific or personal factors.

The impacts of restrictions imposed by a transportation reservation policy should thus be measured against the impacts of all other factors governing planning behavior, irrespective of the policy. The approach followed is to identify potential paratransit users, and to investigate their planning behavior in the absence of substantially restrictive paratransit reservation policies. We consider this to be “baseline” behavior. The

question we ask is, how easily could “baseline” activities be accommodated on a hypothetical paratransit system, given a particular reservation policy and current planning behavior?

If potential users plan all of their activities and travel in advance for reasons unrelated to the reservation policy, then a previous-day reservation policy would not impose additional constraints on the users. If, on the other hand, potential users are not motivated by other factors to do advance planning, then use of such a system will require significant behavioral adjustments, with possible equity and effectiveness implications.

Ideally, “baseline” planning behavior should be observed directly. However, data on planning lead times are not typically available in activity datasets, and an indirect approach needs to be followed. The approach makes use of the discriminant model estimated in the previous chapter, which expressed the planning behavior associated with a particular activity as a function of characteristics of the activity, of the trip by which it is accessed, and of the activity maker. We name the discriminant function $Z(A, z^*)$, with A the vector of estimated coefficients and z^* the (scalar) critical discriminant value used to classify observations as either planned or unplanned. Planned activities are those scheduled a day or more before execution, and unplanned activities are those scheduled and executed on the same day. Assume that the calibrated model is applied to a set of observed activities X , of which the planning behavior is unknown. Observations can be partitioned into subgroups of interest, such as by the type of activity or the type of

individual undertaking the activity. Observation X_i^j is the i th observation and belongs to group j . The number of observations of type J is N^j .

Application of the model consists of finding the discriminant value, z_i^j , for each observation ($z_i^j = A \cdot X_i^j$). This value is a single-value summary of the characteristics of observation X_i^j that are statistically associated with whether it was planned or unplanned. We define the predicted planning behavior for each observation as follows:

$$p_i^j = \begin{cases} 0 & \text{if } z_i^j < z^*; \\ 1 & \text{if } z_i^j \geq z^*. \end{cases}$$

Given its characteristics, activity i is more likely to be unplanned than planned if $p_i^j=0$, and more likely to be planned than unplanned if $p_i^j=1$.

Predicted planning behavior can be summarized for all observations of the same type by calculating the fraction of those activities more likely to be planned than unplanned:

$$\text{Fraction predicted planned, group } J = F^J = \frac{\sum_{i \in J} p_i^j}{N^j}$$

and $\text{Fraction predicted unplanned, group } J = 1 - F^J$.

By carefully defining subgroups and comparing these measures across them, insights can

be obtained into the aggregate differences in planning behavior across subgroups of a population.

3. DATA

3.1 Bay Area Travel Surveys, 1990

Data for this analysis was obtained from the San Francisco Bay Area Travel Surveys (BATS) of 1990, a travel survey sponsored by the Metropolitan Transportation Commission. Survey respondents recorded detailed travel diaries, which were later retrieved via telephone interviews. Data from single-weekday surveys of 9,359 households were used for this analysis. The methodology and results of the survey are discussed extensively in MTC [1991] and Purvis [1994].

The survey sample included 397 individuals who recorded having a disability impacting their use of public transit. This definition of disability is broader than that specified by the Americans with Disabilities Act (1990). The ADA requires that a person's disability prevents them from using transit, not just cause some difficulty [Thatcher et al, 1991]. A more detailed breakdown of the types of mobility difficulties respondents identified is provided in Table 6.1.

Type of Difficulty Using Transit	Number (%)*
Has difficulty walking up to 3 blocks	250 (63%)
Has difficulty boarding a standard transit bus	201 (51%)
Has difficulty riding seated in a standard transit bus	136 (34%)
Has difficulty riding in a taxicab	101 (25%)
Has other difficulty using public transit	127 (32%)
Has disability impacting use of public transit	397 (100%)

Table 6.1: Distribution of mobility difficulties reported by BATS respondents

* Numbers do not add up to totals because respondents indicated all categories that applied to them

Source: MTC, 1991.

While most disabled respondents had difficulty accessing and using standard transit vehicles, three quarters could use taxi vehicles — the standard paratransit vehicle in the Bay Area — without difficulty. Special accommodations such as wheelchair lifts are needed for the remaining 25% of disabled riders.

At the time of the survey, before implementation of the ADA, paratransit service was very limited in the San Francisco Bay Area. Paratransit service was provided by some transit operators, but restrictions on the number and types of trips limited paratransit use. A 1994 study estimated that paratransit served only 16% of the Bay Area's potentially ADA eligible population [based on Crain & Associates, 1995]. The city of San Francisco, providing almost 40% of regional paratransit trips, operated the least restrictive service with very low fares and exclusive-ride, immediate response taxi service.

The BATS survey results reflected the limited presence of paratransit service. Only five trips was recorded by disabled people on the taxi mode, and a single trip by dial-a-ride.

3.2 Comparison of Bay Area General and Disabled Populations

The distribution of activity types, travel characteristics, and personal characteristics for the sample of disabled Bay Area residents is shown in Table 6.2. Shopping, work, recreation, and “other” activities were the most common out-of-home activities. Except for work activities, these results agree with earlier studies of the trip purpose distributions of disabled travelers [Grey Advertising, 1978]. The dominance of the automobile over other modes is evidenced by the fact that about two thirds of trips were taken as auto drivers, and 70% of respondents lived in households with at least one automobile per licensed driver. This suggests that many disabled people in the Bay Area enjoyed relatively high levels of mobility despite their difficulty in using transit. The average age of people in the sample was 54 years, and only 34% of individuals were employed. All of these findings are consistent with general insights from the literature regarding the travel habits and demographics of disabled populations in the United States (see the literature review in Chapter 2).

Comparative statistics are also shown for the complete BATS sample of respondents over 16 years of age. Significant differences between the general and the disabled populations

are evident. Disabled respondents were, on average, 14 years older than the general population, 34% less likely to be employed, and 10% less likely to live in households with children. Disabled respondents had lower access to automobiles, and took significantly fewer trips by auto and more trips with travel companions. Trips by disabled people in the sample tended to be shorter, on average, with average travel times of 26 minutes versus 30 minutes for the general population. The lower employment level among disabled people is reflected by the distribution of activity types: the disabled population tended to have proportionally fewer work activities and more shopping and medical/dental activities. In fact, medical/dental activities were proportionally three times as frequent among disabled people as among the general population.

3.3 Comparison of Windham and Bay Area Samples: General Populations

The analysis relies on transferring a discriminant model of planning behavior from the calibration sample from Windham, CT, to a population from the San Francisco Bay Area. The validity of such a model transfer depends on whether these two samples are comparable. Table 6.2 shows sample statistics for the Windham, CT sample, for comparison with the Bay Area general population sample.

In general, the Windham and BATS samples are very similar. Activity type distributions are similar, except for slightly higher proportions of work and shopping activities in the

Bay Area as compared to the Windham data. This probably reflects the higher presence of students in the Windham population — as also evidenced by the slightly lower average age and the higher fraction of people living in households with children in the Windham area. The number of trips taken as automobile drivers and trips with companions are comparable. The most significant difference is in the travel times from the home location to each activity: Bay Area travel times average 31 minutes, compared to 22 minutes for the Windham region. Probable reasons for this discrepancy include the larger geographical size of the Bay Area and the bridge-crossing transportation patterns in the Bay Area.

In the aggregate, the Bay Area sample seems similar to the Windham, CT, sample. However, the subsample of physically disabled people in the Bay Area differs substantially from the general population.

4. UPDATING AND TRANSFER OF ACTIVITY PLANNING MODEL

4.1 Reestimation of discriminant model with Windham data

Complete descriptions of the activity planning model, dataset, and motivations for the variables, are provided in Chapter 5. Appendix B describes the theoretical and empirical basis of discriminant analysis. In order to use the model for prediction rather than

inference, both the vector of coefficients (A) and the critical z-value (z^*) were updated to reflect the following realities:

- The Bay Area dataset does not include frequency and planning horizon information to identify regular and urgent activities *a priori*. The discriminant function is thus reestimated on the Windham data with regular and urgent activities included. Regular activities are considered as planned and urgent activities as unplanned observations.
- Three variables in the original discriminant model are removed, namely TYPE-COMMUNITY, IMPORTANCE, and FREQUENCY. Information on these variables do not exist in the Bay Area dataset. Observations of the “Community” activity type are coded as “Other” type activities.

