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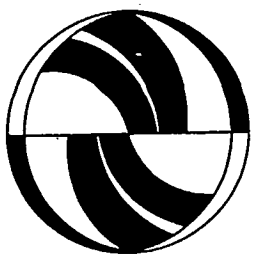

Transportation Demand Management: Policy Implications of Recent Behavioral Research

Martin Wachs

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Transportation Demand Management: Policy Implications of Recent Behavioral Research

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ABSTRACT

Transportation planners are increasingly adopting policies aimed at changing travel choices made by citizens. Rather than trying to solve transportation problems by building highways and transit routes, "transportation demand management" relies on incentives and disincentives to promote carpooling, vanpooling, transit use and changed work hours. These approaches attempt to accommodate travel demand by more efficiently utilizing existing facilities. While many argue that transportation behavior cannot be changed, this review demonstrates that many years of behavioral science research on travel show otherwise. Commuters respond to differences in travel time and travel cost, to changes in work hours and other attributes of travel in systematic ways which are quite predictable. As a consequence, travel demand management is a promising approach to regional transportation planning.

NOTE

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Changing Priorities in Transportation Planning

American attitudes toward transportation planning have recently undergone significant change. For three decades after the end of World War II, public policy emphasized the construction of new highway and transit facilities in order to remove the backlog of needs resulting from the combined effects of depression, a war economy, continued urban growth, and accelerating automobile ownership. For the most part, there was consensus among transportation policymakers that their primary goal was to accommodate growth by constructing facilities which would have adequate capacity to handle future demand. It was understood that land use patterns and economic development were the sources of traffic, yet there was general agreement that transportation policy should aim to accommodate forecasted land use and economic growth rather than to institute regulations to control traffic.

Views of transportation policymakers have been changing under pressure from increasing growth and traffic congestion, coupled with growing limits on transportation budgets, and increasing opposition to highway construction by environmental coalitions and community groups. Now, policymakers frequently argue that "we can't build our way out of our problems," and that attempts to accommodate growth solely by increasing transportation system capacity impose greater costs on communities than are warranted by their benefits. In the seventies, this shift in emphasis gave rise to "transportation system management," the augmentation of capacity through low-capital-cost approaches such as traffic signal synchronization and reserved lanes for high occupancy vehicles. In the early eighties, "transportation demand management" was also emphasized, including efforts to promote ridesharing and transit use by workers through a variety of subsidy and incentive programs. In the late eighties this growing movement toward management rather than facility construction has gained momentum. In addition to transportation system management and demand management, we are seeing increasing effort to change land use policy and attempts to spatially redirect residential and economic growth to control traffic at its source.

Los Angeles is the region which for many epitomizes the historical reliance on the construction of new facilities to accommodate growing travel demand. Yet, the current Regional Mobility Plan (Southern California Association of Governments 1989) and Regional Air Quality Management Plan (South Coast Air Quality Management District 1989) both give unprecedented emphasis to strategies which encourage the reduction of single-occupant

automobile commuting through increased reliance on public transit, vanpools, carpools, telecommuting, changed work hours, and land use changes to encourage greater jobs-housing balance. While about seven percent of the region's trips are presently made on public transit, these plans project a goal of about 19 percent transit utilization by the year 2010, in addition to major increases in carpooling and vanpooling. There is reason to question our ability to achieve a change of this enormous magnitude.

Can We Change Travel Behavior?

Many are skeptical about prospects for achieving substantial behavioral change in travel patterns. Consumer behavior shows a very strong and steadily growing preference for the automobile in America. The National Personal Transportation Studies, based on national samples of several thousand households, showed that the proportion of households not owning automobiles dropped steadily from 20.6% in 1969 to 15.3% in 1977, to 13.5% in 1983, the most recent survey year. During the same period, the proportion of households owning three or more vehicles rose from 4.6% in 1969 to 15.6% in 1977 and to 19.3% in 1983 (U.S. Department of Transportation 1986). And, annual rates of automobile use are growing among those who own cars. Enormous public subsidies to new transit systems have proven cost-ineffective, and transit continues to lose ground to the automobile despite major public expenditures (Wachs 1989). Americans made 3.6% of their trips on public transit in 1969, and that share declined to 3.0% in 1977, and to only 2.6% by 1983 (Dole 1987).

