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# City CarShare: Assessment of Intermediate-Term Travel-Behavior Impacts

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## ABSTRACT

Some nine months into the introduction of car-sharing in the City of San Francisco, an estimated 7 percent of members' trips were by City CarShare vehicles, up from around 2 percent just six months earlier. At the nine-month mark, more than 20 percent of members' vehicle miles traveled (VMT) was by car-share vehicles, a substantial jump from what it was earlier.

Evidence suggests that access to car-share vehicles is stimulating motorized travel. Most members do not own cars and many appear to be leasing vehicles in lieu of walking and biking. Car-share vehicles are used more for personal business and social-recreational travel than non-discretionary, routine travel such as to work or school. Cars generally are not used frequently during peak periods or to dense settings well-served by transit, like downtown. In this sense, car-sharing appears to be stimulating a resourceful form of "automobility." Users are accruing substantial travel-time savings, and willingly pay market prices for these benefits.

Survey results also suggest that car-sharing is cutting into private car usage, especially among higher income members. This appears to be less because members are getting rid of cars and more due to them selectively substituting City CarShare vehicles for their own. Predictive models revealed that the likelihood of car-share usage increased with members' personal incomes, educational levels, and age. Also, members were more likely to lease vehicles if they lived in zero-car households.

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## 1. INTRODUCTION

A previous analysis of San Francisco's City CarShare program found impacts on travel behavior three to four months into the program to be fairly modest. This was a short-term evaluation, however, thus the finding of negligible impacts early in the program was not unexpected. What about impacts eight to nine months into the program, once it has time to settle in? The purpose of this report is to address this very matter — i.e., the intermediate-term impacts of San Francisco's City CarShare program.

This report is a companion to the initial impact assessment, titled *City CarShare: Assessment of Short-Term Travel-Behavior Impacts*.[1] The interested reader is referred to that report for background on the City CarShare program as well as more detailed discussions on research design, measurements, and methodological issues surrounding the evaluation. Briefly, surveys were conducted on background characteristics and travel patterns of participants and non-participants of the City CarShare program prior to its inauguration in early March 2001. For purposes of studying "before and after" changes in travel demand, data were also compiled three to four months into the program, allowing a short-term evaluation, and eight to nine months later, to support the intermediate-term evaluation presented in this report. To remove the influences of other factors that could explain changes in travel demand besides car-sharing itself, a controlled experimental framework was adopted for both short- and intermediate-term evaluations. This involved comparing changes in travel demand between City CarShare participants and an otherwise comparable group of non-participants over time. Besides evaluating impacts, car-sharing is profiled in terms of trip purposes, travel durations, spatial patterns of trip-making, and other attributes.

## 2. SURVEYING TRAVEL DEMAND

To support the intermediate-term evaluation, surveys were compiled from members and non-members over two time periods. The first, which largely corresponded to a "before" survey, covered the period from February 18 to March 5, 2001, roughly two to three weeks before the City CarShare program was formally launched.[2] Similar data were also compiled some eight to nine months into the program during the period of October 28 to November 11, 2001.[3] While data were also compiled during June and July for the short-term evaluation, the focus of this report is on changes in travel demand between the first (i.e., "before") and third (i.e., "intermediate-term") surveys. Differences between the short-term and intermediate-term (i.e., between the second and third surveys) are also reported when of interest.

For each survey period, two different questionnaire instruments were designed and administered. One collected background information, such as personal socio-demographic, car-ownership, and household attributes. The second compiled travel information for all trips made over a two-day period, such as addresses of trip origins and destinations, mode of travel, occupancy levels, trip purpose, time of departure and arrival, and expenditures. All responses were self-reported. A cover letter provided telephone numbers and e-mail addresses for contacting the research group in the event respondents had questions or needed clarifications. Also, a web site (www-iurd.ced.berkeley.edu/citycarshare.htm) was created that explained the purpose of the research, provided answers to Frequently Asked Questions (FAQs), and allowed individuals to key-in survey information on-line. Because of the complexity of recording travel-diary information and the difficulty of recalling the specifics (e.g., departure time) of trips made earlier in a day, most respondents opted to complete and mail in hard-copies of the questionnaire. The Appendix of the May 2002 short-term evaluation report contains copies of the survey instruments.

Surveys were administered by first obtaining master lists of individuals who had signed up to join City CarShare. These individuals were divided into two groups: (1) *Members:* those who officially became members by paying a fee and had been formally accepted by the City CarShare program; and (2) *Non-Members:* those who had expressed an interest to one day join City CarShare but had yet to formally enroll in the program.

### 2.1 Surveys #1 and #2

For the first survey, called Survey #1 throughout this report, every member and non-member received, via mail, a package that included an instructional cover letter, a background questionnaire, and two travel-diary questionnaires. E-mails were sent out to all City CarShare members one week before the mailings to alert them that surveys would soon be arriving and to encourage them to complete questionnaires.

The cover letter asked each person to complete and return both the background survey and two travel-diary surveys (thus providing travel data over two consecutive days). To obtain a balance of responses (spanning all days of the week over a two-week survey period), survey-participants were given two sets of two consecutive days from which they could choose a single pair of days to record their travel behavior.[4] In all, 780 sets of surveys were initially mailed to all members and non-members on the original City CarShare list of interested individuals. Non-respondents received a second round of surveys and were given wider latitude on selecting days for recording travel diaries. A total of 298 surveys were received from the initial list of 780 individuals for a response rate of 38.2 percent. Background data were compiled from all 298 respondents, however not everyone completed travel diaries, resulting in 170 sets of travel records.

The second survey, conducted three to four months into the program, solicited information from all of those who were sent Survey #1 as well as new individuals who

had joined or planned to join since the first survey. A fairly high response rate of 34.6 percent of the 575 individuals receiving surveys was obtained.

### 2.2 Survey #3

For the third survey, sent out in late October 2001, everyone who had completed Survey #1 or Survey #2 was mailed the third set of surveys. Those joining City CarShare (or expressing an interest to join) since the second survey were also sent packets.[5] In addition, non-respondents from Surveys #1 and #2 were given the opportunity to complete Survey #3. Only those who completed both Surveys #1 and #3, however, provided records that could be used in making intermediate-term "before-and-after" comparisons.

Feedback from the first survey revealed that some individuals felt the assignment of specific dates for completing the survey was too restrictive. To provide greater latitude, we gave people the option of choosing any two days from a range of days for completing the third survey. For example, an individual might have been asked to complete travel diaries for any two days between the period of Friday, November 2 and Monday, November 5. Requested dates were evenly spread in an effort to obtain a balance of responses across all seven days of the week. Experiences from the first two surveys, and confirmed by the third survey, showed that people prefer to complete surveys during weekdays. Evidently, many surveyees prefer not to be bothered with the chore of completing questionnaires during their "free time" on weekends.

The third round of surveys was sent to 1,055 people — 858 City CarShare members and 197 non-members. In all, 220 sets of responses were received. After eliminating mailings to those who had moved out of the area and postal returns, the response rate was 22.6 percent. This is lower than the response rates of the first and second surveys. We suspect asking for fairly laborious travel-diary information three times within a nine-month period caused an erosion of interest. In contrast to the other two surveys, the majority of respondents to the third survey were members.

## 3. RESEARCH CONTEXT AND METHODOLOGY

As discussed in the prior report, a focus of this research is on measuring the degree to which car-sharing reduces versus stimulates travel. Cooperative sharing of private vehicles could reduce travel by spawning cost-conscious behavior. More mindful of the out-of-pocket cost of each individual trip, participants might become more judicious and selective in their choice of mobility options — such as foregoing motorized trips that are non-essential. On the other hand, providing more private mobility could very well increase motorized travel, particularly when, as discovered in the earlier study, many members come from households without cars. Trips that previously were not made might now be made — presumably in the form of more discretionary travel like single-purpose

convenience shopping. Or trips that were by bike, bus, or walking might now be by single-occupant cars.

### 3.1 Evaluation Approach

From a research design standpoint, the greatest challenge in evaluating an initiative like car-sharing is *attribution*. To what degree are changes in travel due to car-sharing or other factors, like the price of gasoline, that also change over time. To control for such factors, a matched-pair analytical approach was adopted, as in the short-term analysis. This involved examining differences in travel patterns between the members and non-members over two time points. As long as the influences of other factors (e.g., rising fuel prices) that occur over time are comparable across both groups, any *differences* in travel changes can be attributed to the presence of car-sharing.

In the first-year analysis, the control group consisted of those who had registered to join City CarShare but had yet to formally join, for reasons like a POD (point-of-departure) where car-share vehicles are parked was not in their neighborhood. The advantage of using these individuals as the "control" group is that they have comparable levels of motivation as participants — i.e., they have taken the time to sign up for the program.

The analytical framework used in assessing impacts was as follows:

$$Impact = (T_{t,a} - T_{t,b}) - (T_{c,a} - T_{c,b}), \text{ where:}$$

T = trip or impact measure;
t = "test" (car-sharing) cases;
c = "control" (non-car-sharing, but otherwise comparable) cases;
a = later time point; and
b = early time point.

Statistically, this amounts to a "differences in difference of means" test. If car-sharing exerts real and meaningful impacts on travel behavior, then this approach should reveal statistically significant "differences" across the two "different" neighborhoods.

For this research, an example of why the introduction of controls was important was the marked differences in weather conditions over the two survey periods. For the three-week period of February 18 to March 5, 2001, when people were asked to record travel-diary information for Survey #1, the total rainfall recorded in downtown San Francisco was 5.39 inches — a particularly heavy period of precipitation. For the period of October 28 to November 11, 2001, when the bulk of responses from Survey #3 was recorded, only 1.16 inches of rainfall was recorded in downtown San Francisco.[6] Rainy conditions could have dissuaded people from walking and cycling in Survey #1 and perhaps forego some trips altogether, whereas better conditions could have invited more foot and bicycle travel in Survey #3. Falling gasoline prices — from a Bay Area average of $1.76 per gallon for medium-octane unleaded in late February 2001 to $1.42 in early October 2001

— could have further stimulated travel.[7] As long as weather conditions and gasoline prices affected members and non-members equally (and there is no reason to believe they should not), then the effects of rainfall are netted out in a "difference of difference of means" analysis.

Because travel behavior is known to vary between weekdays and weekends as well as days people go to work and days they are off, some of the analyses were stratified by "day type." Four day types were examined: weekdays/workdays; weekdays/non-workdays; weekends/workdays; and weekends/non-workdays. The largest number of travel diaries was obtained for weekdays/workdays, followed by weekdays/non-workdays. As noted, comparatively few of the returned travel diaries were for Saturdays and Sundays, thus there tended to be few instances of "weekends/workdays" day type, and hardly any "weekends/non-workdays" responses.

### 3.2 Travel-Consumption Metrics

To address whether car-sharing increased or reduced total travel, trip records were aggregated to obtain one-day summaries of travel for each respondent.[8] The following three metrics of travel consumption were created from survey responses and used in the analyses.

> *Vehicle Miles Traveled (VMT)* equals total miles logged on roadways in motorized vehicles.[9] In calculating VMT, all non-vehicle (i.e., walk and bicycle) trips were assigned zero values. In the analyses presented later in this report, VMT was measured as the mean daily VMT per person, averaged over the two days of travel as recorded in travel diaries.
>
> *Mode-adjusted Vehicle Miles Traveled (MVMT)* represents total miles logged on roadways in motorized vehicles, adjusted for the occupancy levels. Mathematically, MVMT equals (total highway VMT)/(vehicle occupancy) where values for transit, walking, and cycling equal zero. If someone drives alone for 30 miles, this represents a MVMT of 30. If instead they drive 30 miles with some else, the MVMT is 15 (30/2). And if the trip is made by public transit wherein no new vehicles are added to the streets, the MVMT is zero. In this sense, MVMT reflects the mileage impacts of additional vehicles on the street due to a person's trips.
>
> *Mode and Engine-Size adjusted Vehicle Miles Traveled (MEVMT)* is an overall index of transportation resource consumption. It measures total miles logged on roadways in motorized vehicles, adjusted for the occupancy level and engine size of vehicles. MEVMT = [(total highway VMT)*(engine displacement in cubic centimeters)]/(vehicle occupancy) wherein engine size was either recorded in surveys or estimated based on the most common engine size given the make, year, and model of vehicle used for a trip. MEVMT represents a multi-factor gauge of resource consumption as reflected by engine sizes and vehicle occupancy levels.

Trips with low MEVMT values can generally be expected to correspond to ones with low levels of fuel consumption and exhaust emissions; trips with high values are more resource-consuming.

### 3.3 Measurement of Travel Impedance and Consumption

All measures of travel impedance (e.g., trip distance, travel times) and travel consumption (e.g., VMT) were estimated using "network path" travel times between centroids of traffic analysis zones (TAZs) maintained by the city of San Francisco. The city's TAZs are considerably smaller in land area than those of the typical regional transportation planning organization, including the Metropolitan Transportation Commission (MTC). The city has more than 300 TAZs (for a land area of 49 square miles) compared to MTC's 1,099 TAZs (over a land area of some 3,200 square miles covering nine counties). Thus, impedance and travel-consumption estimates made for surveyed trips are usually more accurate than those estimated from regional travel networks. While errors invariably seep into the estimation process when calculating centroid-to-centroid values, there is no reason to believe estimates are systematically biased.

For all modes, including walking and cycling, distance-related estimates were derived over highway networks, except in the case of transit trips on fixed-guideway rail systems (e.g., BART, San Francisco Muni), in which case estimates were derived over rail networks. Travel-time estimates accounted for mode of transportation; for example, bike trips were estimated to take more time than automobile trips based on assumed differences in mean travel speeds between any two points on a road network. For transit trips, means of access and egress (e.g., walk-and-ride, bike-and-ride, park-and-ride) were weighed in deriving travel-time estimates.

We note that survey respondents self-reported estimated travel times of each trip. Since recalling travel times of trips previously made is prone to considerable errors, it was felt that estimated travel times based on the mean TAZ-to-TAZ times for the mode used provided more reliable estimates.

## 4. INTERMEDIATE-TERM TRAVEL PATTERNS AND MEMBER PROFILES

This section summarizes travel behavior and member attributes eight to nine months into the City CarShare program, based on results from Survey #3. Comparisons are made between City CarShare members and non-members, providing a cross-sectional portrait of how car-sharers differ from non-members. Information on 1,573 and 574 trips were obtained from Survey #3 for members and non-members, respectively. The numbers of people recording this information were 247 members and 157 non-members.

## 4.1 Trip Purpose

More than one-half of recorded trips of members and non-members were to work or home (Figure 1). Compared to non-members, members tended to make more social and shopping trips. For both groups, well over three-quarters of all trips were essential, "non-discretionary," such as to work, for medical services, or to take care of personal affairs. Around 17 percent of trips made by members could be considered "discretionary" — i.e., for social, recreational, or other non-essential purposes.

