EFFECTS OF INCREASED HIGHWAY CAPACITY: RESULTS OF A HOUSEHOLD TRAVEL BEHAVIOR SURVEY

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INTRODUCTION

Few current transportation issues engender more controversy than the effects of adding new highway capacity on traffic and travel demand. The purpose of adding new highway capacity is to reduce traffic congestion and improve automobile travel times, and in some cases, air quality. These changes in turn affect travel behavior by affecting peoples' choice of modes of travel, their choice of destination, and their choice of travel route.

Less well known is how travel time changes caused by capacity increases may affect total travel demand, especially trip generation (i.e., the number of vehicle trips made per person or per household). Estimating the magnitude of this effect on trip generation is particularly unclear. One of the primary purposes of this project was to examine the effects of new capacity on trip generation, since in most conventional North American travel forecasting models, trip generation is not sensitive to transportation supply variables (In some models, such as that used by the San Francisco Bay Area MTC, trip generation is indirectly linked to transportation supply. In MTC's case, it is through the auto ownership model, in which accessibility drives auto ownership rates, which in turn are the basis for trip generation).

The Importance of the Issue to Clean Air and Transportation

Federal, state and local governments spend billion dollars a year on new road improvements to reduce congestion, improve safety, and provide for economic development. Popular, and some professional, opinion has it that new capacity in urban areas is swamped by new demand, so that in the end motorists are no better off than before the improvement was made (Downs, 1962; Bass, 1992). Disagreements arise as to whether this effect exists, and if it does, what its magnitude is. The issue has moved to center stage because the *1990 Clean Air Act Amendments* prohibits recipients of federal transportation funds from constructing projects that worsen air quality in non-attainment areas.

Depending on the trip-inducing effect of the road improvement, it may improve air quality. New road capacity, to the extent that it reduces speed variations (stop-and-go driving) and allows vehicles to travel a steady 30-45 MPH, improves air quality. This claim has been challenged by others, who maintain that any air quality benefit of new road capacity in the short-term will be offset in the longer-term by increased travel demand that will nullify any improvement in the total emissions.

Of course, the trip induction effects of new highway capacity do not have to be zero for there to be a net air quality benefit, but they must be smaller than the increase in emissions per vehicle. An improvement that reduces vehicle emissions by five percent per trip, but increases trips by two percent, would still result in a three percent reduction in emissions.

Study Purpose and Research Approach

The purposes of this study were to answer two fundamental questions: do capacity increases increase trip-making? And if so, what is the magnitude of this increase, if it exists? The overall research objectives were accomplished through a variety of means; this paper reports primarily on the results of a household survey of traveler behavior conducted as part of the study. Past attempts to assess the travel impacts of new highway capacity have generally relied on before-and-after traffic volume comparisons. In some cases traffic counts have been supplemented with roadside interview or home interview surveys. A few investigators have attempted to fit regression models for predicting regional VKT (vehicle-kilometers of travel) increases that result from regional increases in highway capacity. However, this approach has generally not been fruitful, since there are many extraneous factors that can affect the results, including the availability of alternative modes and routes in each corridor; the condition of the local economy (growing or stagnant); zoning; and natural constraints to development. These factors not only affect the conclusions but also limit the validity of extending these results to other situations and locations.

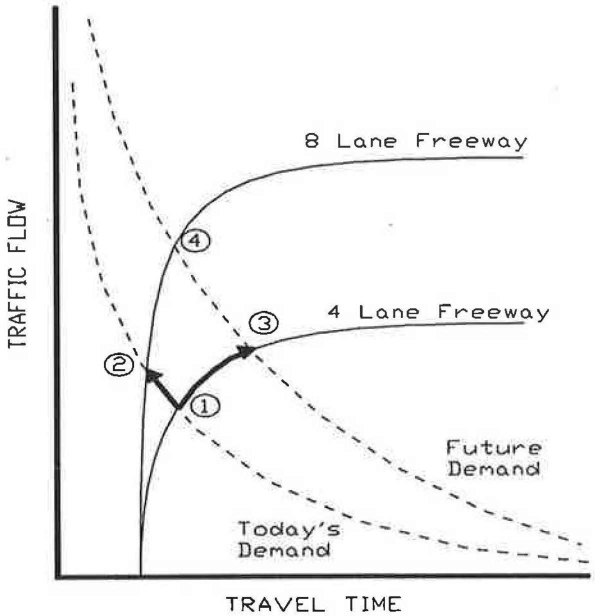

FIGURE 1 Demand vs. capacity change.