The resulting dataset has 1356 observations. Table 6.3 shows the results of the discriminant model estimation. Coefficients for the EMPLOYED and VEH/DRIVER variables were insignificant and dropped from the model. The final coefficient estimates are similar to those of the original model, indicating that statistical correlations in the data are stable even after removal of the two most significant variables, namely IMPORTANCE and FREQUENCY. Two exceptions are the COMPANION and TRAVELTIME-HOME variables. A significant coefficient estimate is obtained for the COMPANION variable, indicating that a positive relationship exists between respondents’ tendency to plan activities in advance, and whether the trip was undertaken

with other people. This result confirms earlier bivariate analysis of this factor (Chapter 5). The coefficient of the CHAINED variable is significant at $\alpha=5\%$ but has a counterintuitive negative sign, implying that activities are less likely to be planned in advance if they are chained. This variable is not included in the final model. The TRAVELTIME-HOME variable is only marginally significant, but has the expected positive sign and is retained in the final model.

VARIABLE	FULL MODEL		FINAL MODEL	
	Estimated Coefficient	Partial F (p value)	Estimated Coefficient	Partial F (p value)
TYPE-WORK	0.629**	18.75 (0.00)	0.699**	23.79 (0.00)
TYPE-RECREATE	-0.524**	5.04 (0.03)	-0.486**	4.16 (0.04)
TYPE-SHOP	-0.696**	19.94 (0.00)	-0.694**	19.36 (0.00)
TYPE-SCHOOL	0.365	2.05 (0.15)	0.418*	2.81 (0.09)
TYPE-DINE	-1.329**	24.21 (0.00)	-1.335**	24.27 (0.00)
TYPE-MEDICAL	-0.336	1.01 (0.32)	-0.327	0.86 (0.36)
COMPANION	0.206*	2.81 (0.09)	0.211*	3.25 (0.07)
CHAINED	-0.243**	4.49 (0.03)	—	—
TRAVELTIME-HOME	0.113*	2.67 (0.10)	0.103	2.04 (0.15)
EMPLOYED	-0.120	0.67 (0.41)	—	—
AGE	0.019**	21.68 (0.00)	0.019**	25.79 (0.00)
CHILDREN	0.384**	12.49 (0.00)	0.387**	12.48 (0.00)
VEH/DRIVER	0.067	0.37 (0.54)	—	—

Table 6.3: Estimation results of full and final models

* = Significant at $\alpha=10\%$

**= Significant at $\alpha=5\%$

The final model is statistically significant with an F-statistic of 14.79 (the critical F-value

at a 95% significance level is 1.83). The critical z^* value is 1.161. The percentage of observations reclassified correctly is 66%.

4.2 Transferability issues

Use of a model calibrated on one population for predicting the behavior of another population raises concerns of transferability. The activity planning model is a behavioral model and therefore context dependent. As such, the true parameter values of the model are not expected to be the same in the Bay Area population. Ideally, validity of the model transfer should be improved by partial updating or complete reestimated of model parameters using local data [Ben-Akiva, 1981]. Unfortunately, since no Bay Area data is available on the dependent variable in the model (the lead times of activities), no updating is possible. Planning behavior is predicted using local data on independent variables, allowing us to control for some differences in activity, travel and personal characteristics, however small these differences may be. Nevertheless, the direct transfer of model coefficients makes a strong assumption on the similarity of underlying planning behavior across space and time.

In particular, applying a discriminant model $Z(A, z^*)$ calibrated on one population (termed here the “original” population) to another population (the “transfer” population), can be problematic for three reasons:

- (1) The underlying behavior of the two populations is different, implying that the relationships between the variables in the model are different. Thus, the estimated coefficients (A) are not optimal for the transfer population;
- (2) The ranges of the variables in the transfer dataset are different from those in the original data. This may cause the discriminant values of the planned and unplanned groups (which are weighted sums of the variables) to be shifted relative to each other. Thus, the critical z^* is incorrect for the transfer population;
- (3) The relative sizes of the planned and unplanned groups in the transfer sample differ from those in the original sample, causing z^* to be biased towards one of the groups in the transfer population.

We have some information to assess the risk of encountering each of these problems. As for the first, the variables included in the model were developed from qualitative research in the Bay Area population (Chapter 4). The coefficient signs estimated for the Windham data are consistent with these local findings. Qualitatively, at least, the coefficients for the original population seem reasonable for the transfer population.

As for the comparability of independent variables, the discussion in Section 3 highlighted the aggregate similarity between the Windham dataset and the BATS general population dataset (which includes both disabled and non-disabled people). A measure of the overall similarity between the two datasets is the average values of the discriminant function, \bar{Z} . This value is 1.286 for the original data and 1.271 for the transfer data.

The difference between these values is only 3.3% of the mean (Mahalanobis') distance between the planned and unplanned populations in the original dataset.

Unfortunately, no information exists on the ratio between the group sizes of the unplanned and planned activities in the Bay Area data. It is worth noting what an assumption of similar ratios in the two datasets implies. Group sizes (n_{up} and n_p) are related to the overall mean (\bar{Z}) and the group means (\bar{Z}_{up} and \bar{Z}_p) as follows:

$$\bar{Z} = \frac{n_{up} \cdot \bar{Z}_{up} + n_p \cdot \bar{Z}_p}{n_{up} + n_p}$$

Since \bar{Z} was found to be similar in the transfer as in the original population, the assumption of similar group size ratios (n_{up}/n_p) implies similarity also of the group means in the two populations. This is not unreasonable given the similarity of the data.

In conclusion, we have failed to prove conclusively that the activity planning model is not representative of Bay Area behavior. Nevertheless, strong assumptions on the similarity of underlying planning behavior accompanies this "naive" transfer of the model. The results from the model application should therefore be considered as suggestive rather than representative of true behavior. The analysis serves more as an exploratory application of the discriminant model as an evaluation tool than an exhaustive treatment of the policy question.

5. RESULTS: PREDICTED PLANNING BEHAVIOR OF BAY AREA RESIDENTS

5.1 Predicted planning behavior of general population

A subsample of 776 individuals was randomly selected from the BATS database of the general population. Individuals under 17 years of age were excluded. Results of the application of the activity planning model to this data are summarized in the second column of Table 6.4.

	Estimated % of activities likely to be planned	
	Bay Area General Population	Bay Area Disabled Population
TOTAL	56.8%	44.4%
Work activities	100.0%	100.0%
Non-work activities	25.9%	32.9%
<i>Medical</i>	42.3%	45.7%
<i>Recreation</i>	22.1%	40.9%
<i>Restaurant</i>	0.0%	0.0%
<i>Shopping/Personal business</i>	6.3%	12.1%
<i>School</i>	82.8%	91.7%
<i>Other</i>	68.4%	90.0%

Table 6.4: Prediction results: Estimated % of activities more likely to be planned than unplanned

Overall, 57% of activities were predicted to be more likely to be planned than unplanned.

This is slightly below the number observed in the original Windham data, namely 63%. The model associates work and restaurant activities so strongly with certain planning behaviors that it predicts 100% of work activities and 0% of restaurant activities as more likely to have been planned than unplanned¹. Other activity types vary between 6% (shopping/personal business) and 83% (school) likely to be planned.

5.2 Predicted planning behavior of disabled population

Table 6.4 shows also the prediction results for the sample of physically disabled people in the Bay Area. Overall, 44% of observed activities were likely to be planned a day or more in advance. This is significantly lower than for the general population. However, the result reflects the lower incidence of work activities — which were very likely to be planned — among disabled tripmakers. Non-work activities were overall more likely to be planned by disabled people than by the general population. In particular, recreation and shopping/personal business activities were twice as likely to be planned, while medical, school, and other activities were also slightly more likely planned by disabled people.