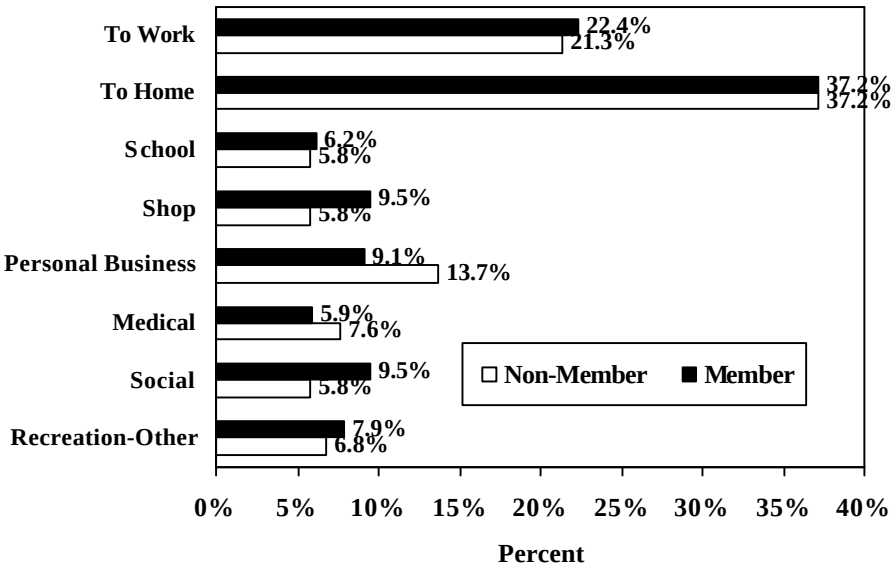


**Figure 1. Trip Purposes of Trips by Members and Non-Members, Survey #3**

## 4.2 Mode of Transportation

What share of total trips made by members some nine months into the program were by City CarShare vehicles? Table 1 reveals a respectable share: 8.1 percent. This is a sizable jump from the 2.2 percent recorded just three months into the program. Thus, between June-July and October-November 2001, City CarShare travel as a share of total trips rose by nearly 6 percentage points. And adjusting for length of trips, City CarShare's role was even greater, making up 21.6 percent of total vehicle miles traveled (VMT) by members some nine months into the program.[10] This is up considerably from the 7 percent of VMT recorded three months after the program's launch. (Relative to private cars and taxis — i.e., excluding public transit — City CarShare comprised 30.7 percent of VMT in October-November 2001). Clearly, City CarShare constitutes a growing share of members' "travel pie."

**Table 1. Modal Comparison: Percent Distribution of Mode, All Trip Purposes, City CarShare Members and Non-Members, Survey #3**

| | Members | Non-Members |
|---|---|---|
| **City CarShare** | 8.1% | 0.0% |
| **Private Car** | 14.1% | 22.8% |
| **Bus Transit** | 15.3% | 9.5% |
| **Rail Transit** | 15.6% | 13.5% |
| **Walk-Bike** | 39.8% | 48.4% |
| **Other** | 7.1% | 5.8% |
| **Total** | 100.0% | 100.0% |

Table 1 provides additional insights into the travel characteristics of members. One, members were generally more inclined to use transit than non-members, as was the case in the two earlier surveys. However, in contrast to Survey #2 where both groups had identical shares of trips by walking and bicycling, in Survey #3 non-motorized travel by members was considerably lower than that of non-members. Between Survey # 2 and #3, walk-bike trips fell from 43.5 percent to 39.8 percent of members' trips. This could be a sign that some City CarShare trips are substituting for journeys previously made by foot or cycling.

Among the sample trips from Survey #3, most rail-transit trips by members (54.2 percent) were via Muni (San Francisco Municipal Railway's light-rail transit, tramways, and cable cars), followed by the heavy-rail Bay Area Rapid Transit (BART – 41.8 percent) and commuter-rail (CalTrain – 4.0 percent).[11] Among all trips (including walking and biking), Muni constituted 8.5 percent of journeys made by members and BART 6.5 percent.

Figure 2 presents summary statistics on "supply-side" factors that might have swayed mode-choice decisions among members and non-members. Members often face parking constraints, both at their workplaces and residences. Most have to pay for parking at their work sites and have no off-site residential parking, more so than non-members. Parking constraints could explain high levels of employer allowances for transit and ownership of Muni Fast Passes. The majority of members and non-members also own bikes. The strong orientation of members and those signed-up to one day become members toward transit and bike travel is a further sign that car-sharing could substitute for trips made by "green" modes. In section 8.2 of this report, a predictive model is presented that accounts for the role of these factors in explaining mode choice and car-share usage.

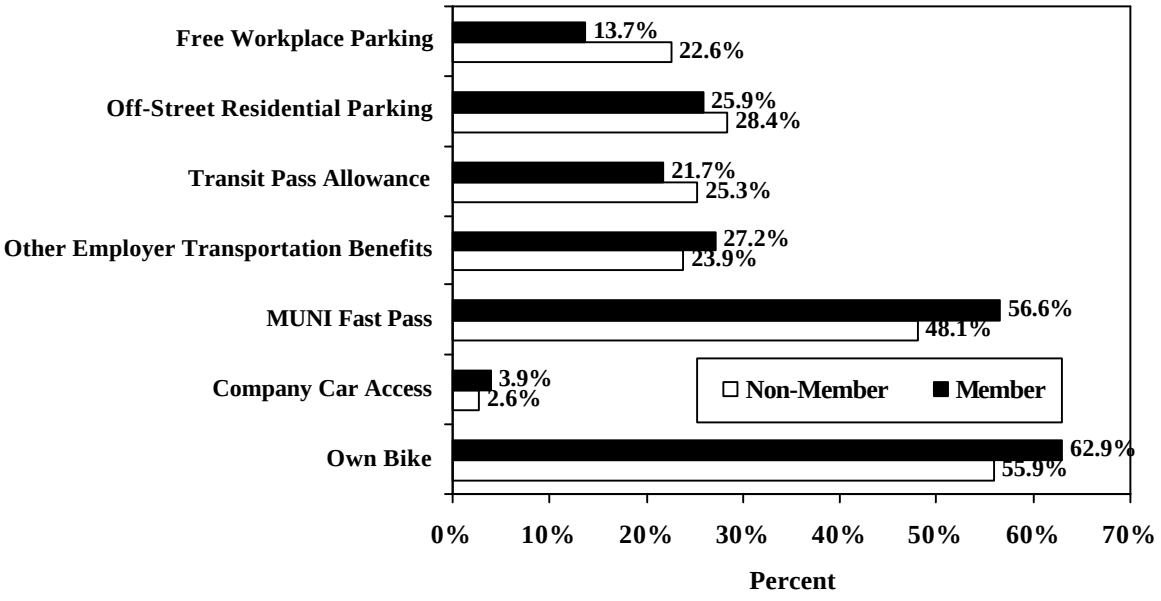


**Figure 2. Shares of Members and Non-Members with Various Supply-Side Attributes Associated with Mode Choice, Survey #3**

### 4.3 Modal Splits by Trip Purpose

Breaking modal statistics down by trip purpose reveals transit was used heavily by members to get to and from work, followed by walking and biking (Table 2). Some nine months into the program, City CarShare vehicles captured one-quarter of all personal business trips made by members; although not shown in the figure, car-sharing made up 15.5 percent of recreational trips and 8.4 percent of trips to school.

Table 2 further reveals that non-members tended to walk or bike more across these four trip purposes than did members, further suggesting the availability of car-share vehicles on demand might be inducing modal switches. When compared to the mode choices of non-members, a bigger differential seems to be the reliance upon City CarShare vehicles for personal business trips in lieu of private cars. Non-members appear to rely on private automobiles for personal business trips nearly three times as much as members. City CarShare vehicles seem to be favored for such activities as going to banks, restaurants, and libraries or meeting a business associate or financial advisor.

**Table 2. Percent Distribution of Mode by Trip Purposes, City CarShare Members and Non-Members, Survey #3**

| | Member | | | | Non-Member | | | |
|---|---|---|---|---|---|---|---|---|
| | Trip Purpose | | | | Trip Purpose | | | |
| | Work | Return Home | Social | Personal Business | Work | Return Home | Social | Personal Business |
| **Car Share** | 1.3% | 5.6% | 6.3% | 25.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Private Car** | 7.7% | 13.5% | 29.1% | 11.5% | 5.7% | 26.1% | 32.1% | 32.4% |
| **Bus Transit** | 20.3% | 16.7% | 12.6% | 13.1% | 12.4% | 11.4% | 7.1% | 5.9% |
| **Rail Transit** | 27.0% | 17.3% | 11.0% | 8.2% | 24.8% | 14.1% | 10.7% | 4.4% |
| **Walk-Bike** | 36.7% | 39.4% | 33.2% | 41.0% | 50.4% | 40.8% | 42.9% | 51.5% |
| **Other** | 7.0% | 7.4% | 7.8% | 0.8% | 6.7% | 7.6% | 7.2% | 5.8% |
| **Total** | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

## 4.4 Rail Access and Egress

Among members who patronized rail transit, Table 3 shows that 79 percent got from their homes to the rail station by foot and around 90 percent walked from the station to their workplace (representing "egress" trips). Non-members tended to bike or ride bus transit to and from rail stops more than members. For members, these modal distributions for rail access and egress were similar to those recorded in Survey #2.

**Table 3. Percent Distribution of Modes of Access and Egress for Rail Transit Trips, Members and Non-Members, Survey #3**

| | Members | | Non-Members[1] | |
|---|---|---|---|---|
| | Access | Egress | Access | Egress |
| **Walk** | 79.0% | 90.0% | 66.7% | 71.4% |
| **Bicycle** | 6.5% | 5.0% | 12.9% | 9.1% |
| **Bus** | 8.1% | 5.0% | 14.6% | 19.6% |
| **Other** | 6.5% | 0.0% | 5.8% | 0.0% |
| **Total** | 100.0% | 100.0% | 100.0% | 100.0% |

[1] Non-member data represent responses mainly from the second background survey administered in June-July 2001.

## 4.5 Travel Consumption

Around 86 percent of both members and non-members responding to the survey resided in the city of San Francisco. Over time, City CarShare appears to be drawing larger shares of members from outside the city, given that the share living in San Francisco was 5 percentage points higher in the second (June-July 2001) survey.[12] Also, a comparable share — around 86 percent — of both members and non-members worked in San Francisco, up from the second survey. This suggests a slight trend toward City CarShare appealing to non-San Francisco residents who work in the city. In all, 93.5 percent of San Francisco residents who were City CarShare members also worked in the city.

High rates of intra-city travel equate with fairly short average trips, as shown in Table 4 (for all trip purposes combined). While trips were fairly short by urban standards, given that high shares were by foot and bicycle, average travel times were around a half-hour for members and even longer for non-members. Because of the large share of non-motorized travel, mean VMT per trip fell below 3 (lowered by zero values for walk and bike trips). The mode-adjusted VMT, which accounts for occupancy levels of private car trips and nets out transit trips (since no new buses or rail vehicles are added to accommodate these trips), was far lower –1.1 for members and less than 1 for non-members. Lastly, multiplying MVMT by the engine size of private-vehicle trips yielded the "mode & engine-size adjusted VMT," or MEVMT, which as an index of "private travel consumption" yielded mean values that were one-third higher for members than non-members. In Survey #3, there was a tendency of members to drive bigger cars than non-members. Among members, MEVMT was the lowest on weekends that were workdays and highest on non-workday weekends. The highest "travel resource consumption" was generally for trips made on Saturdays and Sundays when members were not working, often corresponding to social-recreational and personal business travel. Compared to Survey #2, there was a decline in MEVMT and other indicators of travel consumption for the typical trip.

Across all variables in Table 4, standard deviation statistics were fairly high compared to mean values. This suggests relatively high variation "within groups" — i.e., amongst members themselves. High "within group" variation usually translates into statistically insignificant relationships. This means very large differences between members and non-members will have to exist for relationships to be statistically significant.

## 4.6 Socio-Demographic Characteristics

In late 2001, more than half of surveyed members were in their thirties (Figure 3).[13] The penchant to join car-sharing among those in their thirties was also found in the case of Portland's car-sharing program.[14] Most of the surveyed City CarShare members, 62.3 percent, were women (compared to 52.1 percent of non-members). Whites made up 87.6 percent of surveyed members, Asian-Americans 5.8 percent, and those who classified themselves as "other" 7.3 percent; shares were comparable for non-members. Those who

**Table 4. Comparison of Travel Statistics for Individual Trips Among Members and Non-Members, Survey #3**

| | Member | | Non-Member | |
|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Mean** | **Std. Deviation** |
| **Trip Distance** (Road network miles) | 3.5 | 6.2 | 3.3 | 6.1 |
| **Trip Time** (minutes) | 30.4 | 41.0 | 38.5 | 105.7 |
| **Vehicle Miles Traveled** (VMT) | 2.9 | 6.3 | 2.6 | 6.1 |
| **Mode-Adjusted VMT** (MVMT) | 1.1 | 3.9 | 0.9 | 3.7 |
| **Mode & Engine-Size Adjusted VMT** (MEVMT)**: All trips** | 1307.5 | 7454.6 | 978.8 | 7535.1 |
| **MEVMT: Weekday-Workday** | 1148.4 | 7090.5 | 415.0 | 2352.6 |
| **MEVMT: Weekday-Non Workday** | 913.1 | 5447.2 | 477.6 | 5496.1 |
| **MEVMT: Weekend-Workday** | 481.5 | 1736.2 | 228.7 | 686.0 |
| **MEVMT: Weekend-Non Workday** | 2142.2 | 10261.5 | 2085.7 | 11325.2 |

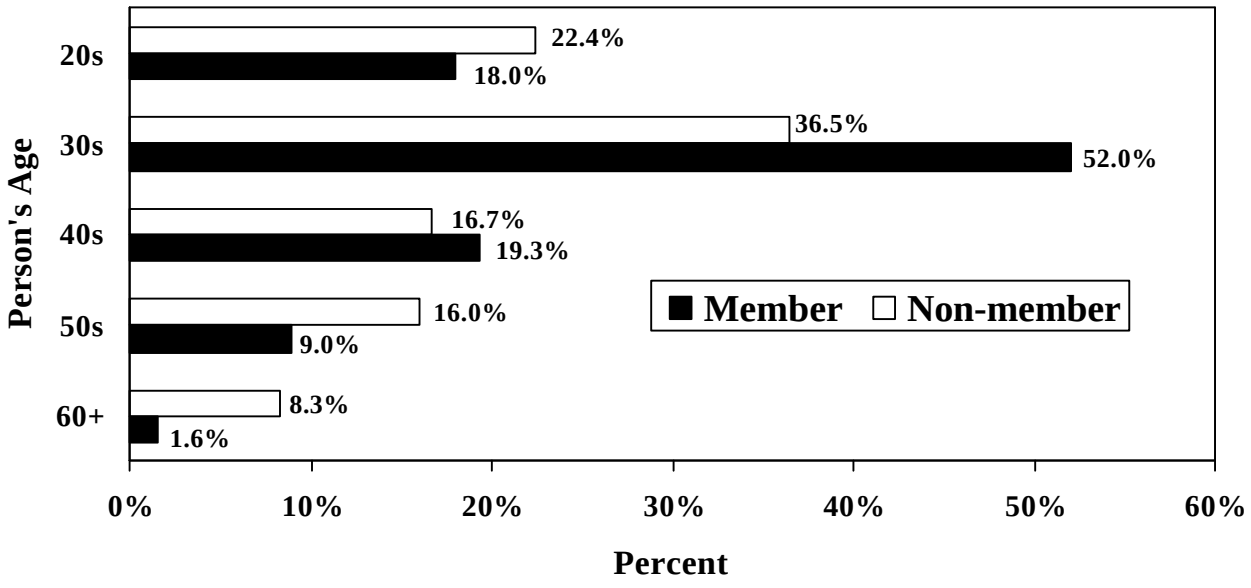


**Figure 3. Age Distribution, City CarShare Members and Non-Members**. Based on responses from Surveys 1, 2, and 3, representing year 2001 profiles.

identified themselves as Hispanic comprised 3.9 percent of surveyed members and 7 percent of non-members.