Underlying transportation policymaking in the coming decades is the critical assumption that we have the ability to change people's travel behavior. Will people accept alternatives to the singly occupied automobile, especially for their trips to work, and for other peak hour travel as well? It is said that Americans have developed lifestyles which are dependent upon driving to meet many needs. Urban form has adjusted to universal automobile ownership and use. At this point in time, many think that perhaps very little can be done to reverse this trend. Yet, public policy is increasingly relying on such changes to lessen congestion while meeting future demands for travel at reasonable levels of public expenditure.

Contributions of Transportation Research

Over thirty years, transportation researchers have produced many studies which give partial answers to this critical question. The purpose of this paper is to provide an overview of selected findings from behavioral science examinations of travel in order to arrive at useful insights for policymakers. Many of the relevant studies involved sophisticated mathematical models of interest primarily to travel demand researchers whose reports would rarely be read by public policymakers. Other insights are derived from careful comparisons which have been made of travel patterns before and after some systematic change has been made - such as the opening of a new facility or the imposition of a new fare structure. The literature contains a wealth of knowledge which bears upon the critical question being posed here, but that knowledge is sometimes available in technical jargon and complex mathematical expressions. The purpose of this review is to simplify and generalize for application to policy, and not to debate the finer points of behavioral science research or statistical significance levels.

Researchers and decision makers bring particular ideological commitments or frameworks of belief to their understandings of travel behavior. Some, for example, believe that people always behave rationally, and that when travelers are given choices they will behave by maximizing their personal utility. This view is particularly prevalent among researchers who have studied economics. Others believe that an understanding based upon the notion that the traveler is a rational, economic person is always incomplete. Those trained in psychology or sociology often claim that travel decisions reflect wants, needs, attitudes, and beliefs that go far beyond economic rationality. Some, for example, believe that travel behavior can be better explained by learning theory than by economic theory. In preparing this review, I have been willing to accept the validity of any premises underlying systematic behavioral research, as long as the research has had an empirical component. I have presumed the results of behavioral and attitudinal investigations were useful when they included actual studies of real people regardless of the philosophical position which motivated the study. Public policymakers need to make decisions today, and those are best served by real data from actual experience. They cannot wait for the resolution of debates between theorists espousing competing concepts of human nature. Incidentally, it is interesting to note that findings from behavioral experiments in transportation have often produced similar results even though researchers initiated them on the basis of different premises about human nature.

I believe that the collected body of behavioral research in transportation is unequivocal. It shows that travel behavior does vary greatly with the conditions of choice which confront travelers, and that very different policies can elicit very different choices. John Pucher (1988), for example, has compared travel behavior in eleven European countries and Canada with travel patterns in the United States. Many of the countries were characterized by standards of living which are as high as or higher than that of American cities, yet transit use, bicycling, and walking were far more common for journeys of all types, and there was less reliance on the automobile. Pucher attributes the differences in habits among the countries not to cultural differences or to learned tastes or preferences, but to substantial differences in their transportation, taxation, and land use policies. Typically, countries having very high gasoline taxes and automobile excise taxes, providing much less subsidy to roads, and much less subsidized parking, show much lower use of the automobile. Land use planning is also an important factor in Pucher's results. Zoning to discourage low density single-family communities, provision of appropriate pedestrian and bicycle facilities, and the building of relatively few access-controlled highways all give rise to travel patterns which differ greatly from American patterns.