These results reflect two important characteristics of the disabled sample: their generally

¹ The planning model results are probabilistic. An activity that is predicted more likely to be planned could still have a relatively large (but smaller than 50%) probability of being unplanned, and may actually be observed to be unplanned.

higher age, and the fact that disabled people were more likely to travel with companions. During earlier analyses, both of these factors were associated with an increased tendency to plan activities in advance.

The effect of travel companions can be seen in Table 6.5, showing the distribution of modes used by each group. The table includes only non-work activities. Almost 62% of activities by disabled people were reached as auto drivers, and 21% as auto passengers. Corresponding figures for the general population are 74% and 11% respectively. The effect of companions on predicted planning behavior is seen from the higher fraction of activities more likely to be planned among auto passenger trips than among auto driver trips

MODE USED	DISABLED POPULATION		GENERAL POPULATION	
	Total % of non-work activities	% of activities more likely to be planned than unplanned*	Total % of non-work activities	% of activities more likely to be planned than unplanned*
Auto Driver	61.6%	31.8%	73.8%	27.5%
Auto Passenger	21.0%	41.2%	11.4%	30.4%
Transit	3.7%	11.1%	1.9%	36.0%
Walk	11.8%	28.1%	11.4%	10.8%
Other	1.9%	55.6%	1.5%	15.8%
TOTAL	100.0%	—	100.0%	—

Table 6.5 Modal distribution of observations and planning prediction results, non-work activities

* Prediction results of discriminant model

for both populations. The effect is more significant for disabled tripmakers, who were predicted to have planned 41% of auto passenger trips but only 32% of auto driver trips.

Disabled people used transit more than the general population, but prediction results showed that transit trips were significantly less likely to be planned by disabled people (11%) than by the general population (36%). This is caused by the fact that, for disabled people, transit trips include a higher proportion of shopping, restaurant and recreational trips, which are inherently less likely to be planned in advance. (These three activity types account for 83% of non-work transit trips among disabled people, and 56% among the general population.) Disabled people thus tended to access short-notice activities more frequently by transit modes than the general population, which used the auto mode more frequently to access the same types of unplanned activities.

5.3 Differences in planning behavior according to driver's license

We are also interested in differences in planning behavior across subgroups of the disabled population with different levels of disabilities. Possession of a driver's license is thought to reflect the severity of a person's disabilities (from a mobility perspective) better than the type of difficulty with transit reported by respondents. Tables 6.6 and 6.7 summarize the prediction results for disabled people with and without a driver's license. As can be expected, people without licenses were much more dependent on non-auto

MODE USED	DISABLED POPULATION Total % of non-work activities	
	WITH DRIVER'S LICENSE (n=488)	WITHOUT DRIVER'S LICENSE (n=97)
Auto Driver	74.1%	3.6%
Auto Passenger	13.8%	54.8%
Transit	2.3%	10.7%
Walk	9.0%	25.0%
Other	0.8%	5.9%
TOTAL	100.0%	100.0%

Table 6.6 Modal distribution of observations by driver's license

ACTIVITY TYPE	DISABLED POPULATION Total % of activities more likely to be planned*	
	WITH DRIVER'S LICENSE	WITHOUT DRIVER'S LICENSE
Medical	38.9%	70.0%
Recreation	38.5%	50.0%
Restaurant	0.0%	0.0%
Shopping	11.1%	17.6%
School	88.2%	100.0%
Other	90.3%	100.0%
ALL NON-WORK ACTIVITIES	31.6%	38.1%

Table 6.7 Distribution of predicted planning behavior by driver's license

* Prediction results of discriminant model

modes. More than half of their activities were accessed as car passengers. As a consequence of the need to coordinate travel with other people, and also of the higher average age of non-drivers, the fraction of activities more likely to be planned is higher for virtually all activity categories, as compared to other disabled people with driver's licenses.

6. DISCUSSION: IMPLICATIONS FOR PARATRANSIT USE

The distributions of predicted planning behavior across individuals and activities provide some insight into the likely impacts of reservation policies on paratransit use. Relevant figures are summarized in Table 6.8.

6.1 Paratransit and the automobile driver mode

When considering the likely impacts of a reservation policy on paratransit use, it is reasonable to concentrate only on trips where the mode choice set was likely to have included paratransit. Otherwise, the effects of a policy change may be grossly overestimated. The present sample includes disabled people that were probably not ADA eligible, and that enjoy high levels of automobile mobility. Earlier qualitative interviews (Chapter 4) indicated that paratransit generally does not compete well with the ubiquitous availability, speed and comfort of the automobile driver mode. For these reasons,

TOTAL NUMBER OF ACTIVITIES 585 (100%)	
ACTIVITIES REACHED BY AUTO DRIVER MODE 378 (65%)	ACTIVITIES REACHED BY NON-AUTO DRIVER MODES 207 (35%)
PREDICTED LIKELY TO BE PLANNED* 86 (15%)	PREDICTED LIKELY TO BE UNPLANNED* 121 (20%)
<u>Activity types:</u> Work 21 (24%) Medical 10 (12%) Recreation 18 (21%) Restaurant 0 (0%) Shop/Pers. Bus 13 (15%) School 8 (9%) Other 16 (19%) 86 (100%)	<u>Activity types:</u> Work 0 (0%) Medical 8 (7%) Recreation 19 (16%) Restaurant 23 (19%) Shop/Pers. Bus 67 (55%) School 2 (2%) Other 2 (2%) 121(100%)
<u>Modes used:</u> Auto Passenger 49 (57%) Transit 11 (13%) Walk/Other 26 (30%) 86 (100%)	<u>Modes used:</u> Auto Passenger 60 (50%) Transit 16 (13%) Walk/Other 45 (37%) 121(100%)
	<u>Fraction urgent** =</u> x 0.43 = 0.0 x 0.80 = 6.4 x 0.22 = 4.1 x 0.13 = 3.0 x 0.19 = 12.9 x 0.00 = 0.0 x 0.41 = 0.8 27.2 (5%)

Table 6.8 Summary of planning model results for BATS disabled sample

* Prediction results of discriminant mode

** Estimated from Windham data

observed activities reached by the auto driver mode are not considered here as likely to be impacted by paratransit. Our analysis will consider only activities reached by non-auto driver modes, such as auto passenger, transit, walking, and other modes. We will refer to these as candidate paratransit activities. Thirty five percent of the activities observed for the sample of disabled people were accessed by non-driver modes.

6.2 Advance planning and reservation policies: planned activities

Candidate paratransit activities least likely to be affected by a previous-day advance reservation requirement are those that are planned in advance for other reasons — such as the need for activity appointments, or being part of repetitive activity patterns. Accessing such activities by advance reservation paratransit does not require a major adjustment in planning behavior.

Planning model results indicated that 15% of all activities (or 40% of observed non-auto driver activities) were likely to be planned a day or more in advance (Table 6.8). These candidate activities include a wide range of types, including work (24%), recreation (21%), other (19%), shopping/personal business (15%) and medical (12%) activities. It follows that advance reservation requirements do not seem to exclude any activity types in particular, except perhaps restaurant activities which tend to be undertaken very much on short notice. To the extent that any of these are part of regular activity patterns

(particularly work activities), they can efficiently be served by a subscription paratransit service.

Over half of these candidate activities were reached by the auto passenger mode. The 7% higher mode share of the auto passenger mode among likely planned than among likely unplanned activities illustrates the fact that advance planning results in many cases from the need to coordinate trips in advance with drivers. This reflects, to some extent, behavior that is already adjusted to transport constraints, rather than desired behavior on the part of tripmakers. An immediate response paratransit service would allow some disabled tripmakers to loosen constraints on advance planning that are currently binding. Such a service could offer real benefits in terms of increased flexibility for some tripmakers.

6.3 Flexibility and reservation policies: unplanned activities

A group of activities less easily served by advance reservation paratransit are those associated with more flexible planning behavior. The activity planning model estimated that about 60% of non-driver activities were likely to be planned less than a day before execution. These comprise only 20% of all activities.