### *Income and Educational Profiles*

Figure 4 shows around half of members had annual personal incomes less than $50,000, comparable to non-members. In fact, median incomes for both groups were exactly $50,000.[15] Both members and non-members are well educated, with well over 90 percent having graduated from college (Figure 5).

### *Occupational Profiles*

Most survey respondents — 87 percent of members and 63 percent of non-members — had full-time jobs. Over 90 percent of members and non-members worked in professional occupations (e.g., consultants, engineers, lawyers, planners, teachers). The most common occupation, for both members and non-members, was urban planning: 4.6 percent of surveyed members and 7.5 percent of non-members. Architecture was the second most common line of work — 4.4 percent of members and 2.4 percent of non-members. Affiliation with urban issues might have drawn relatively large shares of planners and architects to a progressive program like car-sharing. Around 1.5 percent of members were full-time students. Also, 21.3 percent of members and 18.3 percent of non-members were self-employed, suggesting appreciable numbers of existing and future car-sharers work at home.

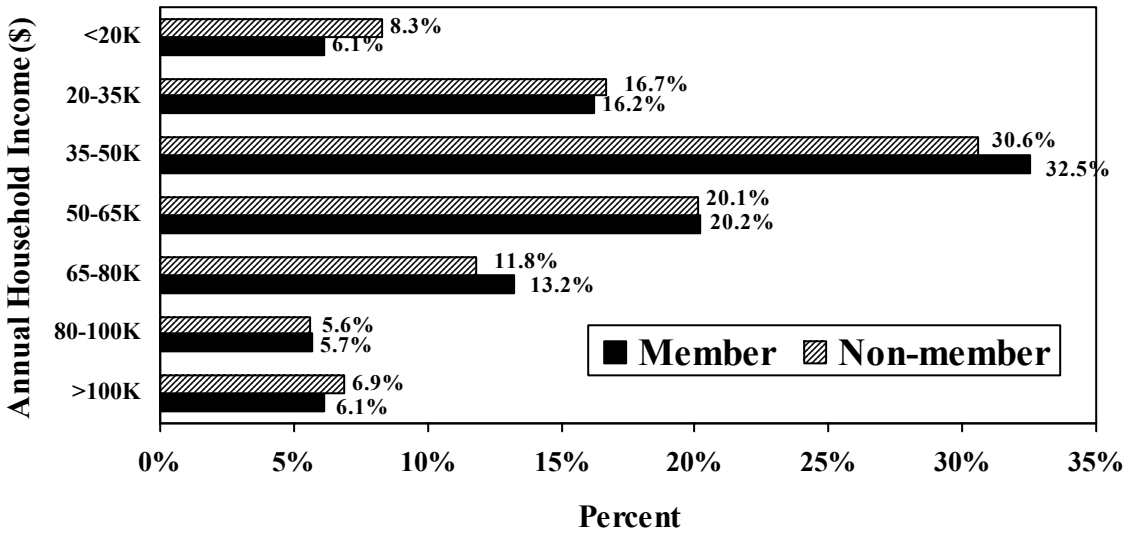


**Figure 4. Personal Income Distribution, City CarShare Members and Non-Members.** Based on responses from Surveys 1, 2, and 3, representing year 2001 profiles.

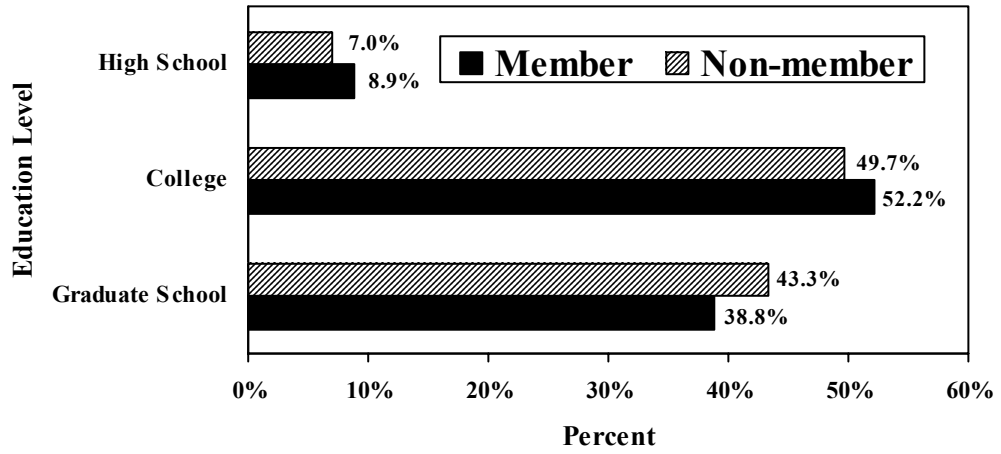


**Figure 5. Highest Level of Education, City CarShare Members and Non-Members.**
Based on responses from Surveys 1, 2, and 3, representing year 2001 profiles.

### *Household Profiles*

Most surveyed City CarShare members lived in "non-traditional" households, reflecting San Francisco's unique demographics (Figure 6). Over a third lived alone and nearly one-quarter lived with other non-related adults. Around seven out of ten lived in households without children. One out of 14 members lived in traditional "Ozzie and Harriet" households — i.e., married with children. Larger shares of members lived in group-quarters (e.g., dormitories, short-term residential occupancy hotels) than in households with a spouse and children.

The relatively small average household sizes — 1.84 for members and non-members — reflect the high shares of live-alone and non-traditional household arrangements. Over 82 percent of members and a comparable share of non-members live in one- or two-person households.

City CarShare participation often runs across household members. Among members responding to the survey, 30 percent lived in a household with another adult who was also a member; for non-members who were registered to one day become a member, the share of adults in the household also signed-up to eventually join the program was 11.5 percent. These high shares bode well for the prospects of carshare-pooling: members from the same household riding together in City CarShare vehicles.

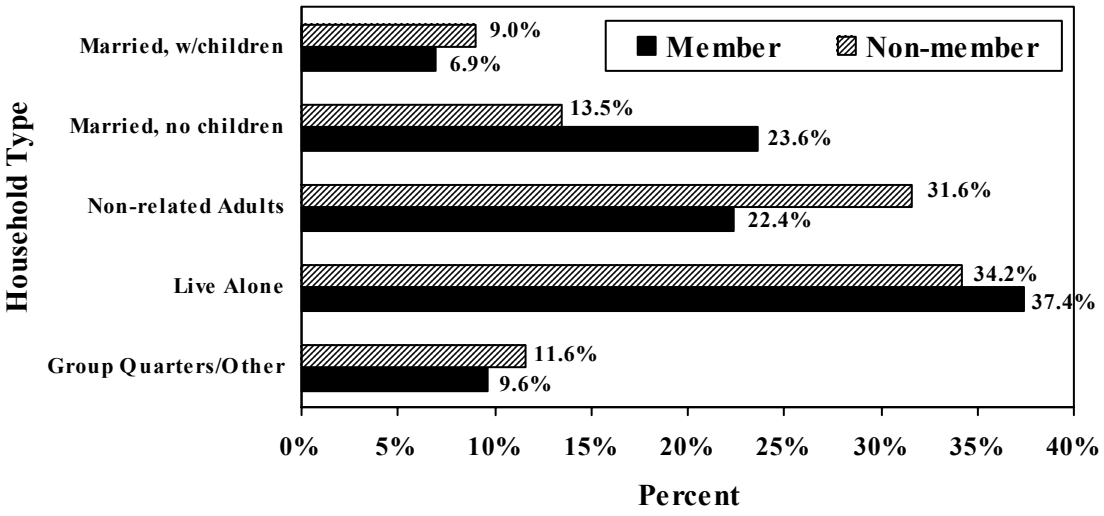


**Figure 6. Household Types, City CarShare Members and Non-Members.** Based on responses from Surveys 1, 2, and 3, representing year 2001 profiles.

## 4.7 Car Ownership

Car-sharing is thought to reduce vehicle ownership over the long run. The convenience of having a fleet of vehicles available, on-call, can be expected to prompt some member-households to give up a second car and perhaps relinquish car ownership altogether. Establishing a profile of car ownership patterns is thus important.

From the background data compiled in the first three surveys, 67.6 percent of members were from zero-car households and 21.9 percent were from one-car households. Thus, around nine out of 10 members were from households with 0-1 cars, a statistic that is well below the national and Bay Area average. Also, the share of member households that are carless is well above the 59 percent figure found in Portland during its program's first year.[16] Non-members tended to have higher levels of car availability — 43.9 percent were from zero-car households and 36.3 percent were from one-car households. Just 3.2 percent of member-households had more than two cars. In general, the high share of carless households among members suggests that car-sharing will induce some degree of motorized travel.

While some members came from households with cars, often they themselves did not own these cars. Among the cars in members' households, 37.7 percent were owned by members themselves and 21.1 percent were not owned by but were available to members. All other household cars — more than 40 percent — were unavailable to members. Non-members owned and had access to larger shares of household cars.[17]

Among cars in surveyees' households, the most common types were 4-cylinder medium-size sedans, like Honda Civic (most popular of all), Honda Accord, Toyota Camry, and Toyota Corolla. Hondas and Toyotas comprised 32.8 percent of members' and 38.3 percent of non-members' cars. Relatively few large vehicles — e.g., recreational vehicles, sport utility vehicles, vans, or minivans — and hardly any motorcycles were reported by survey respondents.

For the most part, members and non-members lived in households with older, well-used cars. Table 5, organized in order of the household vehicles listed by survey respondents, shows the typical member's primary car was around a decade old and had been driven, on average, 8,500 miles a year. Among members with second vehicles, vehicle #2 tended to be smaller, not even one-half the engine size of primary vehicles. This suggests, that among the small share of member households with two or more vehicles, these extra cars tended to be sub-compacts, perhaps used for niche purposes like shuttling around neighborhoods to take care of personal business — the very sorts of trips that City CarShare vehicles are frequently used for.

Nine months into the program, it was likely too soon to expect significant changes in vehicle ownership patterns. While the survey instruments were designed mainly to compile information on travel demand versus car ownership, it was possible to discern changes in car ownership among those who filled in information on household vehicles available for their trip. Two of the 80 surveyed member households with at least one car available in February 2001 had fewer cars in November 2001: one household got rid of two cars and one got rid of one.[18] This represented a 2.5 percent reduction in the population of vehicles among member households over the first nine months of the program. Among surveyed members, there were no instances where the number of cars in the household increased over this nine-month period.

**Table 5. Characteristics of Motor Vehicles in Households of Survey Respondents, Members and Non-Members, Surveys #1, #2, and #3**

| | Member | | Non-Member | |
|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Mean** | **Std. Deviation** |
| **Vehicle #1: Year** | 1991 | 7 | 1991 | 8 |
| **Engine Size** (cubic centimeters) | 1860 | 1210 | 950 | 1000 |
| **Odometer Reading (miles)** | 85,400 | 53,100 | 77,820 | 58,920 |
| **Vehicle #2: Year** | 1991 | 8 | 1989 | 10 |
| **Engine Size** (cubic centimeters) | 780 | 255 | 1015 | 880 |
| **Odometer Reading (miles)** | 70,450 | 63,840 | 74,440 | 47,015 |
| **Vehicle #3: Year** | 1980 | 13 | 1988 | 8 |
| **Engine Size** (cubic centimeters) | 900 | 460 | 735 | 120 |
| **Odometer Reading (miles)** | 80,135 | 36,350 | 62,295 | 52,990 |

An April 2002 survey was conducted by Nelson\Nygaard Consulting Associates that specifically addressed impacts of City CarShare on members' vehicle ownership rates.[19] That survey of 130 members found 65 percent had no vehicle, remarkably close to the figure obtained in our 2001 surveys. The survey also found that 52 percent "gave up" their vehicle since joining City CarShare and 12 percent got rid of a second car. Moreover, some 60 percent of members said they put off purchasing a vehicle and 85 percent said they would "think twice" about buying another car. These results show a substantial reduction in car ownership among members that will likely hold over time. Changes in car ownership patterns can be expected to have substantial impacts on travel behavior. As to whether this was reflected nine months into the program or whether it will take longer for structural adjustments in travel demand to manifest themselves, we turn to the remainder of this report.

## 5. TRAVEL BY CITY CARSHARE VEHICLES VERSUS OTHER MODES

This section compares travel of City CarShare trips versus non-carshare trips made by members during Survey #3. A sample of 1,565 member trips was available for this analysis. As noted earlier, 8.1 percent of these trips, or 130 in all, were by City CarShare vehicles. The April 2002 Nelson\Nygaard survey sheds additional light on car-share travel. The survey found that 55 percent of member respondents used City CarShare once or twice a month. Just 5 percent used it six or more times a month, and only 2 percent used it 11 or more times a month (e.g., every two to three days). Twelve percent of members said they had yet to rent a City CarShare vehicle.

### 5.1 Trip Purposes

Some nine months into the program, the most common use of City CarShare vehicles was for recreation and other purposes, followed by personal business, returning home, socializing, going to school, going to work, and attending to medical needs (Table 6). Compared to other transportation modes, trips made by City CarShare vehicles were most oriented to recreational and personal business trips; private cars tended to be used far more for social trips, public transit for going to work, and walking for reaching schools. In general, City CarShare vehicles were not turned to for essential, non-discretionary trips that are routinely made, such as going to and from work and school.

### 5.2 User Profiles

Who made up the surveyed City CarShare users? Two-thirds were women — higher than the 62.3 percent of surveyed members who were women. Also, 64 percent of surveyed car-sharers were 30-39 years of age — higher than the share of members in this age group. The majority of surveyed users — 51.2 percent — made $35,000 to $50,000 in annual earnings. Sixty percent of surveyed car-sharers owned a bike and 65 percent had

**Table 6. Percent Distribution of Trip Purposes Among Modes for Daily Trips Made by City CarShare Members, Survey #3**

| Trip Purpose | City CarShare | Private Vehicle | Transit | Walk | Bike |
|---|---|---|---|---|---|
| To Work | 3.2% | 10.8% | 30.4% | 17.9% | 20.2% |
| To Home | 22.2% | 31.5% | 36.2% | 31.2% | 38.3% |
| School | 5.6% | 5.6% | 5.1% | 6.3% | 2.1% |
| Shop | 0.8% | 1.4% | 2.4% | 1.6% | 0.0% |
| Personal Business | 24.6% | 6.6% | 5.6% | 9.2% | 3.2% |
| Medical | 2.4% | 8.0% | 2.1% | 8.4% | 3.2% |
| Social | 6.3% | 17.4% | 6.4% | 6.1% | 11.7% |
| Recreation-Other | 34.9% | 18.7% | 11.8% | 19.3% | 21.3% |
| All | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

a Muni Fast pass, suggesting a number of users had non-automobile alternatives. One-third of members making recorded car-share trips had someone else in their household who was a City CarShare member.

### 5.3 Travel Consumption Measures

Comparative statistics reveal that among members filling out Survey #3, those using City CarShare vehicles drove farther, longer, and logged more VMT than members driving private vehicles (Table 7). Car-sharers also averaged higher VMT when adjusted for occupancy levels and engine size. This suggests some degree of travel inducement, to the degree car-share travel substituted for private cars as well as walking, cycling, or transit usage.

