SUBURBAN COMMUTER RESPONSE TO RIDE SHARING INCENTIVES AND AUTO-USE DISINCENTIVES

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1. INTRODUCTION

Traffic congestion is a major problem affecting suburbs of metropolitan areas today (Cervero 1986, Chicago Tribune 1990a, New York Times 1988). Many actions have been proposed to ameliorate suburban congestion. These include transportation supply expansion, land-use and site design management, and demand management. Among the alternate actions to ameliorate congestion, demand management actions have become increasingly popular. Demand management actions may be classified as demand reduction strategies and demand shifting strategies. Demand reduction strategies alleviate congestion by reducing the built-in biases that favor solo-auto commuting, thus placing various forms of ride sharing (carpooling, vanpooling, and transit) on a more equal footing. Demand shifting strategies alleviate congestion by temporal dispersion of peak-period trips (*e.g.*, flex-time and shift in work hours).

Demand reduction actions may be classified into two types: 1) actions that promote ride sharing through ride sharing incentives, and 2) actions that promote ride sharing through auto-use disincentives. This paper employs a marketing research approach to obtain a better understanding of factors that influence mode choice to work and travel responses to alternate ride sharing incentives and auto-use disincentives.

The remainder of this paper is organized as follows. The next section very briefly reviews earlier empirical work on commuter travel behavior and distinguishes our study from earlier ones. Section 3 develops a conceptual framework for our analysis. Section 4 focuses on the modeling strategy adopted in our research. Section 5 discusses the estimation results obtained from the analyses. Finally, section 6 summarizes the important findings of our study.

2. MARKET RESEARCH STUDIES OF COMMUTER TRAVEL BEHAVIOR

Several important studies of ride sharing behavior and effectiveness analysis of incentives/disincentives have been conducted in the past two decades.[1] While the specific results from the various analyses vary based on study location, there seems to

[1]A detailed review of these studies is presented in Koppelman et al. (1991).

be general agreement that attitudinal factors are more important in determining ride sharing propensity than socio-demographic attributes or the standard travel time and cost variables used in transportation mode choice models.

2.1. Differences between Current and Previous Research

This study is distinguished from previous studies in at least four ways. First, almost all earlier studies have focused on metropolitan cities or very highly congested suburban areas (mainly the suburbs in Southern California). Our focus is on a midwest suburban area. Unlike central cities which have a relatively good transit service, suburban areas are characterized by sprawling campus-like work centers and are typically designed for solo-auto commute. Also, unlike the southern California suburbs, there are no over-riding concerns yet about environmental quality in the midwest suburbs. Hence the effect of altruistic or regulation-driven environmental and social attitudes on ride sharing intentions are likely to be quite different in the two settings.

Second, we model the influence of an individual's travel pattern between her/his time of leaving home in the morning to her/his return back home in the evening (which we shall henceforth refer to as work travel pattern) on commute behavior.

Third, we adopt a joint modeling approach to analyze mode choice behavior and stated intentions to use new services. Such a procedure accommodates the correlation in unobserved tastes that affect both current mode choice and stated intentions. The joint modeling approach also enables us to anchor the stated intention to use new services to observations of current mode choice behavior. Failure to do so can lead to overly optimistic expectations about market acceptance of new services (Bradley 1991).

Fourth, we explicitly recognize the ordered structure of stated intentions. Stated intentions are recorded in categories. An ordinary least squares (OLS) analysis using the responses directly as the dependent variable is not appropriate in such a situation since it violates the assumptions of zero mean and constant variance for the error term.

In the next section we develop a conceptual framework of mode choice behavior and travel behavior responses to demand reduction actions.

3. The Conceptual Framework

The forces that influence current mode choice behavior and stated intentions are illustrated in Fig. 1. We postulate that opinions/perceptions regarding alternate modes (that form part of the block referred to as "Attitudes" in the figure) are affected by prior mode usage experience. An individual's work travel pattern is influenced by these mode-related attitudes and social/environmental attitudes (that form a second part of the block termed attitudes). Work travel pattern is also a function of situational