Activities likely to be unplanned are dominated by shopping/personal business (55%),

restaurant (19%), and recreation (16%) activities (Table 6.8). These activity types were earlier found to be significantly associated with short-notice activity behavior. Analysis of the Windham survey also showed that most “unplanned” activities could have been planned in advance if needed. This suggests that most of these short-notice activities could be accommodated on an advance reservation mode, if tripmakers were sufficiently motivated to change their planning behavior. The actual number of trips that would be planned earlier to access advance reservation paratransit would depend on paratransit’s other service attributes vis-a-vis those of other modes, such as fare, reliability, and comfort. The inconvenience and costs imposed by being forced to plan in advance are also unknown and in need of further study.

6.4 Urgent activities and reservation policies

Potential paratransit trips most severely affected by an advance reservation requirement are those that are so urgent that they can not be planned a day in advance. In the analysis of the Windham survey, urgent activities included mostly shopping/personal business, medical, and “other” activity types. For lack of more precise information, we assume that urgent activities comprise similar proportions of unplanned activities by type in the Bay Area population. An estimated 5% of all activities for the Bay Area disabled sample are classified as urgent (Table 6.8). While this group is relatively small, it consists mostly of two activity types — shopping/personal business and medical activities — which

comprise a collective 71% of urgent activities.

A small number of shopping/personal business and medical activities can therefore not be accommodated on an advance reservation paratransit system. This fact, together with the absence of other affordable immediate access modes, may account for some of the latent demand for shopping and personal business trips that was observed in earlier demand studies of disabled populations [Bochner et al, 1978]. More significantly, it is worth noting that ADA paratransit services are increasingly replacing other social service transportation systems, many of which specialize in medical transport. In cases where such changes coincide with a change in reservation policy from immediate response to advance reservation, the consequences in terms of access to medical care may be severe.

6.5 Impacts across groups with different disability levels

Possession of a driver's license is interpreted as an indicator of the severity of the disability of people in the sample. Results show that the impacts of paratransit reservation policies fall more severely on disabled people without driver's licenses than on those with driver's licenses. Non-license holders do not have access to the auto driver mode — 96% of their activities are reached by other modes, compared to 23% for license holders. Because of their greater reliance on the auto passenger mode, non-license holders are likely to plan more of their activities in advance than license holders. Non-

license holders could thus make use of an advance reservation paratransit mode with less need for adjustment of planning behavior than license holders.

This cross-group comparison also allows some insight into the extent of adjustment in planning behavior we already observe in response to mobility constraints. Table 6.7 indicated that disabled people without licenses were likely to plan 7% more of their non-work activities (or 6% of all their activities), compared to those with licenses. Assuming that non-licensed people aspire to similar levels of personal mobility and flexibility as those enjoyed by license holders, this number provides an upper bound to the magnitude of adjusted behavior. In other words, this 6% of the activities of mobility-constrained people can be thought of as an upper bound on the “latent demand” for immediate response transportation — activities that are currently planned but that may become unplanned if immediate response modes were available².

More significantly, the absence of a driver’s license is correlated with a higher incidence of activity types associated with urgent activities. Medical and shopping/personal business activities that are more likely to be unplanned, and taken by modes other than the auto driver mode, make up 31% of total activities for non-license holders and only 9% for license holders. This supports the conclusion that non-licensees are more severely disabled and in need of more medical care. It is clear that this group would be

² This argument ignores differences in underlying activity needs and behavior, due to inherent differences between the two groups of licensed and non-licensed disabled people.

disproportionately affected by a policy requiring advance reservation for paratransit service.

7. CONCLUSIONS

This analysis attempted to assess the implications of a previous-day advance reservation policy on the use of paratransit by disabled people. An empirical model calibrated on another population was used to predict the likely planning behavior of a sample from the San Francisco Bay Area. The model could not be updated owing to a lack of planning behavior data. Consequently, this analysis does not represent an exhaustive treatment of the policy question, and the results are not necessarily generalizable to other populations. It serves more to illustrate the application of the activity planning model for analysis purposes.

The analysis indicated that the planning behavior of disabled people in this population is likely substantially different from that of the general population. Overall, disabled people are likely to plan more of their non-work activities a day or more in advance, and maintain less flexible daily schedules. Two major factors cause this result: (i) disabled people tend to be older — and in previous analyses age was found to be positively associated with risk-averseness and a tendency towards more advance planning; and (ii) the fact that disabled people are more prone to travel with companions, which typically

requires advance coordination with those companions.

Looking at current travel patterns, many disabled people seem to be substantially mobile, with 65% of their trips taken as automobile drivers. This conforms to the results of other travel studies on disabled travelers [Rosenbloom et al, 1980]. Since paratransit is unlikely to compete well with the auto driver mode, we focus on the implications of reservation policies for the remaining 35% of activities — those currently accessed by other modes.

The main finding is that a previous-day reservation policy is likely to affect only a small number — approximately 26% — of the activities undertaken by this disabled population. This number corresponds to non-driver trips that were likely scheduled less than a day before their execution (20% of activities), plus the estimated demand for same-day flexibility among activities that are currently planned longer in advance due to other transport constraints (up to 6% of activities). Activity types likely to be affected include mostly shopping/personal business, recreation, and restaurant activities. Other activity types such as work and educational activities were mostly predicted to be planned a day or more in advance, and would not be significantly affected by a previous-day reservation policy.

While this does imply that one would expect to see less shopping, personal business, recreation, and restaurant trips on an advance reservation paratransit system, the effect is

less severe than it seems. In the Windham analysis, these same activity types were found to be mostly plannable: most of them could be planned a day in advance if needed. One could therefore expect some shift of these activities to an advance reservation paratransit mode, to the extent that the net benefits of using paratransit (versus existing modes) outweigh the inconvenience of having to plan them earlier. The mere availability of an advance reservation paratransit mode could thus benefit users by increasing the mode choice set for plannable activities.

Exceptions occur in the case of activities that are too urgent to be planned in advance at all. Such activities can not be accommodated on an advance reservation paratransit system and are most severely affected by the restriction. While these are estimated to be quite small in number — approximately 5% of all observed activities — they represent activities that are arguably more critical for this population. Support for this is provided by three observations: among unplanned activities in the Windham data, urgent activities were generally perceived by respondents as more important to their well-being; shopping/personal business and medical activities (which are the bulk of urgent activities) are more frequent activity types among disabled people than among the general population; and these activity types are even more frequent among disabled people without driver's licenses.

It follows that a previous-day reservation restriction would likely have more severe impacts on disabled people with more severe mobility limitations. This is a significant

finding, given that the growth of advance reservation paratransit systems has coincided with the demise of specialized transportation systems which cater more specifically for medical trips. From a social service point of view, it seems desirable to devise methods for identifying urgent trips and accommodating them on existing paratransit systems. If abuse of the system can be avoided, the additional number of trips to be served would be small, but the marginal benefit to users could be significant.

Conversely, it is instructive to consider the implications of offering a paratransit service with immediate response to all trip requests. In addition to serving people with urgent activity needs, this will likely benefit two types of tripmakers: non-drivers who lose flexibility by having to coordinate auto trips with drivers; and people accessing short-notice activities by transit and walking modes in the absence of more convenient modes. Travel by the auto passenger mode is associated with a greater need for advance planning. Our estimate shows that up to 6% of otherwise flexible activities of non-drivers are planned in advance in order to secure rides with others. While in many cases the companionship of co-travelers may have positive utility as well, an immediate response service would at least provide the opportunity for increased flexibility and independence for disabled tripmakers in this 6% of cases. Secondly, transit and walking was found to be used as a short-notice access mode more frequently by disabled people than by the general population. This, even though disabled people in this sample indicated having some physical difficulty using transit. An immediate response paratransit mode would provide a physically more convenient alternative for these trips, especially if it is operated

as a door-to-door service.