Table 7 shows member trips via City CarShare Volkwagens were, on average, 14 percent longer than private-car trips and almost twice as long as trips by transit, walking, cycling, taxi, and other modes. Eighty percent of recorded City CarShare trips began and ended in the City of San Francisco. Also, the average distance of City CarShare trips was around one-quarter less than the average length of car-share trips recorded in Portland, Oregon, during its first-year program, which could be partly explained by San Francisco's smaller and more compact geographic area.[20] Compared to private-car driving, City CarShare trips were of slightly longer duration. (Adding the access time involved in picking up a City CarShare vehicle and egress time of returning home, the mean durations of City CarShare trips compared to private-car trips were likely even larger.) Car-share trips took a lot less time than those by other (non-private car) modes, underscoring the personal benefits conferred by automobility.

**Table 7. Comparison of Travel Statistics Among Trips by City CarShare, Private Vehicle, and All Other Modes, Members, Survey #3**

| | City CarShare | | Private Vehicle | | Other Modes | |
|---|---|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| **Trip Distance** (Road network miles) | 5.9 | 8.9 | 5.2 | 7.2 | 3.0 | 6.2 |
| **Trip Time** (minutes) | 14.3 | 16.5 | 13.6 | 14.8 | 37.8 | 2.2 |
| **Vehicle Miles Traveled** (VMT) | 5.9 | 8.9 | 5.2 | 7.2 | 2.2 | 5.6 |
| **Mode-Adjusted VMT** (MVMT) | 5.9 | 8.9 | 3.8 | 6.2 | 0.2 | 1.6 |
| **Mode & Engine-Size Adjusted VMT** (MEVMT), **All trips** | 10653.1 | 16043.2 | 9869.0 | 23,301.9 | 118.0 | 2421.7 |

Because most City CarShare users drove alone, the mode-adjusted VMT of car-share travel was also higher than that of private-car travel: 5.9 versus 3.8. Since the only mode-adjusted VMT above zero for "other modes" was for trips by taxi or other commercial services, the mean VMT statistic for this category was close to zero. When adjusting for engine size in addition to mode (in the MEVMT statistic), City CarShare trips are also seen to score comparatively high in "resource consumption," despite the fact all City CarShare trips were via sub-compact vehicles — Volkswagen Beetles. Whether this relationship holds as City CarShare diversifies its fleet over time remains to be seen.

In terms of time-of-day distributions of trips, Figure 7 shows the preponderance of surveyed City CarShare trips occurred in the afternoon. The highest incidence was between noon and 3 p.m., followed by 3 to 6 p.m. The limited share of car-share trips occurring in the morning, reflecting the limited use of vehicles for journeys to work, means City CarShare travel generally did not coincide with the congested morning peak period. Higher usage during the 3–6 p.m. period did, however, correspond to afternoon peak periods, though afternoon car-share travel was also predominantly for non-work purposes.

There was some temporal variation in usage between weekdays and weekends. Weekday car-share trips tended to concentrate more in the afternoon whereas weekend trips were generally more evenly distributed throughout the day. Higher shares of weekend City CarShare trips also took place late in the evening.

## 6. EVALUATION: AGGREGATE ANALYSES

The remainder of this report focuses on evaluating impacts. An "aggregate" evaluation is presented in this section — specifically, an analysis of total daily travel consumption. Instead of studying individual trips, the focus here is on the sum of all trips made by each surveyed person over a 24-hour period. Thus, the unit of analysis is the person, not the trip. The sample size was considerably reduced for the aggregate analysis because

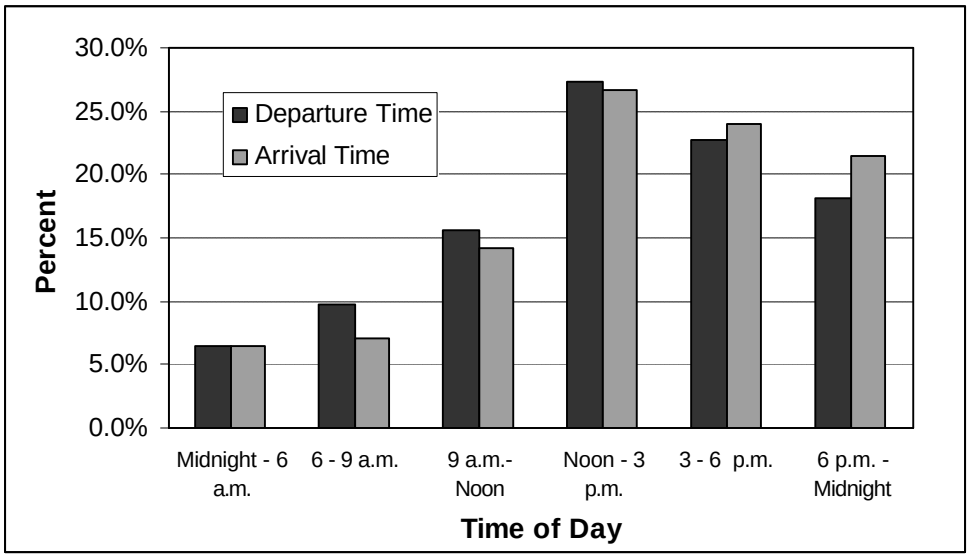


**Figure 7. Time-of-Day Distribution of Sampled City CarShare Trips, Departure and Arrival Times, Survey #3**

respondents needed to complete questionnaires for at least one of two survey days for both Survey #1 and Survey #3.[21] The majority of respondents from Survey #1 did not complete Survey #3 and vice-versa, thus cutting into the number of cases for the paired "difference of difference" analysis. Sample sizes were large enough only to examine trends for weekday travel — both for days that corresponded to respondents' workdays and to non-workdays. For weekdays/workdays, 56 person records were available from members and 49 records from non-members. For the weekdays/non-workdays, there were 78 person records for members and 36 for non-members. There were insufficient weekend responses to tabulate aggregate statistics and compare changes over time. While Survey #3 obtained a good-size sample of weekend trips, this was not the case with Survey #1, meaning most weekend trips were lost in the study of changes over time. Results presented in this section are stratified by day type — first weekday/workday followed by weekday/non-workday.

The techniques of Difference of Means (DOM) and "difference of difference of means" (DODOM) were used to examine impacts. (Pairwise sample comparisons were also produced, however since they yielded nearly identical results, they are not presented.) Because many respondents traveled by non-motorized modes, many records had zero values for VMT. And because of high transit usage, the daily MVMT was also zero for many respondents. Given the fairly small sample of panel responses for some surveys (e.g., non-members in Survey #3), the results were highly sensitive to whether travel-consumption metrics were zero or not. In instances, this led to wide swings in mean values of VMT, MVMT, and MEVMT. Under the assumption that such swings should not be systematically biased in favor of members or non-members, the DOM and DODOM results should hold validity. For these reasons, we believe of most relevance

are the DOM and DODOM results as opposed to the estimates of VMT, MVMT, and MEVMT for specific groups at specific times.

## 6.1 Analysis for Weekday and Workday: Difference of Means

While more travel diaries were recorded for weekdays that were also workdays than any day type, the rate of attrition between Survey #1 and #3 for this day type was fairly high. We assume there was no systematic bias, however — for members and non-members alike, there was no reason to believe that non-respondents from the third survey had fundamentally different travel patterns than those responding. Impacts on VMT, MVMT, and MEVMT are summarized in Table 8 for members and Table 9 for non-members.

### *Vehicle Miles Traveled (VMT)*

There was a sizable decline in average daily Vehicle Miles Traveled (VMT) for both members and non-members between the two surveys, though based on the T statistics, declines were not statistically significant at a 95 percent confidence level. These sharp declines reflect the effects of seasonal variation (e.g., between winter and autumn months), random-sample variation, modal shifts, or a combination of these factors. As noted earlier, heavy rainfall during Survey #1 could have induced more car travel whereas the relatively dry conditions during Survey #3 likely encouraged more walking and cycling (which add zero VMT and thus depress the mean statistic). In theory, the effects of seasonal and random-sample variation should have been similar between the members and non-members.

### *Mode-Adjusted and Engine-Size Adjusted VMT (MVMT and MEVMT)*

Adjusting for mode and engine size, similar patterns of declining weekday VMT were found for both members and non-members over the two survey periods. Declines were not statistically significant indicating there was generally as much within-group as between-group variation.

### *Total Trip Travel Time*

For both members and non-members, average daily time expenditures for weekday travel fell between February-March and October-November 2001. The decline among members was particularly noticeable and was statistically significant at a 95 percent confidence level. Because travel times generally fell faster than distances, average driving speeds rose. For members, speed gains accrued in part from the substitution of City CarShare trips for travel formerly made by foot or bicycle.

### *Net Impacts*

For the most common travel day (weekday/workday), there was some evidence of travel inducement among City Carshare users — not based on increased travel but rather less

**Table 8. Members: Trends in Daily Travel, Survey #1 to Survey #3, Weekday/Workday**

| | Survey #1 | | Survey #3 | | Difference of Means (S3 – S1) | T-Statistic |
|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Mean | Std. Deviation | | |
| **VMT** | 4.79 | 13.34 | 3.34 | 5.67 | -1.45 | -0.602 |
| **MVMT** | 3.98 | 7.42 | 2.86 | 5.09 | -1.12 | -0.773 |
| **MEVMT** | 2177.8 | 8377.0 | 2105.9 | 9807.9 | -71.9 | -0.036 |
| **Travel Time (min.)** | 112.2 | 104.0 | 63.7 | 64.2 | -48.5 | -2.389 |

*Key*: VMT = vehicle miles traveled; MVMT = mode-adjusted VMT; MEVMT = Mode and engine-size adjusted VMT; S3 = Survey #3; S1 = Survey #1.

**Table 9. Non-Members: Trends in Daily Travel, Survey #1 to Survey #3, Weekday/Workday**

| | Survey #1 | | Survey #3 | | Difference of Means (S3 – S1) | T-Statistic |
|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Mean | Std. Deviation | | |
| **VMT** | 8.44 | 20.29 | 4.24 | 6.58 | -4.20 | -1.148 |
| **MVMT** | 7.53 | 19.43 | 3.54 | 5.83 | -3.99 | -1.170 |
| **MEVMT** | 16565.2 | 35998.4 | 7015.8 | 9856.4 | -9549.4 | -1.504 |
| **Travel Time (min.)** | 119.5 | 128.3 | 97.1 | 71.6 | -22.4 | -0.712 |

*Key*: VMT = vehicle miles traveled; MVMT = mode-adjusted VMT; MEVMT = Mode and engine-size adjusted VMT; S3 = Survey #3; S1 = Survey #1.

decline than the control group (Table 10). Overall, VMT declined for both groups, possibly due to seasonal influences and the economic slowdown following September 11, 2001. However, VMT — expressed in all three ways — went down more for non-members than members. Evidence that City CarShare induced travel is consistent with the findings of a Swiss study that, through pre- and post-membership surveys, found a 118 percent increase in total kilometers traveled by previously carless households.[22] Given that around two-thirds of surveyed City CarShare members come from zero-car households, the sudden availability of cars appears to have stimulated automobile travel. While we attribute the slower decline in VMT among members to car-sharing, there could be other explanations, like an "echo effect" — i.e., cognizant of the mobility advantages of cars, members might have unconsciously become predisposed toward a pattern of "automobility" and thus begun driving their own cars or those of friends more often.

**Table 10. Difference of Difference: Changes of Members Minus Changes of Non-Members, Weekday/Workday, Surveys #1 to #3**

| | Difference | T-Statistic |
|---|---|---|
| **VMT** | +2.75 | 0.447 |
| **MVMT** | +2.87 | 0.591 |
| **MEVMT** | + 9,477.5 | 1.133 |
| **Travel Time (minutes)** | -26.1 | 0.501 |

Presumably car-share trips have high value-added for members willing to pay market-rate prices for use of cars. And as noted, many trips did not correspond to the peak periods, suggesting many car-share trips did not contribute to traffic congestion. "Judicious automobility" should be looked upon in a positive light since travel desires are being met while keeping the population of private cars lower, if only marginally, than it otherwise would be.

Table 10 also shows that members enjoyed an overall reduction in average daily travel time, and the reductions were larger than those experienced by non-members. This is partly explained by the switching of some travel from walking, cycling, and transit to City CarShare trips.

From Table 10, the "difference of difference" (DODOM) results — e.g., the degree to which changes in travel differed among members and non-members — were not statistically significant. All of the barometers of travel consumption — VMT, MVMT, MEVMT — decreased less over the two time points for City CarShare members than non-members. None of the differences was large enough relative to the within-group sampling variation to infer statistically significant relationships. Because of the relatively faster speed of trips, daily travel times fell faster for members than non-members, though not significantly so from a statistical standpoint.

While in absolute terms, impacts were marginal, in relative terms, they were more substantial. Figure 8 compares the percentage point difference in relative changes for mean travel statistics of members versus non-members. The biggest difference was in terms of mode and engine-size adjusted VMT — it fell by 3.3 percent for members and by 57.6 percent for non-members, producing a 54.3 percentage point differential. The figure shows that mean travel time fell on workdays/weekdays 24.5 percentage points more for members than non-members.

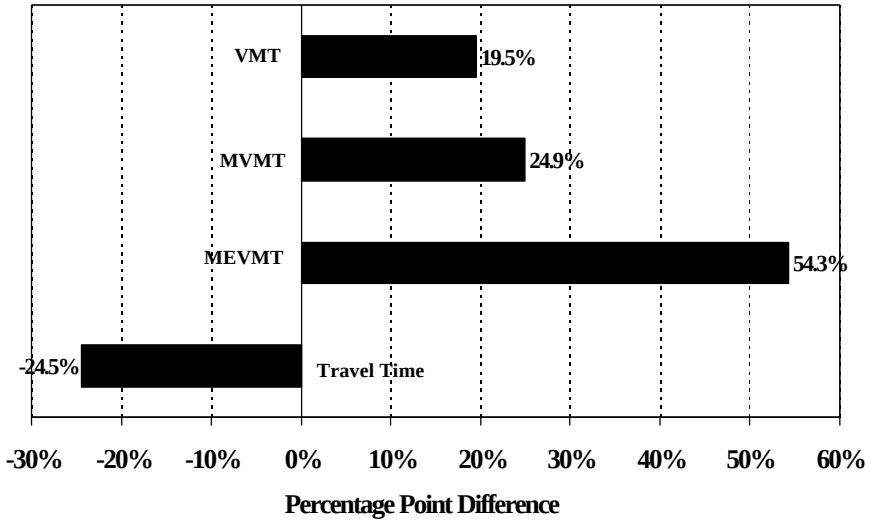


**Figure 8. Percentage Point Differences in Changes in Mean Daily Travel Characteristics: Weekdays that are Workdays, Members Relative to Non-Members, Survey #1 to Survey #3**

## 6.2 Analysis for Weekday and Non-Workday: Difference of Means

Tables 11 through 13 and Figure 9 present aggregate results for weekdays that were non-workdays. Patterns were similar to those of weekdays/workdays, with several exceptions. In general, VMT and mode-adjusted VMT went down less for members than non-members, thus producing positive values in Table 13. Adjusting for engine size, however, suggests a trend toward more resourceful automobility among City CarShare members traveling on weekdays that were not workdays — i.e., their mean mode-adjusted VMT, when also adjusted for engine size, declined faster than that of non-members, producing a negative value in Table 13. (A similar pattern was found in the short-term analysis of changes between Survey #1 and Survey #2.) Thus, while Table 13 hints at travel inducement among members, this often was in the form of small-engine vehicles. Also, the tables reveal that increases in travel time among members were generally less than increases among non-members. Again, increased automobility appears to have brought personal benefits to many members, in the form of fewer minutes spent getting around each weekday.

Compared to the weekday/workday analysis, none of the relationships for weekday/non-workday were statistically significant. This means that while there were dramatic swings between the two survey periods, the swings tend to be almost as large within groups as between groups.