In the United States, automobile, gasoline, and parking prices are extraordinarily low, and driving is encouraged by many explicit and implicit subsidies. An extensive highway network has been built to encourage urban decentralization and convenient auto use. While transit subsidies have grown enormously since 1964, the level of public transit service declined substantially prior to that date and has not nearly recovered, and our transit subsidies, while expensive, are by themselves simply insufficient to counter the cumulative effects of enormous subsidies which we have long provided and continue to provide to the automobile system.

It is now well known that in Los Angeles during the 1984 Olympic Games, daily traffic volumes were about 15% above the daily traffic volumes normally experienced during the summer months, yet congestion was well below normal and travel speeds were faster than usual. Though traffic volumes were high, trips were redistributed in time and space for the Olympics period. Most observers believe that we lack the institutional mechanisms and the political will to change behavior permanently as we did during the brief Olympics period, but the experience of those ten days clearly illustrated that under the right set of circumstances people do adjust their travel behavior in response to changed conditions (Giuliano 1988).

In part, we can answer the question about the ability of policy to influence travel choices by looking closely at past American policy choices. They favored urban decentralization and ubiquitous automobile access, and produced an automobile dependent travel pattern. This leads clearly to the conclusion that policy does influence travel choices. Different policies in the future can shift travel patterns more toward transit use, carpooling, vanpooling, and cycling. We cannot do so, however, unless some politically difficult decisions are made. It is not likely that we can encourage huge shifts toward transit use while maintaining our current policies which encourage auto use. If we wish to change travel patterns in the future, we must change the policies we have pursued for fifty years or more. The question is not whether travelers will respond to public policy, for the evidence is clear that they will. Rather, the literature review leaves us with a far more important question. Will transportation policymakers be sufficiently bold to adopt the policies which research results unequivocally tell us can change travel behavior?

In the next several sections I will review many studies which provide compelling evidence about the likely effects of policies affecting travel cost and time, comfort, convenience, and safety. All show that people can be convinced to change their travel patterns quite dramatically in response to changes in conditions affecting their choices. After that, I address what the literature tells us about consistencies and inconsistencies between attitudes and preferences stated by travelers and the behavior which we observe when their travel choice situations are actually changed.

Changing Travel Behavior by Changing Travel Cost

On numerous occasions, I have heard public policymakers argue that most people will drive to work no matter what the cost, and that most people who have a choice will avoid public transit no matter what the price of using the different modes. On the other hand, I have heard economists argue that we can completely solve the urban congestion problem by pricing - using peak/off-peak pricing differentials and congestion tolls. The truth must lie somewhere between these extreme views, and there is by now a great deal of literature to shed light on this question.

The demand for travel by any mode is not fixed, but it is like the demand for other commodities - steak dinners, shoes, or television sets. As the price for any of these falls, we

wish to consume more of that commodity; as the price rises, we wish to consume less of it. So it is, in general, with travel.

It is important to note, however, that a large number of studies have obtained consistent results regarding the extent to which most commuters or automobile drivers actually estimate the costs of their trips. For the most part, travelers rarely enumerate the total cost of owning and operating an automobile, nor do they attempt to estimate the true total cost of a particular trip, no matter how regularly they make it (Louviere, et al 1981; Johnson 1975; Adiv, 1980). It appears that the capital costs of purchasing a car, insuring it, and maintaining it are borne by travelers regardless of any particular trip. Thus, while these factors enter into automobile ownership decisions, they are typically ignored in daily decisions about trip making. On the other hand, what some call "out-of-pocket costs," the costs of gasoline, parking, tolls, and transit fares are considered quite explicitly in daily travel decisionmaking. Changes in these costs do indeed seem to have strong influences on travel decisionmaking. By weighting out-of-pocket costs much more heavily than capital costs, commuters appear to be acting consistently with economic theory, which views the cost of acquiring an automobile as a "sunk cost" with respect to daily travel decisionmaking.