The original scope of work for this project had called for a relatively large number of case studies (30 or more) to be analyzed to identify the *ceteris paribus* effects of new highway capacity, including comparisons of projected traffic volumes with actual counts. It became apparent that this approach would not yield the desired results. Shortcomings of the case study approach are documented in the literature (ITE, 1980; Stopher, 1991). A brief summary of our own reasons for proposing an alternative approach follows:

Control of Exogenous Variables (e.g., economic conditions)

Transportation changes take place in a highly dynamic environment: variables such as household income, population, employment, fuel and parking prices, and other variables cannot be directly controlled for. A time series approach may not control for the distributional shifts in land use activities that transportation investments may induce if the area of analysis is limited. This creates a considerable problem in distinguishing between a shift *along* the demand curve (due to the reduced price of travel caused by added capacity), and a shift in *the demand curve itself* (see Figure 1). Demand curves may shift due to changes in income, tastes, demographic factors, and so forth. Point number 1 represents an initial condition with a four-lane freeway; point 2 is the result of a capacity increase (travel time reduction) and the associated movement along today's demand curve. Point 3 is purely the result of a demand curve shift, possibly due to such factors as increased population or income, but also possibly due to reduced transit service, higher fares, or changes in taste. Point 4 is the final equilibrium, a combined result of capacity and demand increase.

Completeness of Data Sets

The data requirements of a case study approach require that there be (as a minimum) traffic counts on the new facility and all paralleling routes on an annual basis, along with good records of land use changes in the corridor. Local agencies often lack consistent annual count programs with counters placed at the correct locations to assess changes in corridor demand due to capacity changes. Even if all of the count data were perfectly available, it may not have the appropriate temporal resolution needed to assess the impacts of new capacity. Ideally, counts would be available at 15-minute intervals, to assess the impacts of temporal shifting in travel, and especially the "peak within the peak." Information needs to be available on all paralleling transit services; even then, one would not know what the changes in destination choices were (were people driving further because of the new capacity in order to reach a "better" destination; or the shifts in land uses that took place over time.

Differences/Comparability of Data Collection Years

Traffic counts, income and other demographic information are typically not available on an annual basis. Most agencies make projections or estimates may be available at five-year intervals, and traffic counts are frequently only made at two or three year intervals (sometimes less often than that). This presents an awkward problem of interpolating between demographic data, traffic count, and traffic forecast years. Increased real income and family size (lifecycle issues) typically result in higher levels of auto ownership and a desire for more residential space. Detailed geographic information at the corridor level is usually available only from the US Census, which is conducted too infrequently (every ten years) to be useful.

Institutional Bias

Forecasts may contain an institutional bias, perhaps unconsciously, that tends to support the construction of a facility. An agency may make reasonable assumptions within a "gray area" of discretion that favors the action that the constructing agency wishes to take. This bias can vary with time, place, and the individuals involved, but can all lead to forecasting errors. An agency could use optimistic or pessimistic views of the economy, of population growth, and so forth.

All of these considerations pointed toward the need for an approach that:

- Considers trips in the context of the overall activity patterns of travelers;
- Considers a wider range of alternatives than would be possible to test with the case study approach; and
- Avoids the shortcomings of completeness of data sets, control of exogenous variables, and other limitations noted above.