## Table 11. Members: Trends in Daily Travel, Survey #1 to Survey #3, Weekday/Non-Workday

| | Survey 1 | | Survey 3 | | Difference of Means (S3 – S1) | T-Statistic |
|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Mean | Std. Deviation | | |
| **VMT** | 15.52 | 27.71 | 11.74 | 18.58 | -3.78 | -0.228 |
| **MVMT** | 12.37 | 24.26 | 9.82 | 14.21 | -2.55 | -0.254 |
| **MEVMT** | 23250.0 | 59950.6 | 9270.4 | 23120.1 | -13979.6 | -0.519 |
| **Travel Time (min.)** | 92.98 | 52.55 | 94.10 | 93.92 | +1.12 | 0.043 |

*Key*: VMT = vehicle miles traveled; MVMT = mode-adjusted VMT; MEVMT = Mode and engine-size adjusted VMT; S3 = Survey #3; S1 = Survey #1.

## Table 12. Non-Members: Trends in Daily Travel, Survey #1 to Survey #3, Weekday/Non-Workday

| | Survey 1 | | Survey 3 | | Difference of Means (S3 – S1) | T-Statistic |
|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Mean | Std. Deviation | | |
| **VMT** | 12.21 | 22.28 | 6.13 | 8.44 | -6.080 | -1.383 |
| **MVMT** | 9.36 | 15.76 | 5.47 | 7.10 | -3.89 | -0.273 |
| **MEVMT** | 23187.8 | 56539.4 | 10322.8 | 24445.4 | -12864.9 | -0.926 |
| **Travel Time (min.)** | 87.76 | 91.64 | 99.10 | 55.11 | +11.34 | 0.428 |

*Key*: VMT = vehicle miles traveled; MVMT = mode-adjusted VMT; MEVMT = Mode and engine-size adjusted VMT; S3 = Survey 3; S1 = Survey 1.

## Table 13. Difference of Difference: Changes of Members Minus Changes of Non-Members, Weekday/Non-Workday, Survey #1 to Survey #3

| | Difference | T-Statistic |
|---|---|---|
| **VMT** | +2.30 | 0.144 |
| **MVMT** | +1.34 | 0.097 |
| **MEVMT** | -1114.7 | -0.027 |
| **Travel Time (minutes)** | -10.22 | 0.194 |

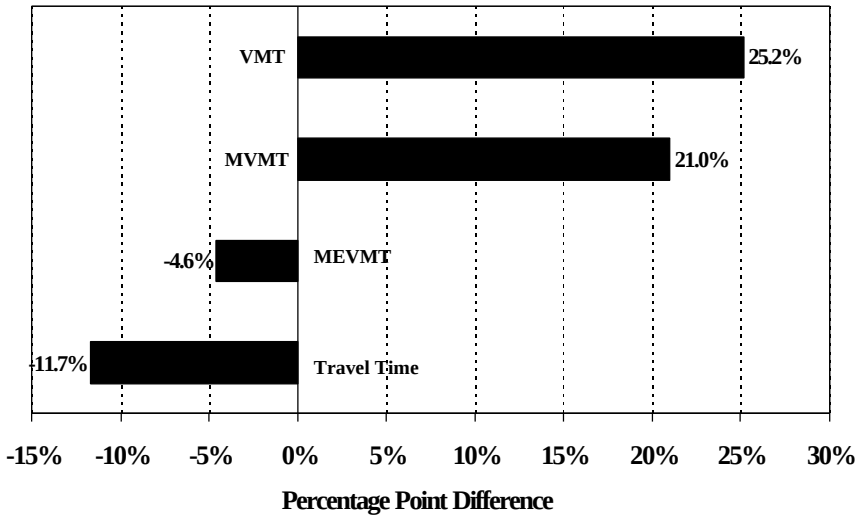


**Figure 9. Percentage Point Differences in Changes in Mean Daily Travel Characteristics: Weekdays that are Non-Workdays, Members Relative to Non-Members**

## 7. EVALUATION: TRIP-LEVEL ANALYSES

Expressing travel at the trip level provided more fine-grained insights into changes in travel consumption and behavior among members and non-members. The analyses in this section separate trip-level statistics by trip purpose rather than day type.[23] Breaking down data by trip purposes reduced sample sizes (especially for infrequent purposes like medical trips), thus such disaggregations are more prone to sampling errors.

### 7.1 Modal Splits

How did modal split distributions vary over the intermediate-term among members versus non-members? This section summarizes statistics showing changes in the shares of daily trips among modes, stratified by trip purpose. (City CarShare is not included as a mode in this distribution since non-members did not have car-sharing as a travel option, precluding the measurement of differences in modal distributions).

Table 14 presents percentage changes in shares of trips by private car, transit, walking, and cycling between Survey #1 and Survey #3, broken down by trip purpose. For both members and non-members, public transit lost market shares across most trip purposes. Non-motorized travel generally gained market shares. This could have had a lot to do

**Table 14. Differences in Percentage of Trips by Modes Among Members and Non-Members, Between Survey #1 and Survey #3**

| Trip Purpose | Status | Private Car | Transit | Walk | Bike |
|---|---|---|---|---|---|
| To Work | M | 2.8%* | -7.9%* | 4.9%* | 3.2% |
| | NM | -6.6%* | -6.1%* | 11.0%* | 14.9%* |
| To Home | M | -1.3% | -1.5% | 2.3% | 2.0% |
| | NM | 0.1% | -4.6% | -0.7% | 3.2% |
| School | M | 14.2%** | -21.1%** | 5.2%* | 7.6% |
| | NM | 2.5% | -18.2%* | 23.4%* | 15.8%** |
| Shop | M | -6.8% | 15.4%** | -12.6% | -12.6% |
| | NM | -18.0%** | -4.5% | 12.7%* | 12.7% |
| Personal Business | M | 21.3% | 8.2% | -18.9%** | -29.5% |
| | NM | 12.6% | -9.5% | -15.1% | -9.0% |
| Medical | M | -17.9% | 1.6% | 10.0% | 13.8% |
| | NM | -12.8% | -35.0% | 44.6%* | 42.5% |
| Social | M | 17.1% | -9.3% | -10.4% | -3.7% |
| | NM | 4.1% | -6.3% | -3.3% | 10.5% |
| Recreation | M | -4.8% | 1.1% | 8.3% | 6.4% |
| | NM | -15.9% | -6.4% | 7.1% | 23.9% |
| Other | M | 10.5% | 8.3% | -21.2% | -22.9% |
| | NM | -13.3% | 25.8% | -14.6% | -11.5% |
| All | M | 4.4% | -3.8% | 0.1% | -3.4% |
| | NM | -3.5% | -5.5% | 3.5% | 8.2% |

*Key*: M = member; NM = non-member; ** = statistically significant T statistic at the 5 percent probability level; * = statistically significant T statistic at the 10 percent probability level.

with differences in weather conditions. As noted earlier, February-March 2001 was a period of particularly heavy rainfall in San Francisco whereas the survey period of late October to early November was fairly dry. The very reason for introducing a "control" group is to remove the influences of such factors. Weather conditions likely affected members and non-members similarly. Thus, a difference-of-difference comparison nets out such extraneous factors.

Table 14 shows a general trend toward private-car use among members for work, school, personal business, and other travel. Members' personal business car travel appeared to replace bike trips. Besides work trips, walking and cycling seemed to gain favor among members and non-members for medical, recreation, and school trips. The table also

reveals that the most statistically significant relationships were for non-discretionary trips, notably going to work and school.

While revealing, Table 14 does not express the relative differences in modal-split changes among members and non-members. Figures 10 and 11 do so. The figures summarize the "difference of difference" results, broken down between motorized modes (Figure 10) and non-motorized modes (Figure 11). None of the "differences of difference" were statistically significant at the 10 percent probability level, however several patterns do stand out. Again, an advantage of taking such differences is that the influences of possible confounding factors, like weather conditions or gasoline price increases, are removed.

Relative to non-members, City CarShare members increased the share of private-car trips for all purposes except medical trips and returning home. Relationships were generally the opposite for transit, except for medical and personal business trips wherein members increased their reliance on transit relative to non-members.

Figure 11 shows that relative to non-members, members became less inclined to walk or bike in most instances. While it is difficult to attribute these trends to the City CarShare program, access to City CarShare vehicles could have, at the margin, cut into walking and cycling activities. A similar result was found in the short term analysis, suggesting a general trend away from non-motorized travel among car-share members. A comparison of changes in modal distributions between Survey #2 and Survey #3 (i.e., the short to intermediate term) further revealed a trend away from walk and bike travel and in favor of private-car travel among members.[24]

### 7.2 Travel Times and Distances

For members, mean travel times declined slightly between the first and third surveys, with the largest drops recorded for school, personal business, and other trip purposes (Table 15). In contrast, non-members' mean travel times went up for all but medical trip purposes. Difference-of-means were statistically significant for all trip purposes, with probabilities of obtaining such large differences from samples (if there were no differences in the population of all trips) falling well below 5 percent in most instances.

With respect to travel distances, Table 15 shows that mean values went down for both groups. For members, the biggest declines were for school and recreation trips. For non-members, distances fell the most for recreation and medical travel.

Figure 12 summarizes the "difference of difference" results by trip purpose. Mean travel times declined more for members than non-members for all purposes except medical trips. Overall, mean travel times declined around 12 minutes more for members than non-members. Some of this was due to the switch from walking, biking, and transit to car-share travel.

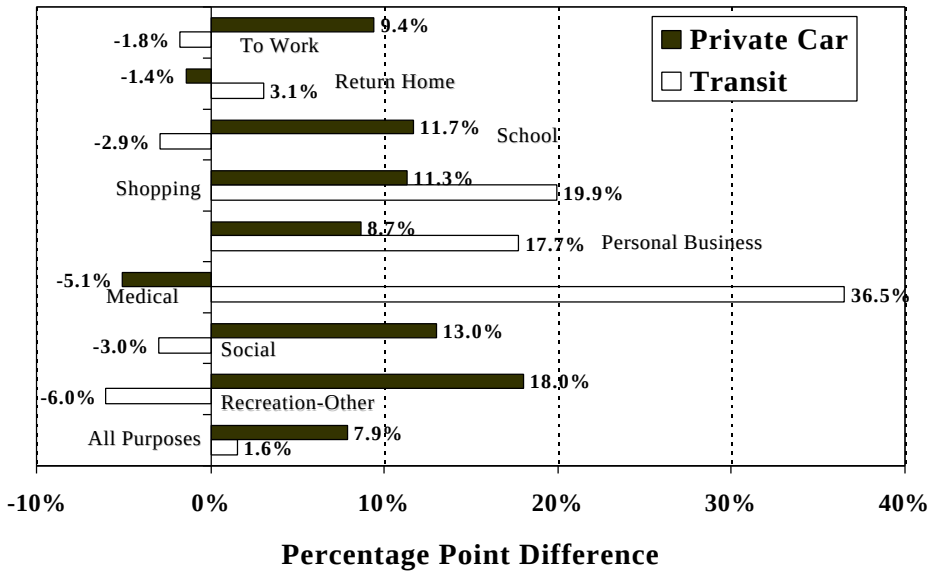


**Figure 10. Relative Changes in Motorized Modal Distributions Among Trip Purposes.** Represents percentage point difference in share of trips by private car and transit between Survey #1 and Survey #3, Members relative to Non-Members.

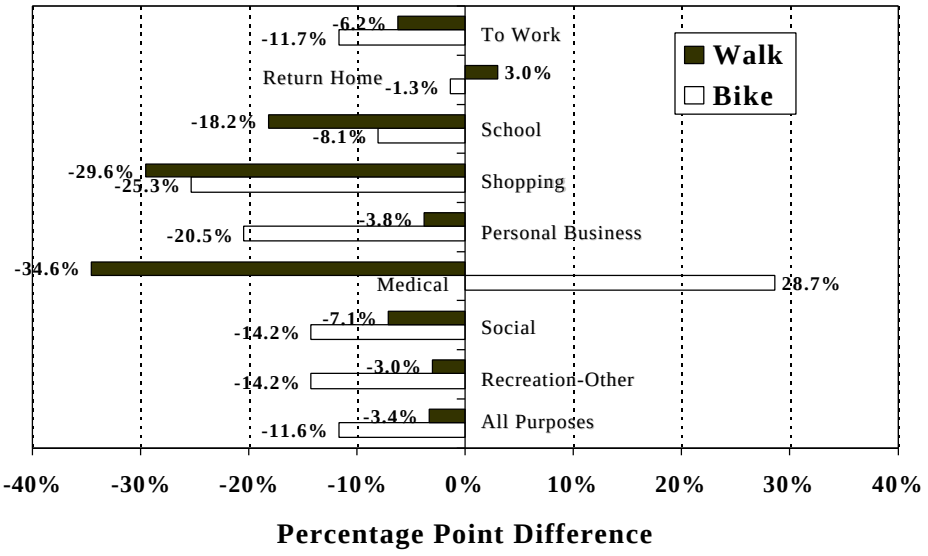


**Figure 11. Relative Changes in Non-Motorized Modal Distributions Among Trip Purposes.** Represents percentage point difference in share of trips by walking and cycling between Survey #1 and Survey #3, Members relative to Non-Members.

**Table 15. Differences in Mean Travel Times, Trip Distances, and MVMT Among Members and Non-Members, Between Survey #1 and Survey #3**

| Trip Purpose | Status | Travel Times | Trip Distances | MVMT |
|---|---|---|---|---|
| **To Work** | M | 3.135** | -0.076 | 0.573 |
| | NM | 18.418** | -1.585* | -0.998 |
| **To Home** | M | 3.833** | -1.922 | -0.746 |
| | NM | 8.999** | -0.654 | 0.211 |
| **School** | M | -18.292** | -3.948** | 0.211* |
| | NM | 2.487** | 1.728** | 2.595** |
| **Shop** | M | 1.306** | -2.268* | -1.099 |
| | NM | 4.400** | -0.326** | -1.165 |
| **Personal Business** | M | -7.791** | .0460 | 1.071 |
| | NM | 3.072** | -0.492 | 0.425 |
| **Medical** | M | 2.573** | 0.245 | -0.181 |
| | NM | -13.067** | -1.839 | -0.469 |
| **Social** | M | 9.346** | -0.237* | 0.735 |
| | NM | 84.087** | -0.471** | -1.052 |
| **Recreation** | M | 2.202** | -2.823** | -1.445** |
| | NM | 7.144** | -2.343 | -1.245 |
| **Other** | M | -0.279** | 0.541 | 0.752 |
| | NM | 5.452** | -1.266 | -1.304 |
| **All** | M | -0.414** | -1.003 | -0.013 |
| | NM | 12.099** | -0.725 | -0.300 |

*Key*: M = member; NM = non-member; MVMT = mode-adjusted vehicle miles traveled; ** = statistically significant T statistic at the 5 percent probability level; * = statistically significant T statistic at the 10 percent probability level.

With regard to trip distances, patterns were not as coherent. In general, trip distances fell slightly more among members than non-members. The largest relative declines among car-share members were for school and shopping trips. Some of this is likely due to the automobility benefits conferred by City CarShare.