Many studies of commuters' willingness to carpool have shown that commuters consider the out-of-pocket costs of carpooling versus driving alone to be among the two or three most important factors influencing the choice between those modes, the others being travel time and convenience (Berry 1975; Olson Market Research, 1985; Harrison and Lung 1985; Gelb and Donnelly, 1985; Gelb and Donnelly, 1985a). For example, it has been shown repeatedly that commuters are more willing to endure the delays and inconveniences of carpooling if they are making longer trips rather than shorter ones. The reason for this is that the dollar cost savings are great enough only on longer trips to compensate for the drawbacks of ridesharing.

The influence of cost savings on travel choices is perhaps most dramatically demonstrated in studies which have examined the cost of parking. It is well established that as many as 90% of American workers receive free parking at the workplace, a subsidy which constitutes a great encouragement to drive to work alone (Shoup and Pickrell, 1980). Consequently, when parking charges are introduced, dramatic changes in mode choice are observed (Willson, Shoup and Wachs 1989). In a study of the Los Angeles Civic Center, 72% of County employees (who parked free at County expense) drove to work alone, while only

40% of comparable Federal employees (who paid to park) drove to work alone (Francis and Groninga, 1969). In Century City, Shoup and Pickrell (1980) found that among workers whose parking was available free, 92% drove to work alone; 85% of those whose parking was partly subsidized commuted in singly occupied vehicles; and only 75% of those who bore the full cost of parking commuted to work as solo drivers. In another study of the employees of Commuter Computer, the regional ridesharing agency, Surber, Shoup and Wachs (1984) found that 42% of the company's employees drove to work when the company paid the monthly parking fee for solo drivers, but when the company ended the practice of paying for parking at work, the proportion of workers driving alone dropped to 8 percent. When free parking was available, average automobile occupancy was 1.2, and after free parking was eliminated it jumped to 1.8. In another recent experiment at a large insurance company at Warner Center, when free parking was eliminated and a fee of thirty dollars per month instituted, the share of solo drivers fell from 90% to 46% (Willson, Shoup and Wachs, 1989). In each of these cases, the mode shift achieved by a monthly market-rate fee for parking exceeded the modal shift which is expected from any new rail construction project in its region. Higgins (1989) surveyed over one hundred transportation demand management programs at suburban mixed-use activity centers. He concluded that a common dimension among the most successful programs was that all of them incorporated parking management, usually involving an increase in the cost of employee parking. On the other hand, the vast majority of the programs had little or no effect on commuting behavior, and virtually all of those that were ineffectual left subsidized employee parking benefits intact. This must leave transportation policymakers with the clear impression that the price of travel is a significant lever available to use in achieving changes in consumer behavior.

Variations in transit fares have also shown that transit ridership is quite sensitive to the price of service. Normally, however, changes in transit fares have been less dramatic than the imposition of major parking fees of thirty of forty dollars. Dozens of transit fare changes have been monitored, and we know with reasonable certainty that changes in transit fare have elasticities in the range of -0.3 to -0.4. This means that a one percent change in transit fare leads to a change in ridership of 0.3% to 0.4% in the opposite direction (a rise in transit fare leads to a decline in ridership; a decline in fare leads to a rise in ridership). Massive fare changes, or outright eliminations of fares have been known in certain instances to bring about much larger, though often highly localized, changes in ridership. In Auburn, New York,

elimination of a 25-cent transit fare led to a jump in monthly patronage from 18,000 to 88,000. In Seattle, elimination of fares within a special downtown transit-free district resulted in an estimated three-fold increase in intra-CBD trips, while in Portland the creation of a fare-free zone is regarded as the major cause of a nine-fold increase in ridership within that specific zone (Barton-Aschman and Associates, et al 1981).