RESULTS OF PREVIOUS RESEARCH

Increased highway capacity may affect travel in a number of ways. In urban areas, new capacity typically reduces congestion, resulting in shorter travel times during some or all of the day, and a less stressful driving experience (In many rural areas and small cities, where congestion is minimal, new capacity may or may not change travel times). The literature (Jorgensen, 1947; Pells, 1989; Loos, 1991; Dobbins, Hansen, 1993) documents a strong relationship between reduced travel times and these short term effects:

- The choice of the route taken. This effect has been found to be consistently important in the literature. A major assumption underlying the conventional four-step travel forecasting process is that people seek routes that minimize travel time and cost.
- The scheduling of the trip (time of day the trip starts/ends). This effect has also found to be consistently important in the literature; new highway capacity has often been found to cause shifts from off-peak or "shoulder" transitional times, to the "core" peak periods of travel. This affect was found in examining traffic count data before and after widening of California Highway 78 in San Diego, the M10 Orbital Motorway (Loos, 1992), and other locations.
- The choice of the travel mode used (e.g., carpool, transit, drive alone). This effect has been shown to be a much weaker impact than route and scheduling choice, but still important. The effect is probably more important in the longer term, as changes in auto ownership and land use take place. Studies of the substantial and sudden capacity *reductions* caused by the 1989 Loma Prieta earthquake indicate substantial shifts to transit modes (Homburger, 1990), with about a 10 to 15% reduction in the number of *total* daily trips (Markowitz, 1990). This reduction is modest compared to the very large increase in travel time occasioned by many transbay travelers during the approximately one-month period when the Bay Bridge was closed due to the Loma Prieta quake.
- The frequency the trip is made. The literature has been inconclusive on this topic, with some studies indicating significant impacts, and others indicating little or no measurable impact. Therefore, this impact was one of the primary concerns of this project.
- The linking of trips with several destinations together (sometimes known as "trip chaining" or "trip tours"). This appears to be an important impact, but has proven difficult to measure, and is generally outside the scope of this paper.
- A change in the choice of the destination of a trip; likewise, this impact has proven difficult to measure.

Rothblatt, Colman and Bossard (1994) have examined disaggregate household vehicle trip generation rates as a function of proximity to freeway ramps, using this distance as a proxy for accessibility to destinations in 24 urban California counties. About 6,200 randomly selected households were included in this study, allowing for important demographic variables to be normalized. They found no significant correlation between the two. However, this approach had limitations, in that distance to the freeway could only be measured as distance to the census tract centroid, since survey address records were destroyed (Caltrans, 1993). Furthermore, the results are complicated by the fact that the convergence of freeways near the cores of central cities mean that lower income residents often are the most proximate to one or more freeway interchanges.

Areawide models (derived by correlating VKT growth to highway growth) seem more desirable than facility-specific studies, since they eliminate the route choice effects by considering entire regions (Garrison and Worrall, 1966; Ruiter, 1980). They are also able to take into account long term land use effects by extending the analysis over several decades. However, they focus on VKT rather than PHT (person-hours traveled) and consequently confuse mode shift effects with true induced demand. These studies have been inconclusive about the elasticity of demand (trip generation) with respect to new lane-miles of capacity; although all the reported results have been inelastic, they range from a very inelastic 0.1 to a much more elastic 0.8 (Dobbins and Hansen, 1993).

But the areawide studies suffer from several critical deficiencies; first, they use a single relatively simple measure of capacity increases (such as lane-kilometers or lane-miles) that are insensitive to the potentially significant different demand effects that would occur if the same investment is made in the center of the region versus the fringes. There are definitional problems in computing the denominator of the elasticity equation; the percentage increase in capacity must be estimated, meaning that a "base" capacity must be measured. Should the base capacity be measured at the corridor, county, PMSA, or CMSA level? Economic theory, as well as experience with transportation/land use forecasting models, indicate that transportation supply cannot be treated as a homogeneous product (Association of Bay Area Governments, 1991).

Common sense suggests that new highway capacity has different impacts in an area that is already "built out" as opposed to one where much undeveloped land exists simultaneously with strong pressures for development. The costs of parcel assembly, structure demolition, and so forth, are simply too high. As Meyer and Gomez-Ibanez (1981) point out, in most cases the structure built on a parcel of land in the United States is the only one that has ever occupied that piece of property. Of course, common sense is not always right, but this view is also bolstered by economic theory.