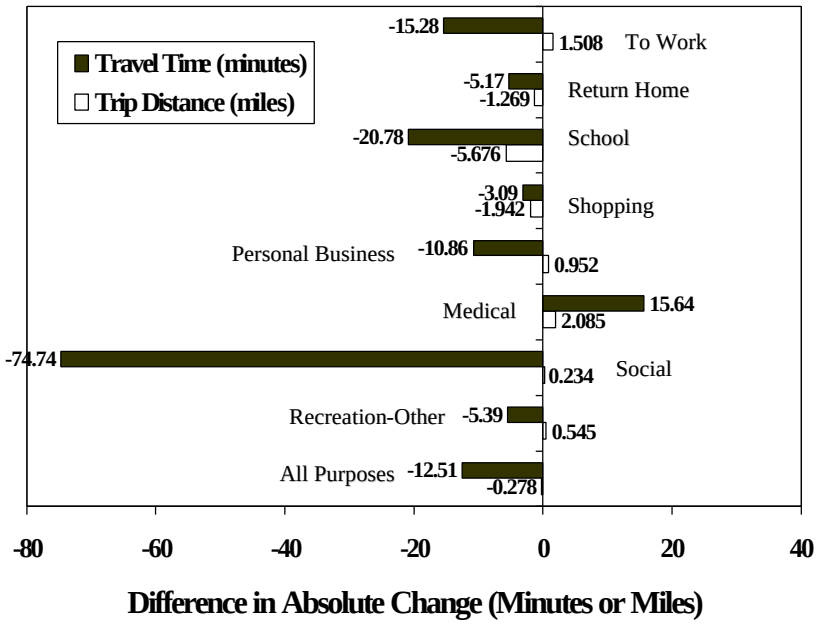


**Figure 12. Relative Changes in Mean Travel Times and Trip Distances Across Trip Purposes.** Represents absolute difference in mean travel times and trip distances between Survey #1 and Survey #3, Members relative to Non-Members.

### 7.3 Mode-Adjusted Vehicle Miles Traveled

The last column of Table 15 shows that mean mode-adjusted VMT per trip fell slightly for car-share members across the two survey periods. The biggest decline was for shopping and recreational trips (as was the case in the short-term analysis). The large increases were for personal business and social trips. For non-members, MVMT fell for work, shop, medical, recreational, and other purposes.

Difference-of-difference results are summarized in Figure 13. Relative to non-members, the mean mode-adjusted VMT of members fell faster for school, shopping, and return-home trips. For work and socializing, mean mode-adjusted VMT fell more quickly for non-members, and for medical and personal business trips it increased for members but fell for non-members (both of which produced negative difference-of-difference scores). Thus, for most trip purposes there was evidence of motorized-travel stimulation among members — relative to non-members, mode-adjusted VMT increased more quickly across five trip purposes. The comparatively large decline in MVMT for school trips


**Figure 13. Relative Changes in Mean Mode-Adjusted Vehicle Miles Traveled Across Trip Purposes.** Represents absolute difference in mode-adjusted vehicle miles traveled between Survey #1 and Survey #3, Members relative to Non-Members.

deflated the average for all trip purposes, however across most purposes, differences of differences were positive.

We note that, as in the case of the short-term analysis, the findings of the trip-level analysis differ from the aggregate analysis presented earlier, wherein mode-adjusted VMT increased for members compared to declines for non-members. The aggregate analysis, however, was conducted for weekday travel only whereas the statistics presented at the trip level are for all days of the week — weekdays and weekends. Besides the effects of using different units of analysis (persons versus trips), differences could be due to some degree of travel inducement on weekdays and travel suppression on weekends.[25] The absence of statistically significant results means one is best advised to hedge when interpreting these findings. Regardless, the evidence suggests that members' mode-adjusted VMT rose in the aggregate and for the majority of trip purposes, a finding that is consistent with the three-month short-term analysis results.

## 8. EXPLANATORY ANALYSES

While differences of means and other statistical tests reveal associations between car-share membership and travel behavior, they provide no predictive insights. Moreover, atomized analyses of data (i.e., "slicing and dicing" the data base) can cause one to focus on fine details but lose sight of the "forest through the trees." Predictive models which identify factors that explain outcomes help not only to synthesize findings presented so far, but also provide a firmer foundation from which to draw causal inferences.

This section presents the results of three predictive models that help to illuminate City CarShare's impacts on travel behavior. All models are based on results of the third survey. Presented first is a model of private-car mode choice. One hypothesis is that car-share membership reduces usage of private cars. An alternative hypothesis is the echo effect — regular use of car-share vehicles exposes members to benefits of automobility which encourages those with access to other cars at home to drive more. The second model predicts whether members chose car-sharing for specific trips. The focus here is on identifying the attributes of members associated with high probabilities of car-share usage. The final model predicts daily travel-time expenditures based on attributes of members and non-members, and their travels. Whereas the first two models use trips as data observations, the third uses people (i.e., member and non-member respondents) as the unit of analysis. Attempts were made to estimate other predictive models, however the three presented in this section provided the most interpretable results and statistically were the best-fitting.

### 8.1 Private-Car Choice Model

Using binomial logit analysis, a reasonably good-fitting model with interpretable and intuitive coefficients was derived. Table 16 summarizes the maximum-likelihood estimation results.

Income levels of City CarShare members appeared to have a bearing on private-car travel. Table 16 shows that while members were more likely to drive their own cars in the October-November 2001 period than non-members, this did not hold for those in the non-low-income category. The model suggests that members with personal incomes above $25,000 per year curtailed their private-car usage once joining City CarShare. Such individuals are thought to represent well-educated professionals with "green" leanings, the very people who might be expected to cut back their use of private cars. The model suggests that other members — i.e., those with low incomes — tended to increase personal car use since becoming car-sharers. Thus while for non-low-income members, there is evidence of a substitution effect, for those with low incomes there could be an echo effect. Car-sharing experiences could have predisposed some of these members to drive cars at other times for other purposes. We note that the short-term logit results (presented in the earlier report) suggested members of all income levels were less inclined to drive private cars. The relationship between car-sharing and private

## Table 16. Binomial Logit Model for Predicting Likelihood Respondents from Survey #3 Chose Private Car for Trip, All Trip Purposes

| Variables | Coefficient Estimate | Standard Error | Probability |
|---|---|---|---|
| **Member Status:** | | | |
| City CarShare Member (1=yes; 0=no) | 0.948 | 0.410 | .021 |
| City CarShare Member & Non-low income (>$26,000) (1=yes; 0=no) | -1.241 | 0.392 | .002 |
| **Modal and Travel Attributes:** | | | |
| Total Travel Time Differential: Transit– Automobile (minutes)[a] | 0.061 | 0.009 | .000 |
| Travel Distance, highway network (miles) | -0.105 | 0.297 | .000 |
| Have a Transit Pass (1=yes; 0=no) | -0.634 | 0.203 | .002 |
| Own a Bike (1=yes; 0=no) | -0.410 | 0.212 | .054 |
| Have Access to Company Car (1=yes; 0=no) | -0.884 | 0.406 | .030 |
| **Socio-Economic Controls:** | | | |
| Annual Personal Income ($000s) | 0.008 | -0.004 | .030 |
| No. of Vehicles in Household | 0.593 | 0.099 | .000 |
| Gender (0 = Female; 1 = Male) | -0.715 | 0.218 | .001 |
| **Day Type:** | | | |
| Weekday (1=Yes; 0=No) | -0.442 | 0.214 | .039 |
| Workday (1=Yes; 0=No) | -0.671 | 0.297 | .024 |
| Constant | -3.768 | 0.717 | .000 |
| **SUMMARY STATISTICS** | | | |
| Number of Cases | | | 2147 |
| -2$\mathcal{L}'$(c): Log Likelihood Function Value, Constant-only Model | | | 898.7 |
| -2$\mathcal{L}'$(*B*): Log Likelihood Function Value, Parameterized Model | | | 722.5 |
| Model Chi-Square (Probability): -2[$\mathcal{L}'$(c) - $\mathcal{L}'$(*B*)] | | | 176.2 (.0000) |
| Goodness of Fit (McFadden) | | | $\rho^2$ =.196 |

***Notes:***

[a] For transit travel, travel time consists of that occurring "in vehicle" (BART, Muni rail, or Muni bus) and "out-of-vehicle" (including walk time for access and transfers and waiting time, and driving to access transit, if any). For drive-alone travel, total time consists of in-vehicle network highway travel time.

automobile usage is far from transparent, at least in the case of San Francisco, thus this issue should be revisited in future evaluations.

In terms of modal and travel attributes, Table 16 shows that personal car usage rose as the time savings of auto versus transit travel increased given a trip origin-destination combination. Longer trips were associated with less car usage. As expected and consistent with the short-term model findings, owning a bicycle, having a Muni or BART transit pass, and having access to a company car lowered the likelihood of private-car travel.

The socio-economic control variables defined other attributes of City CarShare members and non-members who tended to drive. The probability of driving rose with income and vehicles per household and among females, all else held constant. Traveling on weekdays and workdays lowered the odds of driving a private car.

Figure 14 presents a sensitivity analysis, revealing the responsiveness of private-car travel to changes in two variables: membership status and, the strongest covariate predictor, travel-time differential. For members, results are stratified by low versus non-low income to reveal the model's contrasting findings. In the analysis, all other variables are set at their modal or mean values, representing the "typical" survey respondent. The figure shows that for a workday/weekday trip that took 20 minutes more by transit than by driving, there was a 12 percent chance that a "typical" non-member would travel by private car, all else being equal. If the person was a low-income City CarShare member, however, the odds jumped to 23 percent. But if the car-sharer had an income similar to a non-member's, the odds were actually lower — under 10 percent. Since most City CarShare members make more than $25,000, reduced private-car usage appears to be the trend for the majority of members. All else being equal, a professional-class member was less likely to drive a car than a professional-class non-member.

Overall, these results reveal that bicycle ownership, transit passes, speedy transit services, low car ownership, and City CarShare membership are associated with reduced private automobile usage. They also suggest that, except for those with low incomes, membership suppressed private-car travel, whether through encouraging people to reduce car ownership, making members cognizant of alternative mobility options, car-sharing itself, or some combination of these factors.

### 8.2 CarShare Usage

What factors explain whether members select City CarShare vehicles for their trips? Table 17 reveals that travel time is a key one. When the travel time between any two points is longer by public transit than by private automobile, members are generally inclined to choose the car-share option. This held, however, only up to a point of around a 10-minute differential. Based on the quadratic expression of travel time, the probability of car-sharing declined when transit travel saved considerable time over the car. This is

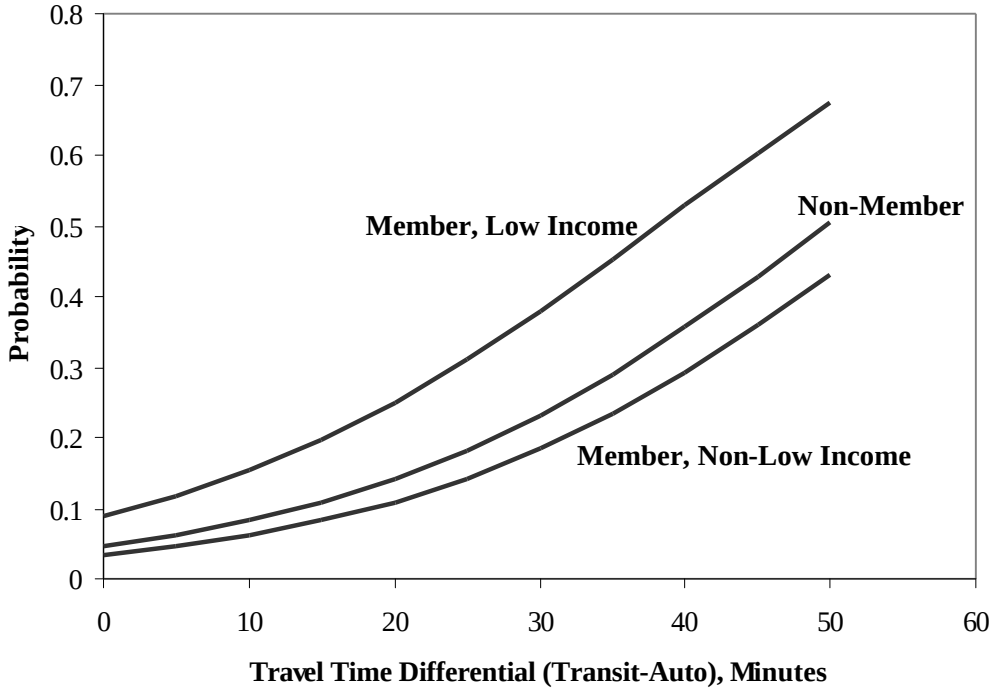


**Figure 14. Sensitivity of Private Car Travel to City CarShare Member, by Income Level, as a Function of Travel Time Differential.** All probabilities based on the mean or modal attributes of survey respondents, assuming: no transit pass, company car access, or bicycle ownership; female; one car in household; weekday and workday travel of 5 miles; and annual personal income of $50,000 for non-members and non-low-income members, and $25,000 for low-income members.

thought to represent situations such as trips to downtown and during peak periods when transit riding in San Francisco can provide sizable door-to-door travel time savings relative to the private car. As confirmed in the spatial analysis presented in the next section, relatively few car-share trips are to downtown San Francisco. This is also corroborated by the findings on trip purposes. A work trip discourages car-sharing whereas traveling for personal business (e.g., to the bank, to meet a business colleague, to pick up clothes at the dry cleaner) increases it.

From a socio-economic standpoint, the most important predictors of car-share usage were income, age, educational level, and private-car ownership. Having a relatively high income and a college education, along with being over 40 years of age, increased the

## Table 17. Binomial Logit Model for Predicting Likelihood Member Respondents from Survey #3 Chose City CarShare for Trip, All Trip Purposes

| Variables | Coefficient Estimate | Standard Error | Probability |
|---|---|---|---|
| **Modal Attributes:** | | | |
| Total Travel Time Differential: Transit – Automobile (minutes)[a] | 0.100 | 0.021 | .000 |
| Total Travel Time Differential Squared | -0.001 | 0.000 | .001 |
| **Trip Purpose:** | | | |
| Work Trip (1=yes; 0=no) | -2.189 | 0.652 | .001 |
| Personal Business (1=yes; 0=no) | 1.780 | 0.370 | .000 |
| **Socio-Economic Characteristics:** | | | |
| Annual Personal Income ($000s) | 0.095 | 0.005 | .042 |
| No. of Vehicles in Household | -1.579 | 0.441 | .000 |
| Less than 40 Years of Age (1=yes; 0=no) | -0.835 | 0.504 | .098 |
| Highest Education Attainment (1 = Grade School; 2 = High School; 3 = College; 4 = Graduate School) | 0.658 | 0.753 | .000 |
| Constant | -6.947 | 2.570 | .007 |
| **SUMMARY STATISTICS** | | | |
| Number of Cases | | | 1573 |
| $-2\mathcal{L}(c)$: Log Likelihood Function Value, Constant-only Model | | | 366.2 |
| $-2\mathcal{L}(B)$: Log Likelihood Function Value, Parameterized Model | | | 250.0 |
| Model Chi-Square (Probability): $-2[\mathcal{L}(c) - \mathcal{L}(B)]$ | | | 116.2 (.0000) |
| Goodness of Fit (McFadden) | | | $\rho^2$ =.317 |

***Notes:***

[a] For transit travel, travel time consists of that occurring "in vehicle" (BART, Muni rail, or Muni bus), and "out-of-vehicle" (including walk time for access and transfers and waiting time, and driving to access transit, if any). For drive-alone travel, total time consists of in-vehicle network highway travel time.

probability of renting a City CarShare vehicle. More significant was vehicle ownership: the fewer private cars available in a member's household, the more likely he or she used a City CarShare vehicle. This is empirical evidence that car-sharing substitutes for private cars: controlling for factors like income and trip purpose, those who own few or no cars are more likely to lease City CarShare vehicles.