An estimate of an upper bound on the additional demand that would result from abolition of an advance reservation requirement is provided by the number of trips predicted more likely to be unplanned: an estimated 57% of the total potential (non-auto driver) trip volume. This implies that Bay Area paratransit operators can expect up to a twofold increase in demand if no advance reservation policies were enforced. While this is quite a substantial number, the actual number of additional trips is expected to be lower, according to the shift towards advance planning before relaxation of the reservation constraint, and the competitiveness of paratransit with other modes.

CHAPTER 7

CONCLUSIONS AND FUTURE RESEARCH

1. CONCLUSIONS

Significant findings of the research were in two areas: fundamentals of the process of activity and travel planning; and policy questions around the user impacts of advance reservation requirements in ADA paratransit systems.

1.1 Theoretical contributions

The review of the literature on activity and travel planning established the need for focused exploratory research as well as the continued development of conceptual frameworks for modeling the role of scheduling in the activity participation process. This research used both approaches, developing a theoretical framework to identify research questions, and using empirical techniques to explore and quantify aspects of planning behavior in more depth. Significant new insights were obtained into the range of planning behaviors observed across individuals, and into the reasons underlying these differences in behavior.

The theoretical framework proposed a rational behavioral model for activity and travel planning, using concepts from control theory to explicitly account for the timing of activity-related decisions and the evolution of future schedules over time. The theory identified two major types of input into the activity planning process, namely *reference input* in the form of regular activity patterns, and *disturbances* in the form of new or unforeseen activity demands and/or constraints. Regular activity patterns are conceived to provide a basic “skeleton” of activities, which form the basis of all subsequent scheduling decisions. Associated with each disturbance is a roster of (perceived) potential locations, timings and other choice alternatives, as well as a planning horizon which defines how quickly scheduling and execution of the activity must occur.

Making scheduling decisions is part of a process of *regulation*, which is conceived as the method by which variety in the schedule is reduced. The control system framework allows a treatment of the activity planning process that explicitly acknowledges time dependencies across regulatory decisions — in other words, the fact that the choice sets and maybe even decision rules of activity-related decisions depend on previous scheduling decisions. In short, the timing of decisions relative to each other and relative to their execution is an important aspect of planning behavior that has traditionally not been included in models of scheduling behavior.

1.2 The role and importance of regular activity patterns

This study found empirical evidence that supports previous findings in the literature regarding the importance of regular patterns in activity and travel behavior. An empirical analysis of the activities and planning of a sample of people in Windham, CT (1980), suggested that about half of all executed activities occurred regularly with daily, weekly or monthly frequencies. Interestingly, while two-thirds of regular activities were for work and educational purposes, the remaining third included many other activity types such as sports and recreation, social, community, and some grocery shopping activities. It follows that regular activity patterns are richer than supposed by traditional definitions of only work and school activities as “mandatory”, as is the convention in some activity participation models. Conversely, by simply modeling all non-work, non-school activities as “discretionary” activities, the particular constraints related to scheduling regular activities are ignored for up to a fifth of all activities.

Further motivation for giving more attention to regular patterns in scheduling is provided by empirical findings on their role in the scheduling process. In-depth exploration of people’s planning behavior provided support for the control theory concept of regular patterns as reference input. In general, regular activities were treated as anchors or pegs in the schedule. They simplify the subsequent scheduling of other activities by narrowing down the possible timings and locations, and as such play an important role in making the process cognitively manageable. More importantly, the choice sets of non-regular

activities are often constrained *a priori* by the presence of regular activities. This finding suggests that models of scheduling behavior will benefit from accurate differentiation of regular and non-regular activities.

At the same time, however, the exploratory interviews showed how difficult it is to measure regular activity patterns in practice. The boundary between regular and non-regular activities seems to be constantly shifting, as regular behavior is preempted by special circumstances, causing the need for extra-ordinary regulatory action.

Interestingly, it may be possible to identify groups of individuals with a higher exposure to disturbances of this sort — particularly people with a high degree of coordination with others — as disturbances in the schedules of other people propagate to these individuals. Examples of such groups include the physically disabled (who often depend on others for mobility), and parents (whose regular patterns and disturbances are often related to the needs of their children).

1.3 Systematic behavior in the scheduling of non-regular activities

Systematic behavior in the decision of when to undertake scheduling of new activities — including choices of activity timings, locations, and modes — was observed during exploratory interviews and confirmed by the empirical analysis. The behavior of planning in advance for activities seems to be motivated by two underlying objectives: to

reduce the risk of unsuccessful completion of the activity; and to reduce the cost of accessing the activity. Accordingly, several activity and travel-related characteristics were found to encourage advance planning in a statistically significant way. These include perceived importance of the activity to the individual, longer activity durations, lower activity frequencies (which translate into less familiarity with that particular activity), longer travel times to access the activity, and the need to coordinate with a travel companion. Apart from these common factors, activities tend to be treated differently according to the type of activity. Shopping and restaurant activities display a strong tendency towards short-notice execution, while work and community activities have a high tendency to be planned in advance, even if they are not part of regular patterns. Overall, 25% of the activities observed in this one-day activity survey (Windham, CT, 1980) were planned on the same day as execution, 22% were planned one to seven days before execution, and 53% were known more than a week in advance. Interestingly, people seemed to undertake short-notice execution of many activities even though they indicated that advance planning of the activity would have been possible. This suggests that the ability to engage in short-notice activity participation is valued for the flexibility it provides.

The data also provided an estimate of the incidence of “urgent” activities — short-notice activities that are so urgent that their execution can not be delayed until the following day. These activities, by definition, can not be planned even a day in advance. Only approximately 6% of the activities observed in the Windham dataset fell into this

category. Activity types most often observed to be urgent include grocery shopping, medical/dental/legal, and “other” (including serve-passenger) activities. The fact that survey respondents overwhelmingly considered urgent activities as important to their well-being — more so than other, non-urgent activities — suggests that their significance goes beyond their small number.

A multivariate predictive model was successfully estimated to discriminate between activities with short lead times and activities with long lead times, incorporating the types of activity, travel and personal variables available in many standard activity datasets. The model successfully predicted the planning lead times of 74% of the observed activities. This suggests that planning behavior is indeed systematic enough that important aspects of it may yet be successfully captured in other activity models where issues of the timing of scheduling decisions are relevant.

1.4 Differences in planning behavior across groups of individuals

One of the objectives of this study was to investigate differences in the planning behavior of disabled and non-disabled people. Most of the observed differences seemed to be caused by differences in activity and travel patterns between the groups, rather than intrinsic differences related to disability status. To the extent that disabled people tended to engage more in appointment activities such as medical visits, more frequently

coordinated trips with others, and faced higher unit travel costs in terms of transit fares, travel times and physical discomfort, they engaged in more advance planning of activities. A higher need for pre-trip information gathering seemed to cause longer lead times among some disabled people. Statements by disabled interviewees confirmed this general finding — some valued flexible lifestyles, while others saw the need to plan ahead as “one of the biggest implications of having a disability.”

Two personal factors that did emerge as being associated with different planning behaviors, controlling for activities and travel, are the presence of children in the household, and age. People with children tended to have more extreme planning behavior, with more regular activity patterns, more advance planning of non-regular activities, and also more urgent activity needs (presumably related to the needs of children). This suggests that parents are sensitive to policies that affect short-notice access to transportation and services, especially if their access to the flexibility of the automobile is restricted.

Secondly, planning behavior was found to be associated with age. All else being equal, older people tended to plan more of their activities in advance. This may reflect an increasing risk averseness with increasing age. This is an important finding, as it suggests that activity planning issues are different for the elderly than for the rest of the population. Policy initiatives aimed at addressing the mobility needs of the elderly may benefit from paying attention to issues of flexibility and planning.

1.5 User impacts of advance reservation policies in ADA paratransit

An analysis of the impacts of advance reservation policies on potential users of ADA paratransit systems was used to illustrate the application of these findings regarding planning behavior to a policy question. The analysis used activity and travel data from the San Francisco Bay Area from 1990, focusing on people with physical disabilities in the population. The analysis is preliminary and should not be considered as an exhaustive treatment of the policy question, as it depended on a direct transfer of a behavioral planning model calibrated on the Windham, CT, population. Unfortunately, updating of the model was precluded by the unavailability of local data.