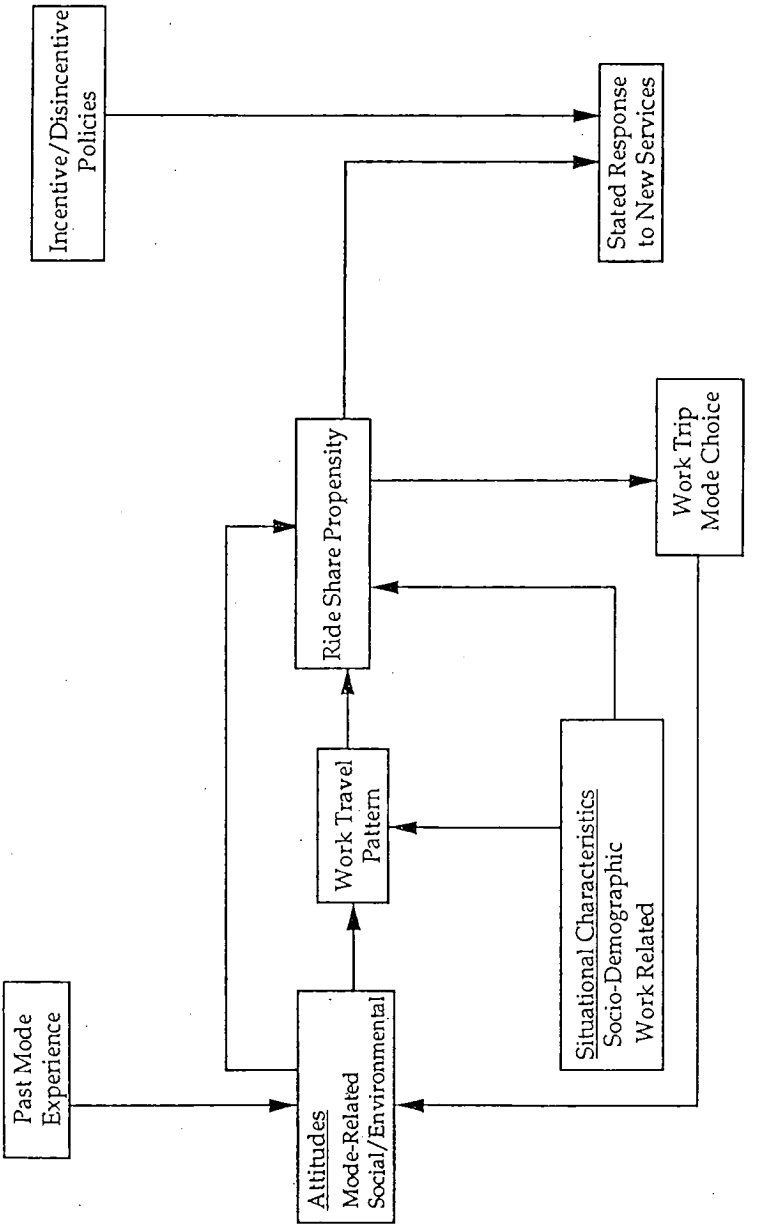

Fig. 1. Conceptual Framework of Work Travel Behavior

characteristics.[2] All of these components; attitudes, work travel pattern, and situational characteristics; influence the propensity to rideshare. Over a period of time, the work-trip mode choice has a feedback influence on attitudes toward alternate modes through an updating process in the light of experience. Finally, an individual's stated intentions is a function of incentive/disincentive policies and her/his propensity to ride share. Current mode choice, in this context, is viewed as an indicator of the underlying ride sharing propensity under current conditions.[3]

4. Modeling Strategy

The procedure used to model current mode choice behavior to work and stated responses of commuters to new ride share services (stated-intentions) is based on the conceptualization described in section 3 and illustrated in Fig. 1. We confine ourselves in this study to a static framework in which attitudes (both perceptions about alternate modes and social/environmental beliefs) are formed over a long-term period and are unaffected by current mode choice. Further, our focus is on the analysis of current mode choice and stated intention about future mode choice. We treat attitudes, travel patterns, and situational characteristics as exogenous to our modeling system. Past mode usage does not have a direct effect on mode choice but has an indirect effect through its influence on attitudes. Since we treat attitudes as exogenous, past mode experience will not be used as an explanatory variable in our analysis.