A sensitivity analysis of the model results is summarized in Figure 15. As before, all predictor variables are set at their mean or modal values to represent a "typical" situation, except the two sensitivity-test variables: travel-time differential and car ownership levels. The convex curves reveal the quadratic relationship between car-share usages and travel-time differential — the probability of car-sharing rises up to around a 10 minute travel-time savings of car versus transit travel and falls thereafter. As dramatic is the influence of car availability. Clearly, odds are far greater (albeit still below 10 percent) of someone without versus with a car available choosing City CarShare for a particular trip. For a trip that takes 10 minutes longer to travel door-to-door by transit than by auto, the odds of City CarShare travel is around 9 percent if the person has no car available, 2 percent if one car is available, and a half percent if two cars are available.

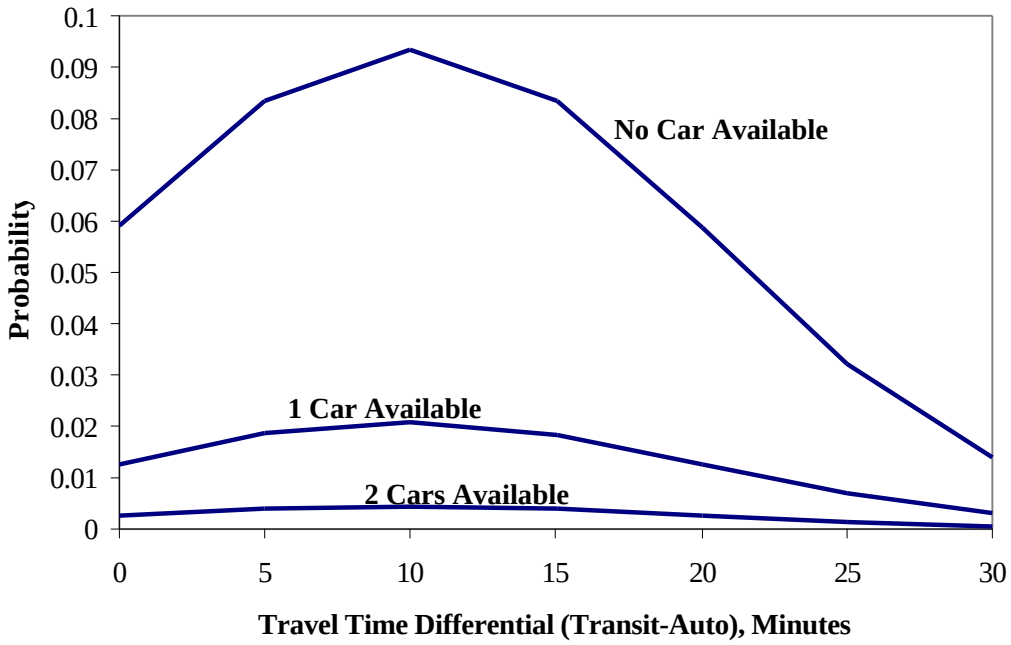


**Figure 15. Sensitivity of City CarShare Travel as a Function of Travel Time Differential and Private Car Availability.** All probabilities based on the mean or modal attributes of survey respondents, assuming: trip purpose other than work or personal business; persons under 40 years of age; college education; and annual personal income of $50,000.

### 8.3 Travel Time Expenditures

A regression model, summarized in Table 18, was estimated that predicted the average daily travel time expenditure for respondents of the third survey. Taking transit to work was associated with less time spent per day traveling, reflecting the time savings conferred by BART, Muni Light Rail, and CalTrain for peak-period trips to work. Owning a bike was associated with more time spent per day traveling, reflecting slow average cycling speeds. Parking also had some bearing. Off-street parking at one's home appeared to induce travel, adding more minutes per day moving around. Free parking at the workplace had a similar inducement effect, except for members of City CarShare.

Of most relevance to this research, Table 18 shows that City CarShare members generally devoted less time traveling per day than non-members. This could reflect the time savings from car-sharing relative to previous modes of travel like walking and cycling. Given the high share of carless individuals who are City CarShare members, low travel-time expenditures could also reflect the effects of travel suppression. Additionally, the table showed living and working in the city of San Francisco generally equated with less time spent traveling. Having a job, living in a small household, and being non-Hispanic also correlated with less time spent getting around each day.

## 9. SPATIAL ANALYSES

This section summarizes the results of studying spatial differences in trip-making between Survey #1 and Survey #3. The section is divided into descriptions of: POD locations; origins of City CarShare trips; destinations of City CarShare trips; and origin-destination patterns.

### 9.1 POD Locations and Trip Origins

"POD," short for "point of departure," has become the accepted name for parking lots where customers pick up and return car-share vehicles. In October-November 2001 when surveys were conducted, there were eleven car-share PODs, shown in Figure 16. This is two more than what existed four months earlier at the time of the short-term impact analysis.

Figure 17 shows the distribution of car-share pick-up locations among the sample of City CarShare trips compiled in Survey #3. Among sampled cases, the most frequently used PODs were at 14$^{th}$ & Castro, 360 Grove Street, and 16$^{th}$ & Valencia Street. The least used PODs were in and around downtown. A similar spatial pattern was found in the short-term analysis. Also similar was the average access distance from a member's home to a POD, around one-half mile. Proximity of PODs to residences no doubt has a bearing on membership levels. As more PODs become convenient to more residents, membership can be expected to increase.

## Table 18. Regression Model for Predicting Respondents' Average Daily Travel Time Expenditures from Survey #3, All Trip Purposes

| Variables | Coefficient Estimate | Standard Error | Probability |
|---|---|---|---|
| **Modal/Transportation Attributes:** | | | |
| Transit Mode to Work (1=yes; 0=no) | -28.668 | 15.185 | .062 |
| Own a Bike (1=yes; 0=no) | 43.509 | 15.104 | .005 |
| Off-Street Parking at Residence (1=yes; 0=no) | 33.786 | 16.106 | .038 |
| Free Parking at Work (1=yes; 0=no) | 28.116 | 32.000 | .382 |
| Free Parking at Work for Members (1=yes; 0=no) | -62.661 | 39.164 | .113 |
| **Person Characteristics:** | | | |
| City CarShare Member (1=yes; 0=no) | -38.925 | 19.447 | .001 |
| No. Persons in Household | 1.780 | 0.370 | .048 |
| Live and Work in San Francisco (1=yes; 0=no) | -41.010 | 18.476 | .029 |
| Employed (1=yes; 0=no) | -83.575 | 53.462 | .121 |
| Hispanic Origin (1=yes; 0=no) | 74.127 | 31.748 | .021 |
| Constant | 229.608 | 60.142 | .000 |
| **SUMMARY STATISTICS** | | | |
| Number of Cases | | | 114 |
| R squared | | | .335 |
| F Statistic (probability) | | | 5.189 (.000) |

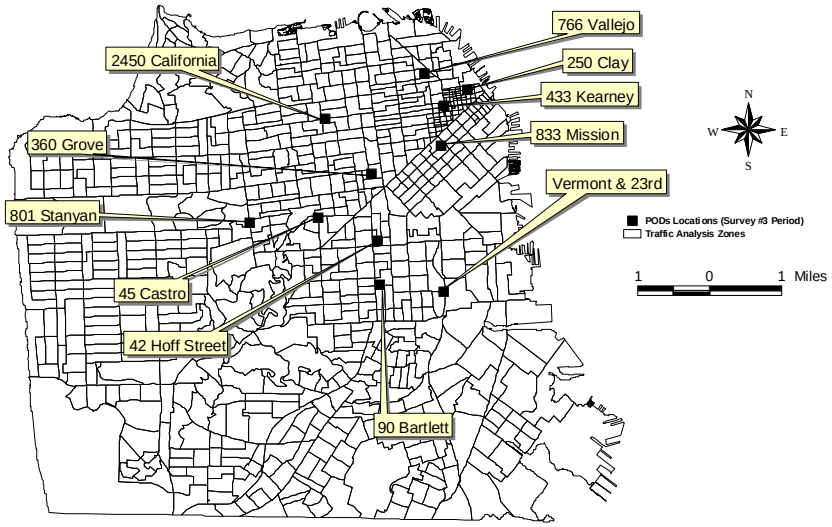


**Figure 16. Location of POD Garages in San Francisco at Time of Survey #3**

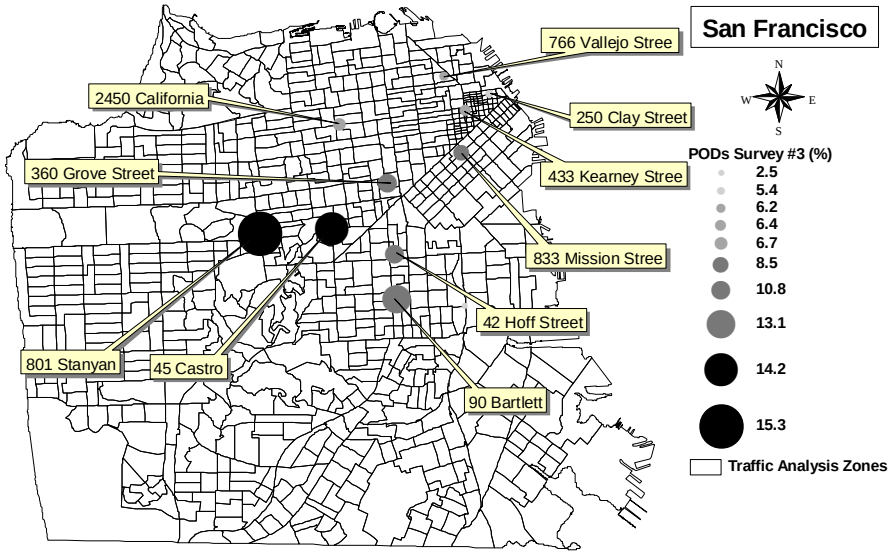


**Figure 17. Percentage of City CarShare Trips Originating in Each POD, Survey #3**

## 9.2 Origins and Destination City CarShare Trips

Figure 18 shows the origins of sampled City CarShare trips, typically representing respondents' residences, in Survey #3. As expected, trip origins were spatially oriented toward the locations of PODs. There was little spatial clustering of car-share trip origins, revealed by a low spatial autocorrelation statistic (based on Moran's I) of 0.02.[26] As a basis of comparison, Figure 19 shows the origins of all work trips made by private cars (excluding City CarShare vehicles) among members in Survey #3. For these trips, a similarly weak Moran's I spatial autocorrelation of 0.02 was found.

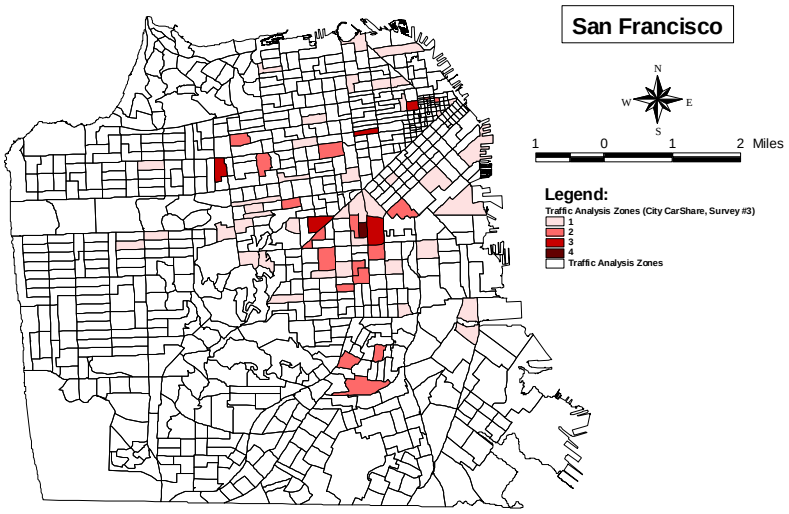


**Figure 18. San Francisco Traffic Analysis Zones (TAZ) of City CarShare Trip Origins, Survey #3.** Origin TAZ of City CarShare trips shown in shade.

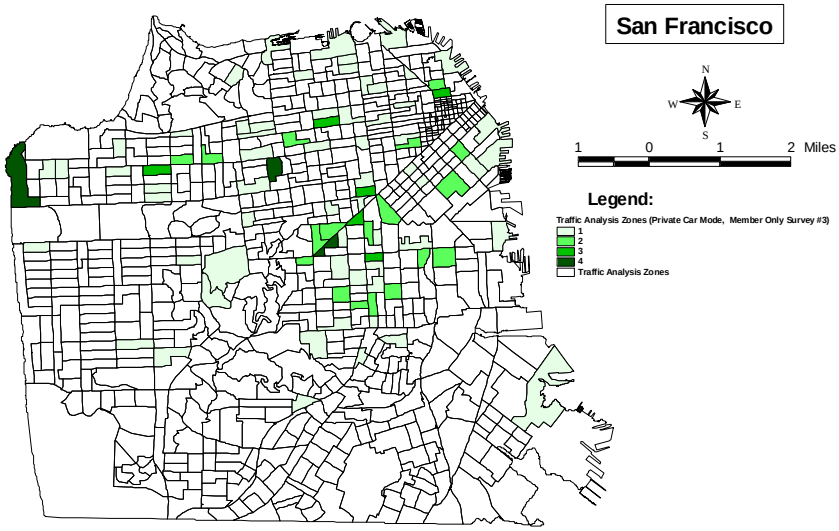


**Figure 19. San Francisco Traffic Analysis Zones (TAZ) of Trip Origins of Private Car Trips, Excluding City CarShare Vehicles, Survey #3.**
Origin TAZ of trips shown in shade.

For purposes of further defining the spatial nature of City CarShare trips, destination of trips from PODs was defined according to four quadrants of the city of San Francisco as well as all destinations outside the city (Figure 20). These were compared to the trip destinations of all trips made by members in Survey #1 (prior to the City CarShare program), Survey #2 (early into the program), and Survey #3 (the intermediate term).

Table 19 shows the comparison results. Compared to travel prior to City CarShare, return-home trips were more spatially concentrated in Survey #3. For social trip purposes, whereas the carshare-using members made all trips to destinations outside the city in Survey #1 (prior to program initiation), in the second and third surveys they were all to the northwest quadrant of the city. The small sample size makes drawing any inferences from these results difficult, however the trends are consistent with the notion that car-sharing encourages localized non-discretionary trips. The table also shows that no work or personal business trips were recorded among CarShare users in Survey #3 who also completed the two previous surveys.