In general, a policy that required previous-day reservation for all paratransit trips is likely to have a modest effect from the standpoint of the user. The estimate of the proportion of activities currently undertaken by this population of disabled people, that are likely to be constrained by such a policy, is around 20%. This number consists of activities currently accessed by non-automobile modes, that were indicated by the planning model as being planned with less than a day's notice. The effects of a planning restriction are mitigated further by the previous finding that the majority of unplanned trips can actually be planned a day in advance if need be. It follows that most of these unplanned activities can actually be accessed by paratransit if users were motivated to change their planning behavior.

This is obviously not true for all unplanned activities. A small proportion — approximately 5% of all activities — are too urgent to be planned in advance, and can not be accommodated on advance reservation transportation systems. These urgent activities include mostly grocery shopping/personal business and medical activities. Significantly, these activity types are more frequent among disabled people without driver's licenses, which are arguably more mobility constrained and more dependent on public transport services such as paratransit. It follows that advance reservation paratransit may fail to serve the most severe needs among the most needy of those at which it is targeted. In light of this, it seems desirable that methods should be devised for identifying truly urgent trips and providing transportation for them. The number of trips is likely to be small — less than 5% of all trips — but the benefit to users may be significant. In principle, the higher costs of these kinds of trips could be recouped from riders, as evidence was found during the exploratory interviews of a willingness to pay more for access to short-notice paratransit service.

Lastly, a comparison of the predicted planning behavior of disabled people with and without driver's licenses provides insight into the extent that unavailability of automobile flexibility induces changes in planning behavior. Thirty-eight percent of the activities of non-licensees were likely to be planned a day in advance, compared to 32% for licensees — a situation mostly created by the higher need among non-licensees to coordinate trips in advance with others who can drive. The difference is relatively small, but gives an indication of the benefit that would result in terms of increased flexibility, if immediate

response paratransit services were provided. Paratransit with short response times would serve to loosen constraints on advance planning for people otherwise dependent on coordination with other tripmakers.

In contrast to the impacts on users, the impacts of loosening advance reservation constraints on paratransit system providers may be significant. The additional pool of trips that are not planned in advance that could be shifted to an immediate response system is at least as large as the pool of planned trips. Operators could thus expose themselves to as much as a doubling of demand by loosening constraints on advance reservations. This finding illustrates the rationale behind the use of advance reservation policies to manage the demand for ADA paratransit service.

2. RECOMMENDATIONS FOR FUTURE RESEARCH

2.1 Role of regular activity patterns in scheduling, activity and travel behavior

This study's findings concerning the prevalence and important role of regular patterns in activity behavior underscore the need for the continued study of these patterns. Activities with regular recurrences are treated differently from non-recurrent activities during the scheduling process; scheduling regular activities can not be described in terms of the traditional choice processes. The choice sets and decision rules typically used to model

activity-related decisions therefore do not apply similarly to all activities.

On a behavioral level, regular activity patterns exhibit many subtleties: regular activities vary over the short term in terms of the degree of fixity of activity attributes, and include a large range of activity types and travel patterns. More exploratory research is needed to find ways of measuring the relevant differences between regular activities and non-regular activities, going beyond traditional definitions of “mandatory” and “discretionary” activities to reflect their different roles in the scheduling process.

Exploratory research should go wider, capturing a broader range of people and situations, and deeper, focusing more on describing repetitive behavior than this research did. This will allow a better understanding of how different kinds of activities are affected differently by changes in transportation policy — a need particularly relevant to the newest generation of micro-simulation-based policy models which attempt to predict behavioral changes in response to new policies directly.

2.2 Short-notice activities

The research suggested several future directions for investigating short-notice or urgent activities with very short windows of opportunities for execution. The ability of people to respond to urgent activity needs is an aspect of the mobility they enjoy, and therefore very relevant to transportation policy. That this issue has important equity dimensions

was pointed out by the comparison of urgent activities across subgroups of the physically disabled population in this study.

Particular questions worth further investigation include the nature, frequency, and implications of urgent activity needs among groups of transportation users. The research showed that a relatively small proportion of the activities observed in a one-day survey qualified as “urgent”; yet, the frequency with which they occur for any particular individual is unknown. Differences in the frequency of urgent activities may be related to demographic and life-cycle variables such as age, health status, employment status, and the presence of children. The costs of responding to urgent needs may differ systematically according to automobile availability, for instance, and thus may be an important dimension of the mobility needs of non-auto owners. The ability of traditionally designed fixed-route transit to serve urgent travel needs is a relevant issue, especially when trade-offs between limited fixed-route service and demand responsive services are considered. Transportation policy studies aimed at particular groups of mobility constrained users such as the elderly, disabled, and welfare recipients may benefit in particular from paying attention to the role of short-notice travel.

2.3 Costs related to advance scheduling

A related question is one of the implications of being forced to plan activities and travel

in advance. The loss of desired flexibility caused by the inability to access activities and travel on short notice may have cost implications for the tripmaker. An example of this was given in Chapter 3, where the enforcement of minimum lead times caused suboptimal travel patterns in terms of backtracking between activities — a situation that could have been avoided if the schedule was allowed more flexibility. The concept of scheduling cost may be useful in this regard, where this is defined as the marginal generalized cost (including perhaps the time and cost of both travel and activity participation) of planning. This cost would be non-decreasing with increasing lead time, as longer lead times translate into greater loss of flexibility.

Scheduling cost thus represents a way of quantifying the loss of flexibility due to advance planning. At the same time, advance planning has been shown to *save* time and/or money, by being a mechanism for securing lower-cost activity options. An example is the purchase of durable goods, where longer planning periods may provide better opportunities for identifying lower prices. The trade-offs between these costs and benefits of advance planning could be useful for assessing the implications of policies affecting people's flexibility. Examples of such policies include those promoting flex-time, and policies promoting shared riding for commute and non-commute trips (such as carpools). Even further down the line, one might imagine a scenario where access to congested highway networks is allocated on the basis of reservation rather than queueing, as is currently the case. Such a policy will avoid the inefficiencies of queueing in a network, but imposing a schedule delay cost at the origins and destinations of trips.

Notions of scheduling cost could thus be used to gain insight into how people value flexibility, and how they may be compensated for the loss of flexibility brought about by transportation policies.

These questions further suggest that the question of advance planning should ideally be studied in a more continuous framework than that followed in this study, which grouped planning behavior into two discrete groups (planned and unplanned activities). More information can be extracted from continuous lead time data such as that used in this study, by capturing the continuous nature of the planning process at the modeling stage.

2.4 The evolution of trip chains during scheduling

Trip chaining is an abiding topic in travel behavior research. Questions around the motivations for chaining, the nature and formation of trip chains, and chaining behavior on different modes, could benefit from being studied in the context of the scheduling process. Trip chains are typically the outcome of an evolutionary scheduling process. Distinguishing between the primary activities in chains which act as the “anchors” of the trip, secondary activities which are planned but added later, and serendipitous activities that are added to chains on the spur of the moment, may provide valuable insight into chaining behavior.

2.5 Impacts of ADA paratransit policies on users' activity patterns

A more profound understanding of the impacts of reservation policies in ADA paratransit on access to activities and mobility of potential users can be gained by further in-depth study of the activities and travel of actual and potential users. Issues of changes in activity and travel behavior in response to transportation constraints, long a topic of latent demand studies among disabled and elderly populations, could receive a new focus in terms of measures of flexibility and advance planning. Questions worth pursuing include the role of paratransit within a multimodal context, in particular which groups of people and for which activities are the impacts of paratransit policies more severe because of a lack of suitable alternatives. This question should also extend beyond response time policies to other service policies specified by the ADA, such as area coverage and pricing, in order to get at the true extent to which publicly supported transportation systems serve the needs of those they aim to serve.

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APPENDIX A

Interview guide used for exploratory interviews

INTRODUCTION

With this research we are trying to understand people's travel behavior, how travel is motivated by the activities people do, and also what type of planning people do for their activities.