4.1. Mode Choice Definition

The survey questionnaire obtained information on mode choice to work over a week. The survey results indicated that solo-commuting on all days of the week is the predominant mode selected for the suburban work trip.[4] Due to the small sample of commuters who use an alternative mode, we combine all such choices into a general mode defined as ride sharing. Thus, we treat mode choice as a binary choice -- either drive alone or ride sharing.

We view the discrete mode choice (ride sharing or not ride sharing) as a reflection of an underlying inclination or propensity to ride share. We do not observe

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[2] Situational characteristics, as used here, refer to individual/household socio-demographic characteristics and individual work characteristics.

[3]The conceptual framework formed the basis for the survey instrument design. Due to the length of our questionnaire and the cost efficiency associated with a mail survey, we used mail questionnaires as the administration method. The survey instrument design, sampling plan and the survey administration procedure are discussed in detail in Koppelman et al. (1991).

[4]About 82% of all respondents drove alone on all days of the week.

this ride share propensity, only whether the individual ride shares or not. However, we know that if the individual ride shares, her/his ride share utility exceeds drive alone utility. We use this information to estimate the ride share propensity of each individual.

4.2. Stated Intention Equation for Proposed Vanpool and Transit Service Use

The stated intention analysis is designed to analyze the intensity or inclination to use various proposed vanpool and transit services. The characteristics of the proposed vanpool and transit services are described below:

Characteristics of Proposed Vanpool Services

Service No.	Service Fee/month	Car Parking Fee
1.	$60	0
2.	$45	0
3.	$60	$60/month

Characteristics of Proposed Transit Services

Service No.	Service Fee/month	Service Headway	Walk Time from Home	Car Parking Fee
1.	$50	30 min.	10 min.	0
2.	$30	30 min.	10 min.	0
3.	$50	15 min.	10 min.	0
4.	$50	30 min.	5 min.	0
5.	$50	30 min.	10 min.	$50/month

Respondents were constrained to selecting from among four possible levels of inclination to use the proposed services from very unlikely (to use the service) to definitely (use the service). We used the approach that they would choose the response category that most closely represents their true willingness to use the service.

4.3. Measures of Attitudes

Two sets of attitude measures were included in the questionnaire. The first set included ten ratings of attributes for the drive alone and ride share modes. The second included twelve measures of agreement with statements about social and environmental issues. We adopt the view that measures in each of these sets reflect a smaller number of underlying attitudes which are not directly measurable (Koppelman and Hauser, 1979). The underlying attitudes were obtained by factor analysis of the relationships among the responses for the detailed attitudinal measures. The service attributes were combined into five factors: Convenience and Independence, Timely Service, Safety and Comfort, Inexpensiveness, and Parking ease (for drive alone only).[5] Four underlying factors were identified to represent social/environmental attitudes. These were: Environmental Concerns, Need for Independence, Sociability, and Need for Control and Status.[6] The composite score on each factor was used in the empirical analysis.

5. Empirical Results

5.1. Mode Choice Model

Mode choice is treated as a binary decision -- ridesharing or drive alone. The final mode choice model is reported in Table 1. The model includes variables representing household characteristics, social/environmental attitudes, service attributes and work schedule. The base for the model is drive alone, and the function measures ride sharing propensity. Thus, a positive (negative) coefficient for demographic, attitudes and work schedule variables implies an increase (decrease) in ride sharing propensity. Service attribute rating variables are included in terms of the difference between ride sharing and drive alone auto; more positive values favor ride sharing.

Of the demographic variables, the sex of the respondent has a significant effect at the 95% level indicating that women have a greater inclination toward ride sharing than men. The effects of income and number of automobiles are not significant but are in the expected direction, indicating that higher income and/or higher car ownership reduce the propensity to ride share.

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[5]Convenience and independence represents the mode attributes of flexibility, easy to use, independence, and privacy. Timely service represents the attributes of getting to work quickly and arriving at work on-time.

[6]Need for independence includes dislike for dependence on others and a need to have a car at all times. A detailed interpretation of the underlying factors and the method used to obtain composite scores on these factors is provided in Koppelman et al. (1991).

Among the attitudinal factors, only the "need for independence" had a significant effect on the mode choice, with a greater "need for independence" resulting in a substantial reduction in ride sharing propensity.