The energy crises of the seventies also provided an opportunity to observe the effects of changes in transportation prices on traveler behavior. During the two energy crises, prices of gasoline rose precipitously, while supplies became limited and long waits at gas pumps were typical. It is difficult, therefore, to attribute observed changes in travel behavior to price changes alone, for many analysts believe that the limited supply of gasoline was the more influential factor. Nevertheless, the joint effects of price changes and supply limitations were clear. First, there were substantial declines in driving, with non-essential trips, vacations, and social-recreational travel declining much more than work trips and personal business. In addition, consumers shifted toward smaller, more fuel-efficient cars when they bought new vehicles, and many accelerated their schedule of vehicle replacement. Finally, we observed much more "trip-chaining" (the combining of trips for multiple purposes) as consumers tried to adopt more efficient movement patterns while accomplishing all of their household needs (Neveu 1977; Hartgen, Brunso, and Neveu 1983). Changes of mode, however, were less dramatic than those measured when substantial increases have been instituted in parking fees (Peskin 1980). That finding is not surprising, considering that the typical twenty-mile round trip between home and work might consume one gallon of gasoline, on average. Thus, even a fifty-cent per gallon increase in the price of fuel during the energy crisis constituted a lesser cost increase than a daily parking fee of several dollars.

Changing Travel Behavior By Changing Travel Time

Many studies, conducted over three decades show that travel time is one of the most critical variables affecting travelers' choices of modes, routes, and departure times. Thus, travel time advantages can be used in the design of policies intended to bring about changes in travel behavior (Fulton 1988). Studies of traveler attitudes and behavior, however, repeatedly demonstrate that commuters reactions to travel time are quite complex, and go far beyond the mere consideration of total elapsed travel time measured in minutes. Rather, attitudinal studies show repeatedly that perceptions of the importance of travel time depend

on travel time reliability, or the day to day variation in travel time, as well as the typical travel time for a particular trip. Arriving on time at an intended destination is often seen by travelers as more important than minimizing travel time. This is understandably important in work trips, but it proves to be significant in non-work trips as well.

When attitudinal surveys were conducted among riders of the Shirley Highway express-bus-on-freeway project in the Washington, D.C. area, it was noted that, among express bus riders who had previously commuted by automobile, travel time savings were the most frequently cited reason for switching to the bus (in comparison with such other factors as cost, congestion levels, and comfort). However, when specifically rating attributes of the bus services which were of great importance to them, 90% of the bus users cited the reliability of the schedules, while only 29% cited a five-minute saving in average travel time (Wachs 1976).

In addition to the consistent finding that travel time reliability is more important than elapsed travel time per se, surveys of travelers' attitudes and behavior also demonstrate that time spent in walking, waiting, looking for a parking space, or transferring modes is more onerous than time spent moving between one's origin and destination. A variety of studies, conducted in different environments, involving different trip purposes and different modes, have shown that people psychologically weight "out-of vehicle time," somewhere between two and three times as heavily as they weight "line-haul" time or moving time in their travel decisions. In simpler terms, a minute spent waiting at a bus stop, walking to or from a bus stop, looking for a parking space, or waiting on a line, influences travel choices between two and three times as much as a minute spent moving on a vehicle between an origin and destination. (Wachs 1976; Domencich and McFadden, 1975). Because the automobile is superior to most ridesharing and public transit modes in minimizing out-of-vehicle time, this finding helps explain the widespread preference expressed for commuting by automobile (Adiv 1980).

Many modern transportation strategies are designed to encourage commuting by modes other than the automobile by eliciting particular responses to commuters' travel time preferences. For example, high occupancy vehicle (HOV) lanes are intended to provide an advantage to carpools, vanpools and buses by allowing them to bypass congestion on the adjacent mixed flow lanes. Often, the greatest advantage of HOV lanes is in the improvement they provide in travel time reliability. They may, on average, save travelers

several minutes in overall travel time, but in addition they may enable HOV occupants to bypass episodes of congestion which make travel times less predictable on a day-to-day basis (Giuliano 1989).