The reason why we are trying to understand how people travel, is that there are many effects that transportation policies have on people's lives that we want to understand better, so that new policies can take those into account.

So in order to understand how some of the activities that you do relate to your day-to-day travel, I'm going to ask you some questions about your activities on a specific day. The questions are open-ended, and you can take all the time you need to answer. You are also free to not answer any question if you don't want to. Everything you say is confidential.

OVERVIEW OF TRAVEL ACTIVITY

- 1- First I'd like to get a general sense of how you get around. Do you use a car, BART, bus, walk, bike, paratransit? How often, for what types of trips?

ACTIVITY SCHEDULE

- 2- We are interested in finding out how the activities you do in a single day relate to each other. So I'd like you to think back over your day [yesterday/ last Saturday/...] and write down all the activities you did outside of your home on that day. I'll walk you through it.
- 3- Which of these activities would you describe as "regular" activities that happen the same time or place every day or every week? Do you usually travel to & from these activities the same way? Do they happen at exactly the same time & place, or do you have some flexibility?
- 4- Let's look at the other activities that we have not marked as regular. I'm going to ask you some questions about each one.
 - 4.1- Can you recall when it first occurred to you that you wanted to do this?
 - 4.2- Did you consider doing this at another location? If yes, when did you decide to do it at this location? [Probe for reasons for chosen lead time.]

4.3- Could you have done this activity at other times? If yes, when did you decide to do it at this time? [Probe.]

4.4- Did you have to make an appointment for the activity? If yes, when did you make the appointment? [Probe.]

4.5- Did you have to coordinate with other people to do this activity? If yes, when? [Probe.]

4.6- Did you consider traveling to the activity in some other way? When did you decide to use this mode? Did you have to coordinate with somebody to travel, or make an appointment? [Probe for reasons for particular lead time.]

4.7- Did the fact that you had this activity planned affect the rest of your day?
[Repeat for all non-regular activities].

5- Can you remember any other recent activities that you had to plan for long in advance? [Probe for lead time & reasons].

6- Can you remember other recent activities that you did on the spur of the moment? [Probe for lead time (activity;travel) & reasons].

7- Can you recall recent experiences when you wanted to go somewhere but you couldn't because you didn't plan the activity long enough in advance? Or because you couldn't get transportation in time to get there?

SUMMARY

In summary, you've told me that some activities you plan long in advance because.... and with other activities you plan closer to the time because... and in general you prefer to... Is there anything you want to add about how you plan for activities that you do in the future?

APPENDIX B

Theory and Application of Discriminant Analysis

C.1 Background and theory

Discriminant analysis is a multivariate technique for classifying objects into mutually exclusive groups on the basis of a set of observations. Groups are defined *a priori*, distinguishing this technique from others that are designed to identify population groupings, such as cluster analysis. Discriminant analysis is useful for both analysis and classification purposes. In analysis, the technique is used to gain insight into the dimensions along which the groups differ. In classification, a decision rule is used to classify objects from unknown origin into one of the groups with minimum error.

Suppose that n members from two distinct populations are observed. For each member j , a vector of k observations $\{x_{1j}, x_{2j}, \dots, x_{kj}\}$ is also observed. The problem is to find a function Z that will best permit discrimination between members of the two populations, based on the values of the factors x_{ij} . Function Z is typically defined as linearly additive such that, for member j ,

$$z_j = a_1 x_{1j} + a_2 x_{2j} + a_3 x_{3j} + \dots + a_k x_{kj} \quad j=1 \dots n \quad (eq.1)$$

where a_i = the weighting coefficient of the i th factor, x_{ij}
 n = the combined size of the two populations.

In matrix notation, this is stated as $Z = AX$, where Z is $1 \times n$, A is $1 \times k$, and X is a $k \times n$ matrix.

Figure C1 shows the distribution of z -values for members of the two populations, for a given set of coefficient values A . The task is to determine an optimal set of coefficients such that the distance between the two populations, indicated as D^2 in the figure, is maximized. Fisher showed that this is achieved when the between-population variance is maximized relative to the within-population variance [Lachenbruch, 1975]. The derivation of the optimal coefficient matrix is provided in numerous texts [e.g. Stopher & Meyburg, 1979; Lachenbruch, 1975].

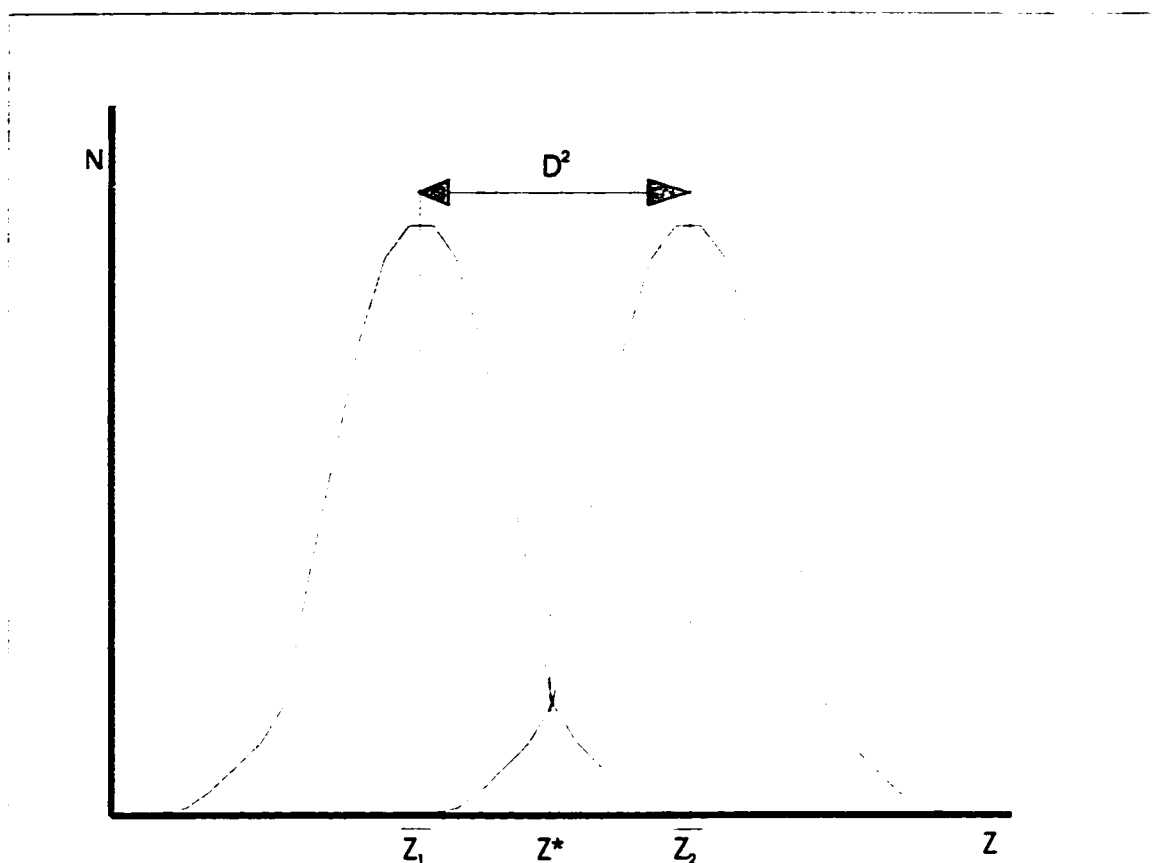


Figure C1: Theoretical distribution of discriminant values for two populations

Mathematically, it is given by

$$A = C^{-1} \cdot Y$$

where A = matrix of weighting coefficients,
 C = pooled variance-covariance matrix of both populations, and
 Y = vector of differences between the factor means for the two populations.