Table 1. Mode Choice Model[7]

Variables	Estim.	t stat.
CONSTANT	1.685	4.21
DEMOGRAPHICS		
Household Income ($ 000)	-0.002	-1.14
Sex (1=female, 0=male)	0.202	1.72
No. of Cars	-0.069	-1.06
ATTITUDES		
Need for Independence	-0.403	5.19
SERVICE ATTRIBUTES (SHARED RIDE-DRIVE ALONE)		
Convenience and Independence	0.275	5.07
Timely Service	0.116	1.78
Inexpensiveness	0.066	1.52
WORK SCHEDULE		
Additional Trips	-0.164	-1.42
Arrival Flexibility	-0.101	-1.74
Stay late at work	-0.548	-3.09
Number of Cases	951	
Log Likelihood		
At Zero	-659.2	
Estimated Model	-315.8	

Three of the five service attributes, "convenience and independence", "timely service" and "inexpensiveness" had a significant effect on mode choice. Of the three, "convenience and independence" had the largest and most significant effect while "timely service" and "inexpensiveness" were considerably less important.

Of the work schedule variables developed, three were shown to have an effect, two having a significant effect, on mode choice. Individuals who made additional trips

[7]The dependent variable in this model is current ridesharing propensity.

beyond the basic home-work-home tour were less likely to ride share (no significant distinction was found as to whether the additional trip(s) are made before, during or after the work day). People who had more arrival flexibility were less likely to ride share. Other work schedule variables including variations of the non home-work-home trip pattern, departure flexibility, and the number of midday trip reasons did not have any significant impact on ride sharing propensity.

5.2. Stated Intentions Analysis

Stated intentions in response to new vanpool and transit modes were analyzed using ordered probit models designed to measure the underlying propensity to use vanpool or transit relative to drive alone given different conditions of service. These analyses were structured to distinguish between alternative designs of vanpool and transit service programs.

The models for stated intention analysis of new vanpool and transit modes incorporate the ride share propensity variable obtained from the estimation of the mode choice model. The estimate of ride share propensity is entered as a single variable (referred to as an instrumental variable) which retains the relative importance among the variables obtained in the mode choice analysis. Thus, these models reflect the hypothesis that the same propensity variable determines current mode choice and stated intentions about future choice. The estimation of the models produces a scaling parameter and a set of threshold values which are discussed later.[8] The models also include a set of variables which indicate the differences in propensity to ride share based on the specific design characteristics of each new service. These rideshare propensity variations among alternative service designs are estimated in our analysis using service 1 as the base for both vanpool and transit stated intention analysis.

5.2.1. Stated Intentions with Respect to Future Vanpool Service

The estimation results of the stated intentions responses to proposed vanpool alternatives are reported in Table 2. The threshold variables represent the boundaries

[8]The effect of demographic, attitudinal, and work/travel pattern variables on propensity to use future services may be obtained as the product of the scaling parameter (i.e., the coefficient on the current mode-choice propensity variable) and the effect of these variables on the mode choice propensity. An alternative to the model used here is to estimate the relative importance of each variable separately and independent of the results of the mode choice analysis (unconstrained stated intention analysis). The estimation results were substantially different in the two cases (Koppelman et al., 1991), indicating that the importance of variables in the ride share propensity which determines stated intentions is different from their importance in the propensity which determines current mode choice.

Table 2. Vanpool Propensity Model from Stated Intentions Data

Variable	Estimate	T statistic
Current Ridesharing Propensity Estimate	0.469	14.82
Differences Among Services		
Vanpool Service 2	0.273	5.33
Vanpool Service 3	0.432	8.45
Threshold Levels		
Threshold 1	-1.032	-17.58
Threshold 2	-0.255	-4.52
Threshold 3	0.625	10.70
Log Likelihood		
At Zero	-3720.7	
Estimated Model	-3869.7	

Table 3. Transit-Use Propensity Model from Stated Intentions Data

Variable	Estimate	T statistic
Current Ridesharing Propensity Estimate	0.345	14.81
Differences Among Services		
Transit Service 2	0.321	6.44
Transit Service 3	0.218	4.25
Transit Service 4	0.173	3.37
Transit Service 5	0.338	6.66
Threshold Levels		
Threshold 1	-0.903	-18.23
Threshold 2	-0.079	-1.64
Threshold 3	0.917	18.09
Log Likelihood		
At Zero	-6201.1	
Estimated Model	-6335.6	

on the scale of the underlying vanpool intensity which distinguish among the four categories of response. They are unrelated to the behavioral relationships which are of primary interest in this discussion.