Second, most areawide studies assume a constant elasticity of demand, probably due to the lack of enough data points to estimate anything else. Intuition suggests that the elasticity is not necessarily constant, but instead depends on the amount of current congestion and capacity of the system, the timeframe involved (short- vs. long-term), the trip purposes of road users, and possibly other factors. This issue requires further research.

Because of the problems associated with the case study before-and-after approaches (facility-specific or areawide), it was decided to use a survey of household travel behavior to isolate the various effects of new highway capacity, and identify those not currently treated by conventional travel forecasting models. The travel survey and its results are described below.

RESULTS OF THE TRAVEL BEHAVIOR SURVEY

A travel behavior survey was developed and administered to fill in the missing information from the case studies on the relative importance of the different effects of new highway capacity on travel behavior. Each potential effect (mode, time, destination, trip generation) would be identified and quantified for the purpose of determining its relative importance in estimating the total demand effects of new highway capacity.

Selection of Survey Approach

There are two general approaches to conducting behavioral surveys: stated preference (SP) and revealed preference (RP). Ben-Akiva, Morikawa and Shiroshi (1989) provide a comparison of these two methods; briefly, a stated preference survey poses various situations to the interview subject and asks: how would you respond to the given situation given certain constraints? A revealed preference survey relies upon the interviewee revealing his actual response to alternatives existing in the field. RP surveys can test only for the conditions that exist in the field, while an SP survey can explore behavioral changes due to a much wider range of options.

RP surveys have traditionally been used to calibrate travel forecasting models. RP surveys provide information on the actual, discrete choices made by individuals in the face of two or more options. A before-and-after study comparing travel diary information before and after the opening of a new freeway would be an example of the RP approach: the change in the number of trips per person would indicate the impact of opening the new freeway.

RP surveys have several limitations when applied to the problem of estimating the behavioral effects of new highway facilities. The critical shortcomings are the difficulty in avoiding bias in the selection of the survey sample and accounting for persons moving into and out of the presumed "impact" area of the new facility, and controlling for changes in background variables, such as economic and demographic changes.

The major drawback in applying an SP survey to the research problem was that traditional SP surveys require that the respondent be offered a choice between trip or transportation system attributes that force a realistic trade-off by the user. In the classic SP survey, the respondent is offered a higher fare/shorter travel time option, and a lower fare/longer travel time option. With increased highway capacity/reduced congestion, such a tradeoff was not possible, since presumably everyone would prefer a shorter travel time. In order to make meaningful tradeoffs between alternatives, the respondent was asked to describe *all* of his previous day's activities, and then contemplate how he would alter them if more (or less) time were available yesterday to perform those activities. Perhaps more precisely, it is how people would used "released" or "freed up" time, if congestion-relief projects made such time available.

The survey also embodied concepts from the developing field of activity analysis (Kitamura, 1991). The basic concept of the activity-based travel model is that everyone has exactly 24 hours in a day, 168 hours in a week, to allocate among various activities-- including travel. For the person who works eight hours a day, and sleeps eight hours a day, this leaves only eight hours for commuting, handling errands, household and family chores, recreation, and so forth. The allocation of time is not a simple process, since each person faces a set of constraints that must be met: be at work by 8 AM, pick up a child from Little League between 4:00 and 4:15 PM, and so on. Within the survey instrument developed here, people were asked about all of the previous day's activities, and then asked to respond to changes in travel and activity patterns given changes in travel time for trips made on the reference day.

Although the 24 hours available each day is fixed for every individual, the allocation of time to each activity is not. The time and money allocated to travel is further subdivided among mandatory activities like going to work, school, etc., and discretionary activities such as going to a movie. These various daily activities can be thought of as "goods" in the economic sense which people "purchase" by spending "time" and money on the activity. A 1987 survey (Wiley, 1991) found that the average California adult spends 1.8 hours a day traveling, more than 10% of his or her waking hours.