Buses, vanpools, and carpools often require much more waiting time, "terminal time" or "passenger collection time" at each end of the trip than the single-occupant automobile. If congestion is not heavy on a freeway, or if the trip being made is relatively short, only a small travel time gain can be obtained from HOV lanes, which might not be sufficient to offset the travel time losses of the high occupancy vehicle modes. It is critical to design HOV programs to maximize travel time reliability and to minimize waiting times, which are weighted by commuters more heavily than moving times. Priority parking locations for vanpools and carpools is one approach which has been widely adopted. The provision of HOV bypass lanes at congested freeway ramps, and of exclusive lanes for HOV vehicles on local streets in downtown areas could be equally important to the provision of HOV lanes directly on freeways, because of the heavier weight travelers give in decisionmaking to travel time delays at the trip ends (Barton-Aschman Associates, Inc. 1981).

It is well known that some workers prefer to leave home very early in order to avoid congestion on the way to work, even though that decision may mean that they arrive at work an hour or more before the official starting time. Others remain at their desks long after the official closing time in order to avoid traffic congestion on the way home (Fulton 1988). This well-known phenomenon has led over the past decade to official programs of work-hour variation in an effort to influence traffic congestion. Staggered work hours, flexible work hours, four-day forty-hour weeks, and a variety of related work time variations are now well established components of transportation system management.

Such programs have proven dramatically effective in some settings, with reductions in peak period congestion as high as 20% or more in some applications (Barton-Aschman and Associates 1981). The benefits of such programs, however, are often quite localized. For example, congestion reductions may be very dramatic on a particular arterial street or at a freeway off ramp near a major employment site, but the reductions are "dissipated" within a half mile or more from the employment site, since with increasing distance from the site the proportion of the traffic stream affected by any such program drops rapidly. Work hours changes have also been used to manage flows of passengers at overcrowded bus stops and rail transit stations quite effectively.

While some employees and employers have resisted work hour changes, the majority of research reports on attitudinal responses to these programs have shown positive reactions. In many instances, changes in work hours facilitates carpooling, vanpooling or transit use, since flexible hours allow workers to adjust their hours to travel options. On the other hand, it has been sometimes noted that work hour changes may push starting and ending times toward periods of sparse transit service, and in such cases the opposite effect on ridesharing has sometimes been noted (Safavian and McLean 1975; O'Malley and Selinger 1973; Port Authority of New York and New Jersey 1975; Harrison, Jones and Jovanis 1979; Tanir and Hartgen 1977).

Other Characteristics of Travel Modes: Safety, Comfort, Convenience

Applications of behavioral science to transportation planning give greatest emphasis to travel time and travel cost as the characteristics of travel modes most likely to influence choices made by commuters. Behavioral science research has, however, addressed other aspects of travel modes which might also affect travelers' choices of modes, routes, and times of travel. In general, the findings support the conclusion that travel costs and times are the dominant factors, but in certain circumstances other variables can become very important also.

Travel modes differ with respect to comfort, convenience, privacy, safety, security, and other factors as well as travel time and cost. Under most circumstances travelers are aware of the differences between modes with respect to these factors, but weigh them less heavily than travel time and cost in decisionmaking. Travelers implicitly assume that automobiles, buses, and subways are relatively safe from accidents, and in general the accident rates per passenger mile indicate that this is a reasonable assumption. On occasion, however, a rash of accidents on a particular rail line, bus system, or highway segment heightens awareness of safety, and commuters for a time may rate safety as being of paramount importance (Wachs 1976). Similarly, travelers expect to be safe from crime while using public transit, or while walking to or from their parked vehicles. In most circumstances the probability of being the victim of a crime when traveling is so low that it is not even considered when arriving at a choice of travel mode. On the other hand, crime rates have become so high on certain bus routes, at particular transit stops, or in the New York and Chicago subways, that some travelers have suddenly reported that safety has become their primary concern when making travel decisions (Levine and Wachs 1985). Planners must be

attentive to the particular circumstances in which unexpectedly high levels of exposure to danger can render ineffective their efforts to affect travel behavior through programs affecting travel time and cost.