This result holds under two assumptions: that the distribution of the factors are multivariate normal, and that the two populations are homoscedastic (i.e. that the covariance matrices for the factors are the same for both populations). Discriminant analysis is relatively robust with respect to violation of these assumptions. Linear discriminant functions have been shown to perform well on binary data, but are less robust to the use of continuous non-normal distributions [Lachenbruch, 1975]. In inference, heteroscedasticity can cause the results of significance tests to be overly optimistic, but only for small or unequal sample sizes of the two groups [Dillon and Goldstein, 1984]. During classification, heteroscedasticity has been shown to cause

overclassification of objects into groups with greater dispersion [Tabachnick, 1989]. However, as long as adequate levels of correct classification is maintained, these problems are of minor concern.

C.2 Use for classification

By applying a calibrated discriminant function to a set of observations, the observations can be classified into two populations. For each observation a z-value is calculated by applying equation 1. The classification rule is of the form:

classify observation j as belonging to population 1 if $z_j < z^*$, and as belonging to population 2 if $z_j \geq z^*$,

as illustrated in Figure C1. Under the assumptions of normality and homoscedasticity, and if the populations are of equal size, z^* is a point exactly half-way between the means of the two populations, or

$$z^* = \frac{\bar{z}_1 + \bar{z}_2}{2}$$

If it is known that the populations are of unequal size, say n_1 and n_2 , the optimal classification point (or “critical z-value”) is:

$$z^* = \frac{n_2 \bar{z}_1 + n_1 \bar{z}_2}{n_1 + n_2} \quad (\text{eq. 2})$$

C.3 Statistical tests

Useful statistical tests for evaluating the results of discriminant analysis include the following:

(1) *Tests for overall significance of the discriminant function*

The overall effectiveness of the function Z in discriminating between the two populations is reflected by the distance by which it separates the two populations. The mean distance between the calculated z-values of the two populations is termed the Mahalanobis’ distance, denoted D^2 (see Figure C1).

It is known that the statistic

$$F = \frac{n_1 n_2 (n - k - 1)}{n (n - 2) k} D^2 \quad (\text{eq. 3})$$

has an F distribution with $(k, n-k-1)$ degrees of freedom [Lachenbruch, 1975]. This statistic can be used to test the null hypothesis that there is no significant difference in the z -values of the two populations.

(2) *Tests for adequacy of classification*

A satisfactory discriminant function can be expected to reclassify the members of the original dataset with reasonable accuracy. A simple method often used to evaluate the performance of a function is to calculate the percentage of the original observations that are classified correctly by the function. This number should be higher than if observations were randomly assigned to groups (exactly 50% for equal group sizes).

(3) *Tests for contribution of individual factors or subsets of factors*

Several approaches exist to evaluate the contribution of individual variables to the overall discrimination. Partial F-values, obtained by computing for each variable a one-way analysis-of-covariance where the covariates are the remaining $k-1$ variables, seem to perform best [Dillon and Goldstein, 1984]. In essence, this statistic reflects the predictive power of each variable, while controlling for its covariance with other variables.

The contribution of a group of variables can be evaluated by comparing the discriminatory power of two separate models: one based on all variables including the group that is of interest, and another excluding the group of interest.

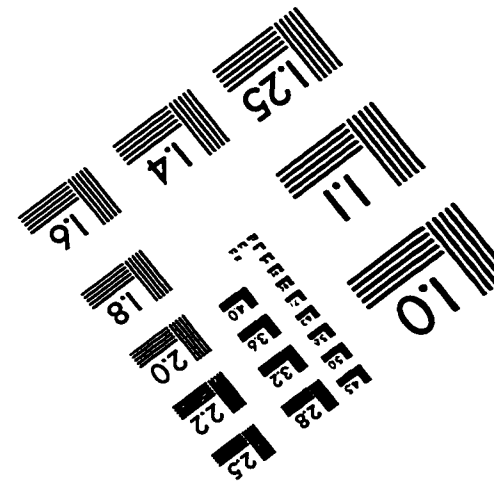
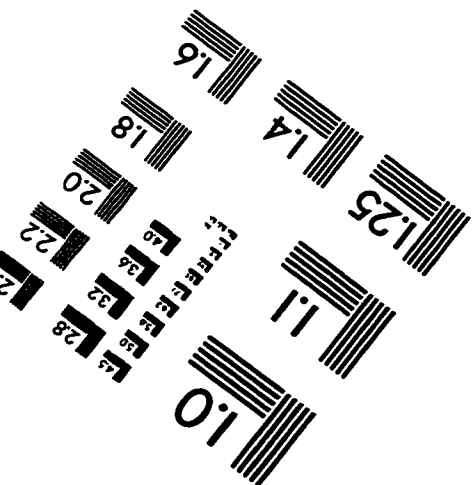
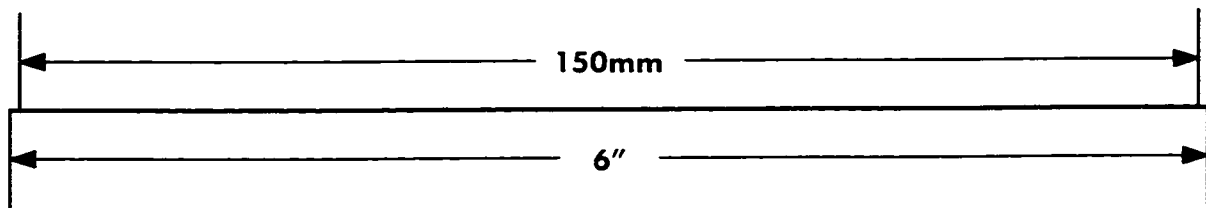
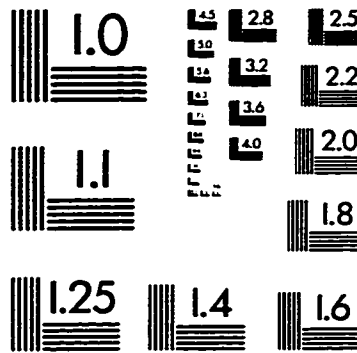
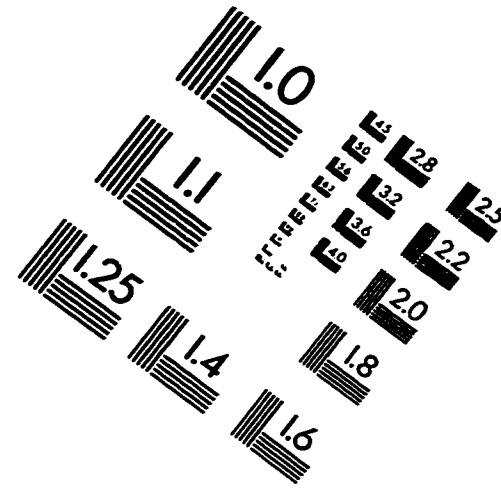
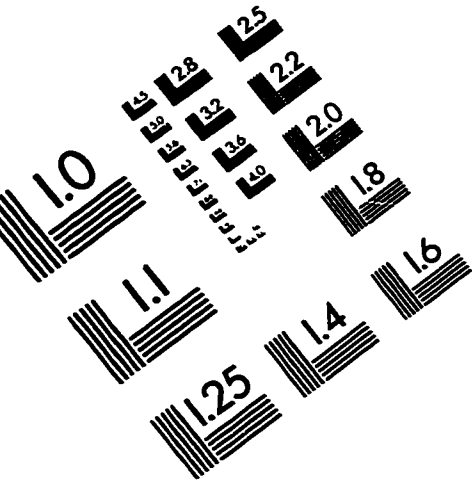
It has been shown that the statistic

$$Q = \frac{n-f-1}{f-r} \cdot \frac{C(D_f^2 - D_r^2)}{1 + C D_r^2} \quad (\text{eq. 4})$$

where $C = (n_1 n_2) / (n(n-2))$
 f, r = the number of variables in the full and restricted models,
 respectively, D_f^2, D_r^2 = the Mahalanobis' distance of the full and
 restricted models, respectively,

is distributed according to the F distribution with $(f-r, n-f-1)$ degrees of freedom [Dillon and Goldstein, 1984]. The statistic is used to test the null hypothesis that inclusion of the subset of variables does not significantly increase the discriminatory power of the model over that of the restricted model.

IMAGE EVALUATION TEST TARGET (QA-3)



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