Each survey respondent was told:

> *We are trying to find out how traffic congestion affects what people do. I am going to describe what might happen if traffic congestion got better or worse, and ask you how you might change your activities or travel as a result. Please take some time to think carefully about what you might do.*

The respondent was then read back all of the trips he or she made the previous day, and asked:

> *Consider what you told me about what you did yesterday. For each trip I am going to ask you what you would have done if it had taken less time to make the trip. Consider your first trip yesterday. You started at... [time] and went to ...[destination] by... [mode]. This trip took ... [duration previously stated by respondent]. Now suppose that this trip took [randomized duration] less time to make. Please select one or more of these statements that best describe what you would have done.*

Respondents were not asked about trips that were less than 10 minutes in duration, since the minimum travel time savings "offered" was five minutes, and it was felt that for trips of less than 10 minutes, a 50% time savings would be unrealistic and unlikely to be achieved by any plausible capacity-increasing project. In fact, one of the survey problems was that the total travel time change was independent of the individual's reported trips. Also the total released time during the day was not keyed to a specific hour, which some respondents indicated would condition their response of how the time were used.

Survey Methodology

Adults over the age of 16 in the San Francisco and San Diego metropolitan areas were randomly selected; these two areas contain about 8.7 million people. Respondents were interviewed regarding their existing travel behavior, activity patterns, and hypothetical behavior under changes in travel time. 'Number plus one' dialing was used to reach unlisted numbers. The Los Angeles area was excluded because the Northridge Earthquake occurred shortly before the survey commenced and had dramatically impacted travel patterns there. The survey was administered using computer-assisted telephone interviewing (CATI), because of the complex branching required in the survey. Interviews were conducted on Tuesday through Friday evenings and Saturday mid-day, because survey questions were asked about the prior day's travel and weekday travel was the focus of the study. Randomization techniques were used to assure that the person who answered the phone was not necessarily the person interviewed.

After all trips were enumerated, the CATI program selects each trip made the previous day that was at least 10 minutes long. Trips shorter than 10 minutes were excluded on the assumption that capacity increases would probably have a marginal impact on them, and also because of the desire to offer travel time savings in increments of five minutes (a savings of five minutes on a trip that is seven minutes today would not seem plausible). For trips between 10 and 15 minutes, a five minute reduction in travel was offered. For trips longer than 15 minutes, a randomized travel time savings of between one and 50% was offered; the randomized savings was a minimum of five minutes if the survey number was odd, and 10 minutes if the survey number was even.

Survey respondents were given the options of: doing nothing differently; starting at the same time and arriving earlier; starting later and arriving at the same time; changing mode; changing trip destination; making an extra stop along the way; or "other". Only one additional "extra stop" was allowed for in the questionnaire, although in reality it is possible that some individuals might add two (or more) trips to their tour. The possibility of entirely new trips was allowed for at the end of this process by asking, *Would you have left home again before the end of your day if you had* [randomized time] *minutes extra time?* If the answer was yes, the respondent was asked where he/she would have gone, how much time they would have spent there, and for what purpose.

Survey Results

A total of 676 individuals over the age of 16 were interviewed in 676 households. They collectively made a total of 2,182 trips the previous day. The respondent demographics (age, income, educational achievement, auto ownership) were compared with the 1990 Census. The respondent pool was very close to the state average, except

TABLE 1 RESPONSES OF TRAVELERS TO TRAVEL TIME *SAVINGS* FOR EACH TRIP

	Travel Time Savings due to Congestion Relief (minutes)				
Response	5	10	15	20+	All
No Change	46.5%	49.6%	35.1%	38.1%	46.5%
Arrive Earlier	34.9%	33.9%	40.5%	31.0%	34.6%
Leave Later	12.9%	12.5%	16.2%	23.8%	13.5%
Change Mode	0.4%	0.4%	2.7%	2.4%	0.6%
Change Destination	0.9%				0.5%
Make Extra Stop	2.9%	2.8%	5.4%	4.8%	3.1%
Other	1.5%	0.8%			1.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 2 RESPONSES OF TRAVELERS TO TRAVEL TIME *INCREASES* FOR EACH TRIP