There is ample evidence that travelers do not expect transit vehicles to provide them with the many amenities they might find in a personal automobile. Attitudinal studies over three decades have shown that plush interiors, extremely smooth rides, and the ability to listen to stereophonic sound are hardly significant in travel decisions. Among the comfort variables which have been tested in attitude studies and marketing experiments, it has typically been found that climate control (air conditioning and heating), and exposure to rain, snow, or the hot sun are much more important than other comfort and convenience variables. These should routinely be taken into consideration in the design of transportation vehicles and terminals. Somewhat less important than climate and temperature control is space for packages. Women have more often than men indicated that their choice of travel mode has been significantly affected by the absence on transit vehicles of appropriate space for shopping bags, strollers, and baby paraphernalia (Wachs 1976; Wekerle 1980; Wekerle 1984).

Relationships Among Attitudes, Behavior, and Situational Variables

What are the best predictors of travel behavior? Which socio-economic characteristics of a traveler are most likely to be accurate predictors of preferences and of travel behavior? These are questions which have preoccupied behavioral researchers in transportation for several decades. While answers to these questions are still debated by experts, certain patterns are by now well understood.

Some researchers believe that attitudes of travelers - statements of preference or behavioral intent - can provide important information in the prediction of travel behavior. One of the best ways to discover whether people will behave in a particular fashion might be, quite simply, to ask them about their preferences. Many researchers, following this line of reasoning, have tried to build mathematical models which predict travel behavior on the basis of stated preferences in attitude surveys. Others have insisted that attitudes - sometimes called "conceived preferences" - provide very poor predictors of actual behavior, and have preferred to build predictive models solely on the basis of "manifest preferences," or behavior that is directly monitored.

It is now pretty well understood that relationships between attitudes or preferences on the one hand, and choices or behavior on the other are quite complex (Charles River Associates, 1978). While we can learn a great deal about behavior by studying attitudes, stated preferences in general cannot be taken directly as effective predictors of travel behavior. This is because constraints on travelers have a great effect on our ability to act in accordance with our preferences. For example, while many citizens might respond in a survey that they "would use a rail transit system if it were built," researchers find, not surprisingly, that the stated preference is a better predictor of behavior among those who reside within a few blocks of a station than it is for those who reside miles away from a station. This comes about, in large part, because it is difficult to ask attitudinal questions which are sufficiently specific and precise to capture the conditions that might limit choices of individual travelers. The respondent might honestly express a preference to use the subway, without thinking of limited spatial or temporal access; and later decide not to use the system because these constraints exist (Hartgen, 1974; Tischer and Phillips, 1979; Tardiff, 1977).

Another complication arises from the fact that we do not completely understand the mechanism by which attitudes and behavior are causally linked with one another in travelers' minds. We do not know whether people adjust their behavior to make it consistent with their preferences, or whether people are equally likely to adjust their preferences to make them consistent with their behavior. In actuality, people probably do both simultaneously. If we observe that people using the bus are more favorable to it than are people who drive to work, we may be tempted to conclude that commuters are more likely to ride the bus when they are favorable to its characteristics. This may be partly true but, on the other hand, some research has applied the theory of cognitive dissonance to travel behavior. Using this theory it can be shown that people who don't have cars - and thus must use transit - actually adjust their attitudes to their behavior, becoming more favorable toward transit so that their attitudes will be more in balance with the choices they must make. Relationships between attitudes and travel behavior become even more complicated because we often observe that personal characteristics - including gender, income, age, level of education, and ethnicity - are correlated with both attitudes and travel behavior. Differences between men and women or between poor and affluent people may be learned products of our culture. They may also merely reflect the fact that some people have more power and control more resources, and therefore may have greater opportunity to behave in accordance with their preferences, while

others may be less able to act in accordance with their preferences because of economic or social constraints.