The significance of the estimated scale parameter indicates a strong relationship between the mode choice analysis and the stated intentions analysis. The effect on van pool propensity of differences in the proposed services suggests that travelers are price sensitive, and that their sensitivity to price disincentives for driving alone may be large relative to their sensitivity to changes in ride sharing price. Specifically, it appears that there will be a substantially increased propensity to adopt van pool service in response to a $15 per month reduction in van pool cost and a much larger increase in propensity in response to a $60 per month increase in parking costs (service 3 vs. service 1). The $60 per month parking fee is (only) equal to the base price for van pooling. This suggests that when the prices for van pooling and parking are equalized, the propensity to ride share increases substantially over the free parking alternative.

5.2.2. Stated Intentions with Respect to Future Transit Service

Table 3 presents the estimation results of the stated intention responses to proposed transit services. As in the vanpool service analysis, the estimated scale parameter is significant indicating the strong relationship between the mode choice analysis and the stated intentions analysis. The estimated parameters on the transit service variables indicate a substantially increased propensity to adopt transit in response to a $20 per month reduction in cost, a somewhat smaller increase in response to a reduction in service headway or walk time and an increase in response to a $50 parking cost equivalent to a $20 decrease in transit fare.

6. Conclusions and Recommendations

6.1. Market Behavior and Policy Implications

In the midwest suburban setting which was the focus of this study, commuters predominantly use, and strongly prefer to use, drive alone auto as their mode to work. There is some indication that incentives to ride share, in the form of service improvements (reductions in transit headways, walk distances) and price reductions, increase the propensity to use these modes. Ride sharing attributes of importance include convenience and independence, timely service and price.

Greater-- in some cases substantially greater-- increases in ride sharing propensity resulted from proposed service packages which combine improvements for the shared ride mode and direct disincentives for drive alone auto, in the form of substantially increasing parking prices. The full spectrum of costs associated with

implementing a drive alone auto disincentive program may make it unlikely that such efforts will be successfully initiated in the absence of larger political, economic, and/or environmental forces. These could come, conceivably, in the form of the new clean air regulations coming into play in the next few years, or perhaps as the result of major, long-term increases in energy prices.

In the near-term, it might be useful to explore employee response to pricing drive alone auto use in a way that provides the commuting disincentive but enables the employee feel "whole". For example, firms might collect the increased parking fees and use the revenues to amplify employee benefits, such as health care programs, day care services, or exercise and recreation facilities and activities. Alternatively, parking prices could be implemented with a compensating increase in salaries. This may make it more palatable to implement drive alone disincentives.

In addition to service characteristics and disincentives, this research shows that attributes of commuters and their households influence ride sharing propensity. The willingness to ride share is greater for women and persons from households with fewer autos. Ride sharing propensity is less for persons who are from higher income households, have a greater need for independence, make additional trips on their way to and from work, have greater flexibility of arrival time, and frequently stay late at the workplace. These patterns of variation in ride sharing propensity suggest tactics for targeting ride sharing programs in suburban settings.

6.2. Methodological Implications

The results of this study clearly highlight the differences between stated intentions and their derived implications for mode choice, and observed mode choice behavior. Studies based on measuring stated intentions (SI), the willingness to use a mode not now used or not available, are particularly valuable for exploring possible market behaviors in response to service, price and policy changes. They represent a way to bridge from what people have experienced to what they might be offered in the future, and to use that "projection bridge" as a basis for supporting innovation in service and technology.

The potentially substantial differences between stated intentions and manifest behavior underscore the need to adjust the stated intentions results by anchoring them with observations of current behavior. This was accomplished in this research by constraining SI tradeoffs to match those derived from behavioral observations. In the absence of such constraints, the relative importance of attributes (the tradeoffs between service characteristics) implied in the SI analysis differs substantially from the observed tradeoffs. This suggests that using SI methods to evaluate radically new technologies and services may be particularly risky, since it will not be possible to anchor the predictions to observed behavior. In such cases, the uncertainty of market response to

such investments should be recognized in the decision process. As a result, the value of meaningful field experiments, supported with careful evaluations, may be especially high in the assessment of new transportation technologies and services.

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