	Travel Time Increase due to Congestion (minutes)				
Response	5	10	15	20+	All
No Change	53.5%	41.3%	38.6%	24.4%	45.7%
Arrive Later	22.1%	31.0%	38.6%	36.6%	27.8%
Leave Earlier	17.3%	17.6%	9.1%	24.4%	17.4%
Change Mode	1.2%	1.5%	4.5%	2.4%	1.6%
Change Destination	1.0%	0.4%	2.3%		0.7%
Make Extra Stop	0.2%	1.3%			0.7%
Other	4.6%	6.9%	6.8%	12.2%	6.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

that poor households (those earning under $15,000 per year) were somewhat underrepresented (About 90% of the respondents were willing to report their household income. Of those answering the question, 9.5% reported household incomes under $15,000 per year. The 1990 Census found the same group constituted 15.1% of the households in the San Francisco Bay Area (CMSA). Some of the difference can be accounted for by inflation between 1989 (the reference year for the census) and 1994, the year of our survey). Very low income groups tend to be underrepresented in most telephone surveys, but the importance of these households is mitigated by the fact that they produce a small percentage of VKT (The National Personal Transportation Survey (USDOT, 1993) found that households with incomes under $10,000 generate VKT/household that is only 40% of the average rate for all households (using auto-driver miles as the measure). The 1990 Census found that these households represent about 15.5% of all households in the US;

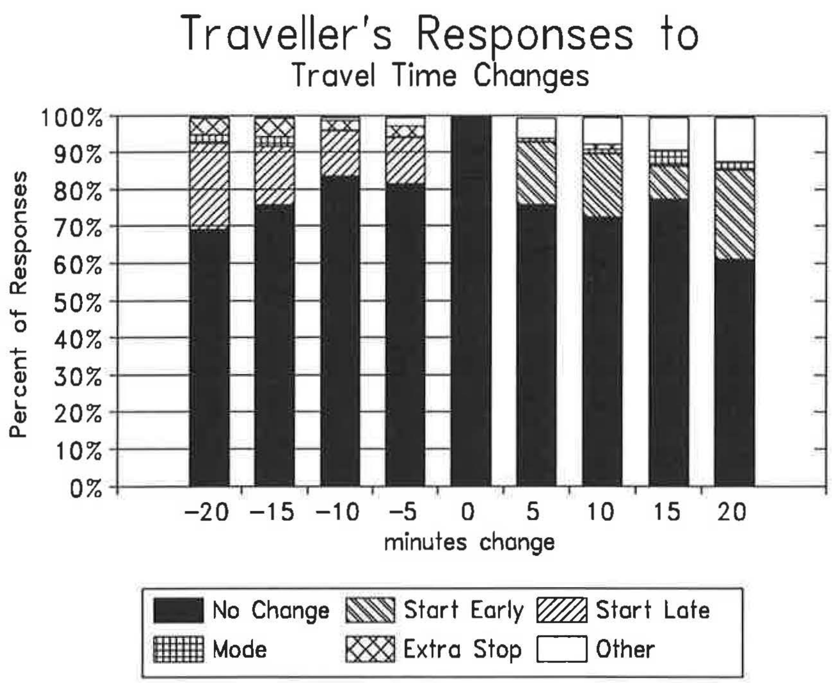

FIGURE 2 Response of travelers to hypothetical trip time changes.

therefore, it appears that they are responsible for somewhat over six percent of VKT).

The key results of the survey (see Tables 1 and 2) were that:

- Over 35% of the trips made would be unaffected when the trip travel time increased or decreased by 15 minutes or less when all trip purposes are considered.
- Another 20% to 40% of trips made would change only to the extent that the respondent would arrive earlier or later at a destination and make no change to the departure time to compensate for the effect of the travel time change.
- About 10% to 15% of the trips would be rescheduled to compensate for or take advantage of the travel time change.
- A time savings of five minutes would generate extra stops for about three percent of the trips where this time savings was offered. This percentage increased to five percent when 15 minute time savings was offered. The average across all time savings offered was three percent.