Because of the enormous complexity in the relationships between attitudes, behavior, and social and economic constraints, it proves useful to employ a technique, called "market segmentation," which is widely used in the field of marketing. When people are grouped by socioeconomic and demographic characteristics, and by constraints (like whether or not there is transit service in their neighborhood or whether or not they own a car), the structure of the relationship between their attitudes and behavior becomes clearer, and attitudes and behavior seem more easily explained on the basis of one another (Dobson and Tischer, 1976; Dobson and Nicolaidis, 1974).

The complexity of the relationship among attitudes, travel behavior, and socioeconomic conditions must be appreciated by decision makers, who should not be discouraged when overly simplistic statements about citizens' preferences prove inconsistent with observed behavior. While a great deal of ambiguity remains in this interesting area of behavioral science research, detailed study of attitudes and behavior by experienced people familiar with the literature, can yield useful insights for policymaking.

Transportation Demand Analysis Capabilities and Future Requirements

The state of the art in travel demand analysis is quite advanced. Mathematical models available for forecasting travel demand and for simulating choices by travelers are more advanced than the tools of analysis available to planners in virtually every other sector. This is the legacy of more than thirty years of research on travel demand forecasting which was relatively well endowed by the federal government, and which attracted the interest of a large group of competent academics and technical experts in consulting firms and government agencies. Most of the interest in travel demand modeling was spurred by a sustained national program of new facility construction lasting over forty years. In the sixties and seventies, there was national consensus that the national system of highways had to be vastly improved, and mathematical modeling for travel demand analysis emphasized improving our ability to make choices between large capital investments in different corridors, and on evaluating highway projects of different capacities and operating characteristics. In the seventies and eighties, as the national highway program was completed, emphasis slowly shifted toward new capital investments in public transit, and again choice models played a

central role in policymaking, with emphasis shifting toward models which were more effective at predicting mode choice. Travel demand analysis techniques were perfected in support of highway and transit facility construction, and our national system of highways and urban rail systems were actually planned using these techniques (Transportation Research Board, 1984). Modeling approaches were strengthened both by the expenditure of resources on their improvement, and by the opportunity to retrospectively evaluate their performance by observing human behavior with respect to the systems which had been planned using those methods.

The late eighties and nineties are characterized by declining resources for the construction of new facilities and increasing commitment to managing our way out of our problems rather than building our way out of them. Declining funding for new facilities is also resulting in declining funding for research on travel demand analysis techniques and for planning studies which might employ these techniques. While the techniques of demand analysis were strengthened in an era of emphasis upon expansion of the physical plant of transportation systems, the techniques themselves are quite generalizable to the analysis of other types of choices faced by travelers as the emphasis in transportation planning shifts toward transportation systems management and travel demand management and away from facility construction. Despite the applicability of travel demand analysis techniques to demand management, most demand management programs are today based on very little analysis, and few applications of existing methods for the analysis of travel behavior. Few data bases are being developed which would allow applications of widely available travel demand forecasting techniques to such demand management strategies as variations in the pricing of auto travel combined with the provision of alternatives including vanpools, flexible work hours, and telecommuting, and a far smaller proportion of transportation budgets are today being spent on demand analysis studies in anticipation of policymaking than was the case a decade ago. I have tried to show in this paper that insights from travel demand analysis are quite applicable to current policymaking, and I believe much more attention to data collection, case studies, and model adaptation is warranted.

We understand a great deal about the relative weights given by travelers to such variables as travel time and cost, and quite a bit about the relationships among travel choices, attitudes, and behavior. Much of this understanding was developed during the decades between 1960 and 1980, while in recent years the progress of this field has slowed as there

has been less funding available for the pursuit of these topics in universities and research institutes. On the other hand, the growing emphasis in transportation planning upon travel demand management provides new opportunities to apply these research findings to transportation policy in ways not always envisioned when many of the seminal studies were conducted. This literature review, hopefully will contribute to a greater understanding on the part of transportation policymakers of the contributions which can be made to their work by the results of behavioral science research.

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