The overall result is that 90% to 95% of the trips would be unchanged or would have schedule changes in response to travel time increases and reductions of 15 minutes or less. As expected, the greater the magnitude of the travel time change, the greater the traveler response. Interestingly, the results are not symmetric: respondents tended to react slightly more strongly to increases in travel time than to decreases (see Figure 2). When faced with a travel time increase, respondents would try to adapt by changing mode, destination, and route for a higher percentage of the trips than if they were offered an equal amount of time decrease. Given the nature of the two metropolitan areas in which the survey was conducted, it is likely that more respondents have had recent experience adjusting to travel time increases than decreases. And this type of asymmetric behavior is probably not surprising. For example, some gaming simulations have shown that even given the same actuarial odds (expected value), people are much more concerned with a possible loss of wealth than they are with a possible gain.

The respondents indicated that only approximately 1.6% of their trips would be susceptible to a modal change given increased travel time for a specific trip. Of these hypothetical "mode switchers," most (38% and 35%, respectively) said they would switch to driving alone or public transit. It was implicit in the survey that the travel time by alternative modes was not changed. Greater time increases and decreases had a greater effect on traveler responses than smaller amounts of time changes. However, given that only 13% of survey trips were greater than 30 minutes in length, it was not realistic to ask the majority of the respondents about time savings of greater than 15 minutes.

CONCLUSIONS AND RECOMMENDATIONS

Most previous investigations of the effects of new highway capacity have been facility-specific "before and after" studies. At first, this approach seems highly appealing and only logical, but on reflection, it becomes clear that it is nearly impossible to use this approach to isolate the effects of new highway capacity on induced trip making. There are too many extraneous factors that can affect the results, including the availability of alternative modes and routes in each corridor; the condition of the local economy (growing or stagnant); zoning; and natural constraints to development. These factors not only affect the conclusions but also limit the validity of extending these results to other situations and locations. These factors may have been responsible for the conflicting conclusions that researchers have frequently arrived at in the past.

The results of this survey must be qualified by its relatively small size (under 700 households) and limited geographic scope. However, some of the indications from this survey are that:

- Current travel forecasting practice probably results in an underprediction of three to five percent in the number of trips that may be induced by *major* new highway capacity projects. Where a project is expected to yield travel time savings of more than five minutes for a large number of trips, adjusting travel demand upward to reflect induced travel is probably warranted.
- A key impact of new highway capacity is temporal shifts in demand (trips formerly made in the off-peak moving to the peak periods). From the highway user's perspective, this is not necessarily bad, since it simply means that he or she can make a trip in response to personal needs rather than traffic conditions. On the other hand, it will affect the congestion, speeds, and emission estimates produced by travel models. There is a strong need to develop better models to predict peak spreading/time of day of travel.

Not surprisingly, there were some questions that could not be answered in this study. They include: expanding the survey in the future to cover more households in more areas of the state; developing alternative survey mechanisms that can assess the possible interactions between household members to changes in travel times; and assessing how difficult-to-quantify factors (such as stress) may influence travel behavior when congestion is reduced. It seems logical to presume that a 30 minute drive in stop-and-go traffic would be perceived differently from a 30 minute drive in free flowing traffic, but our survey instrument was not able to distinguish between the two. A small sample of commuters in Orange County, California (Novaco, 1991) found that most, but not all, drivers perceived commuting in congested traffic as more stressful than commuting in uncongested traffic. To the extent this is true, it suggests that the results of the travel survey conducted here could underestimate the true effects on tripmaking of reduced congestion.

In the longer term, new highway capacity may influence decisions about auto ownership, residential location, the location of where a person finds employment, and the choice of expansion areas for businesses and government. These effects are important, but are beyond the scope of this paper. Indeed, several of these effects cannot be addressed with a household travel behavior survey. However, some of these impacts are already accounted for in current transportation/land use forecasting practices in California's largest metropolitan areas, using models such as DRAM/EMPAL and POLIS.

Key Conclusions

Highway capacity changes influence travel behavior principally by affecting travel time and cost. The principal conclusions from the survey are as follows:

- The sample population had definite preferences as to how they would respond to changes in travel time. Their response preferences are in this order:

  1. Change route (find a faster route if the current one becomes congested);
  2. Change schedule (find another time of day when congestion is less);
  3. Consolidate trips (reduce number of daily trips by accomplishing more activities with a given trip);
  4. Change mode (switch to more convenient mode);
  5. Change destination (find another location with similar services).

- Whether a person prefers to change mode over destination (or *vice versa)* may depend upon the trip purpose, e.g., a destination change is probably preferred over a mode change for most shopping trips.
- The order of preference responses appears to be similar for travel time decreases as well as for travel time decreases, although the magnitude is different. Whether faced with an travel time increase or decrease, both changes would result in the respondent preferring a different route or rescheduling the trip, rather than changing the trip mode or destination.
- Survey respondents indicated a high degree of resistance to change in their travel behavior when offered travel time savings of between five and fifteen minutes per trip. A five minute travel time savings (on average) resulted in a three percent increase in daily trips made per person, and a 15 minute time savings resulted in a five percent increase in trips/person/day.

Since most trips in metropolitan areas are under 15 minutes duration (The *1991 Statewide Travel Survey* (Table 20a, Caltrans final report, December 1993) indicates that 64% of trips (all purpose/all mode) are 15 minutes or less, and that even of home-work trips, 42% are 15 minutes or less) and realistic time savings on such short trips would rarely exceed five minutes, it appears unlikely that new highway capacity would significantly reduce travel times for the majority of trips. Home-work (commute) trips may be an important exception, since these are typically between 20-30 minutes in duration. It has also been pointed out that the commute trip also drives many other decisions, such as vehicle-holdings and household location, and those considerations have a substantial influence on generation of short trips. Thus, there could be some important secondary impacts that are not accounted for here.

This survey asked respondents about travel time changes in five minute increments, a decision made early in the study process that people would not be sensitive to time increments less than this. The reactions of respondents (not captured in the survey form) seems to support this *a priori* decision, since many respondents dismissed five minute time savings as being too trivial to affect their behavior. This is also corroborated by the observation that, in reporting their own travel time, nearly all survey respondents (in this and other surveys) round the time to the nearest five minutes. A similar conclusion has been reached in another study (Hague Consulting Group, 1991) in which British travelers were found to ignore travel time changes less than two minutes.

Recommendations for Future Research and Survey Improvement

It is recommended that the following steps be taken to improve the understanding of the effects of increased highway capacity on travel behavior and to improve the ability to forecast these effects at the regional level. Repeating the behavioral survey in other metropolitan, and possibly rural, areas to determine if the survey results can be reliably extrapolated to all travelers would be desirable. A larger survey sample would also yield more information on the effect of new highway capacity on various trip types and purposes.

The wording of survey questions and presentation of alternatives is critical in most SP surveys, and is one of the known weaknesses of the method. Some respondents were confused as to whether a visit to a different location meant a different location for the same purpose, or a different location for a different or additional purpose. For some respondents who made fairly short trips, the total travel time savings presented was near or greater than the amount of time the respondent had reported in travel. Some respondents who realized this were confused.

This survey did not allow for the possibility that people could save their travel time savings over a week, and "spend" them then. This approach was thought to be appropriate since time, unlike money, is not as easily "banked" and then spent later. However, the authors recognize that the greater the flexibility in allocating time, the more likely the possibility that travel time savings should be investigated using a week as the reference time (rather than 24-hours). The non-employed or those working part-time would appear to have the greatest flexibility in this regard (the increasing use of four-day work weeks may also be important). This area deserves further investigation.

It would be useful to use other research approaches to corroborate the results of this survey. One is activity gaming and simulation, which allows researchers to better understand the intra-household allocation of travel and other activities. This study made only a rudimentary attempt to consider how one household member's travel time changes might affect the travel and activity patterns of other members of the household.

Another approach would be to collect detailed information on the before and after effects of those living in a corridor where travel times are improved. Recently developed automatic vehicle location technology, using cellular phone technology, would allow detailed multi-day travel diaries to be analyzed without the tedium and error associated with the traditional manually kept diaries.

Additional study would need to be done to examine whether travel time savings are treated equally by motorists, regardless of the initial congestion condition. Since some studies by psychologists indicate that commuting in stop-and-go traffic is a stressful experience, traffic relief schemes that reduce congestion could have an impact beyond just the travel time savings. However, since there is no easy way to measure stress and present it to survey respondents, this issue could not be addressed as part of the current research effort.

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