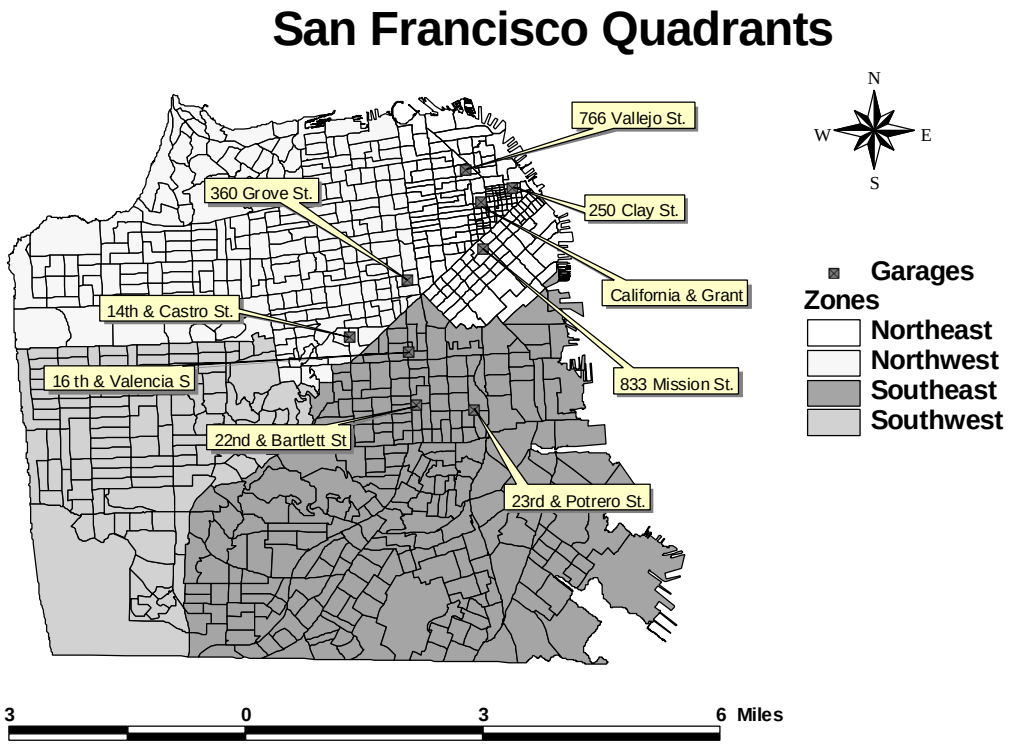


**Figure 20. Quadrants of the City of San Francisco**

**Table 19. Spatial Percentage Distributions of All Trip Destinations by Trip Purpose, Members who were Car-Sharers in Survey #3, Trends from Survey #1 to Survey #3**

| Survey | Trip Purpose | Zones | | | | | |
|---|---|---|---|---|---|---|---|
| | | Northeast | Northwest | Southeast | Southwest | Outside | Total |
| Survey # 1 | Work | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| | Return Home | 21.4% | 57.1% | 7.1% | 0.0% | 14.3% | 100.0% |
| | Social | 0.0% | 0.0% | 0.0% | 0.0% | 100.0% | 100.0% |
| | Personal | 25.0% | 75.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| Survey # 2 | Work | 33.3% | 33.3% | 0.0% | 0.0% | 33.3% | 100.0% |
| | Return Home | 0.0% | 40.0% | 20.0% | 0.0% | 40.0% | 100.0% |
| | Social | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| | Personal | 50.0% | 50.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| Survey # 3 | Work | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Return Home | 0.0% | 60.0% | 40.0% | 0.0% | 0.0% | 100.0% |
| | Social | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| | Personal Business | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

Enlarging the sample to include trips by members and non-members over the three survey periods produced the distributions shown in Table 20. For work and school trips, there is a more even spatial distribution of trips in Survey #3 relative to the two previous ones, both among members and non-members. There is less of a strong orientation of work-school trips to downtown San Francisco (northeast quadrant). Other trip purposes also have more even distributions of trip destinations. For all three survey periods, a small share of trips was to the southwest quadrant. This is largely due to the current absence of PODs in this area, which is apt to reduce membership among those living in this area. Since the "non-members" are those who are signed up to one day become members, the absence of PODs in the southwest area could have discouraged people to register as well.

## 9.3 Origin-Destination Patterns

Figures 21 and 22 compare trip origin-destination patterns between Survey # 3 among members and non-members, respectively, for all trip purposes combined. The "desire line" maps — which identify the straightline, most direct paths that people "desire" to take for each origin-destination pair — show a strong orientation of trips in areas with PODs, both prior to and nine months into the launching of the City CarShare program. This is partly a product of self-selection: those who live near a POD were likely to join or

**Table 20. Spatial Percentage Distributions of All Trip Destinations by Trip Purpose, Members and Non-Members, Surveys #1 Through #3**

| | | | Zones | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Membership | Trip Purpose | Northeast | Northwest | Southeast | Southwest | Outside | Total |
| Survey #1 | Member | Work-School | 61.9% | 11.0% | 12.3% | 4.5% | 10.3% | 100.0% |
| | | Home | 30.1% | 36.5% | 25.6% | 3.7% | 4.1% | 100.0% |
| | | Other | 35.7% | 21.6% | 30.5% | 1.6% | 10.5% | 100.0% |
| | Non-Member | Work-School | 41.6% | 16.4% | 20.6% | 4.7% | 16.8% | 100.0% |
| | | Home | 15.4% | 38.8% | 29.8% | 8.0% | 8.0% | 100.0% |
| | | Other | 21.7% | 29.7% | 30.4% | 5.0% | 13.2% | 100.0% |
| Survey #2 | Member | Work-School | 57.3% | 8.7% | 9.7% | 3.9% | 20.4% | 100.0% |
| | | Home | 29.9% | 30.6% | 26.4% | 2.8% | 10.4% | 100.0% |
| | | Other | 26.8% | 28.8% | 26.8% | 1.0% | 16.6% | 100.0% |
| | Non-Member | Work-School | 39.5% | 13.3% | 12.8% | 4.6% | 29.7% | 100.0% |
| | | Home | 12.1% | 35.0% | 2.02% | 7.0% | 23.8% | 100.0% |
| | | Other | 24.9% | 30.3% | 16.1% | 5.4% | 23.4% | 100.0% |
| Survey #3 | Member | Work-School | 39.8% | 18.0% | 24.5% | 3.5% | 14.3% | 100.0% |
| | | Home | 19.7% | 33.3% | 32.5% | 7.1% | 7.5% | 100.0% |
| | | Other | 22.4% | 26.2% | 30.3% | 8.1% | 13% | 100.0% |
| | Non-Member | Work-School | 35.4% | 20.8% | 20.8% | 4.6% | 18.5% | 100.0% |
| | | Home | 11.2% | 38.2% | 31.5% | 10.7% | 8.4% | 100.0% |
| | | Other | 24.2% | 26.1% | 30.3% | 7.3% | 12.1% | 100.0% |

sign up to one day join City CarShare. The denser pattern of desire lines in Figure 21 simply reflects the larger sample of members' trips obtained from Survey #1. Although not presented here, desire line maps for other trip purposes were similar. While many members' total trips were to the downtown and other dense districts, relatively few car-share trips were destined to these locations.

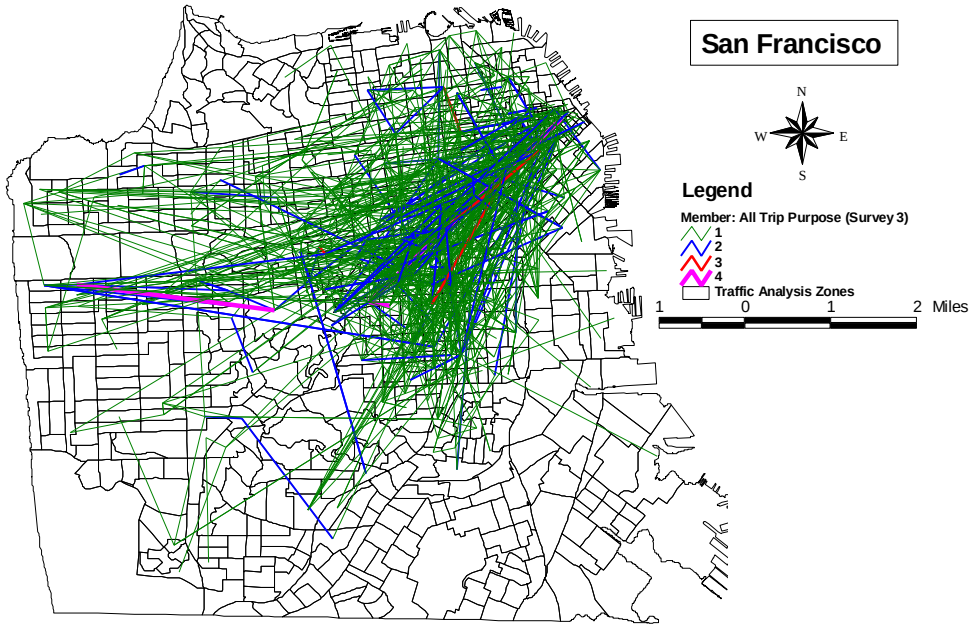


**Figure 21. Desire Line Maps of Trips Made for All Purposes: Members, Survey #3**

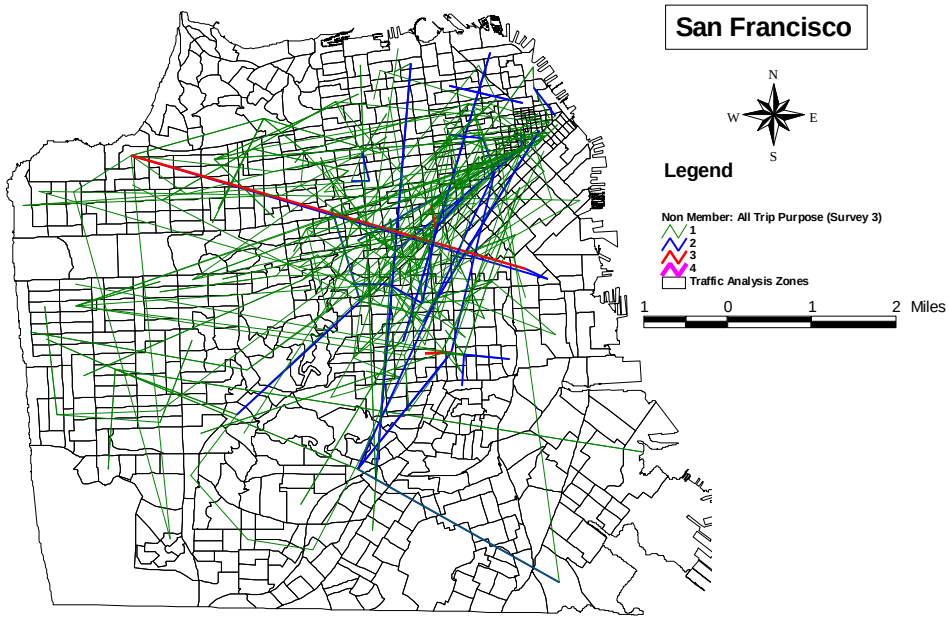


**Figure 22. Desire Line Maps of Trips Made for All Purposes: Non-Members, Survey #3**

## 10. CONCLUSION

San Francisco's foray into car-sharing appears to be gaining popularity. Based on member surveys, car-sharing grew from an estimated 2.2 percent of all trips three months into the program to more than 7 percent six months later (i.e., nine months from the service's inauguration). Adjusting for the fact that car-sharing trips tend to be longer than those made by other modes, City CarShare travel grew from 8.1 percent of vehicle miles traveled (VMT) at the three-month mark to 21.6 percent of VMT some nine months into the program. All signs show that car-sharing is grabbing a growing share of members' "travel pie" over time.

City CarShare also appears to be inducing motorized travel. This should not be unexpected given that over two-thirds of members come from carless households. Basic economics teaches us that as the "automobility" supply curve shifts outwards, all things being equal, more automobile trips will be made. Because car-share trips appear to be substituting for travel that formerly took place by foot or bicycle, and car-share trips tend to be longer than private-car trips, members' VMT also appears to be on the rise. (More precisely, the evidence revealed that members' average VMT fell less than the average of the control group, inferring some degree of travel inducement.)

Increased automobility is not necessarily bad and, in fact, new car trips very likely represent a net social benefit. Members are not using car-share vehicles much for work trips, during congested morning peak periods, or for trips to downtown San Francisco. Rather, car-share vehicles tend to be used more for personal business and social-recreational travel, often during non-peak periods. Presumably members perceive benefits exceed the marginal costs of leasing vehicles. Before-and-after surveys reveal that car-sharing conferred significant travel-time savings to members, due in part to the substitution of motorized trips for trips previously made by walking and cycling. Consistent with the findings from the near-term survey, car-sharing appears to be promoting "judicious automobility" — people are selectively leasing cars at market rates to meet bona fide travel needs, generally not at congested periods or to places well-served by public transit, like downtown. Thus, while the leasing of subcompact cars (Volkswagon Beetles) is providing significant personal benefits in the form of travel-time savings, in general this does not appear to be at the expense of high social-environmental costs (e.g., added congestion, high resource consumption).

Mode-choice models revealed that car-share usage appears to be cutting into private-car travel, especially among members with higher incomes. This appears to be less because members are getting rid of cars and more due to them selectively substituting City CarShare vehicles for their own. Predictive models also revealed that car-share usage tended to increase as personal income, education levels, and age increased, and when members were from zero-car households.

For the intermediate-term analysis, findings were generally more interpretable than from the short-term analysis. This was expected in that three to four months into the program, when the short-term surveys were compiled, San Francisco's City CarShare was still in

its infancy. By the ninth month of the program, many members likely had already settled into a certain pattern of usage. This bodes favorably for the ability to firmly gauge impacts one to two years into the program. To the degree that more members get rid of private cars, car-sharing's impacts on travel behavior and mode choice are likely to be more noticeable. Adjustments in car ownership patterns generally take more than a year, thus we suspect follow-up evaluations conducted during the second and third year of the program will reveal even larger impacts.

## NOTES

[1] Cervero, R.; Creedman, N.; Pohan, M.; and Pai, M. May 2002. *City CarShare: Assessment of Short-Term Travel-Behavior Impacts.* Working Paper 2002-01. Berkeley: Institute of Urban and Regional Development, University of California, Berkeley.

[2] For survey #1, questionnaires were distributed from the period of January 10 to May 21, 2001, although 96.8 percent of the responses were from the periods of February 13 through March 5, 2001. Surveyees were assigned dates spanning February 18 to March 5 to fill-out travel diaries. Some earlier responses were compiled as part of pre-testing the survey instrument. Some responses from April and May were also obtained as part of the orientation process wherein new members were asked to complete surveys prior to joining the program. Since this represented a time point prior to new members using City CarShare vehicles (even though data were compiled following the March 7, 2001, inauguration date), the responses were treated as "before" data observations.

[3] Responses were obtained for dates between October 28 and November 29, 2001, however over 96 percent of the questionnaires were sent out and returned for the requested two-week survey period of October 28 to November 11, 2001.

[4] Most respondents opted to complete surveys on weekdays, not weekends. Hardly any respondents completed surveys on Sundays, thus there was an under-sampling of weekend travel.

[5] Between the first and third surveys, new individuals had signed up for City CarShare, some as members and others as prospective members. New individuals received both background surveys and travel diary surveys. While their responses did not contribute to the intermediate-term before-and-after analysis, they did provide cross-sectional records of travel among City CarShare members that are examined in this report.

[6] Source: National Oceanographic and Atmosphere Administration web site: http://www.wrh.noaa.gov/Monterey/2001WRKCLI.html.

[7] Source: California Energy Commission, *Estimated 2001 Gasoline Price Breakdown & Margins Details*, http://www.energy.ca.gov/fuels/gasoline/margins/2001.html.

[8] Since travel diaries were recorded for two days, information for total trips were summed for each day and a one-day average was computed by taking the statistical mean of the two days.

[9] Information on roadway travel distance as well as travel time was obtained from computer-generated matrices that recorded typical travel distances and times (depending upon mode) for every origin and destination combination. The Transportation Department of the City of San Francisco provided the travel time estimates based on the corresponding traffic analysis zone (TAZ) of trip origin and destination.

[10] Among the sampled City CarShare trips, 582.2 miles were logged in City CarShare vehicles, compared to 2,119.2 miles logged in private cars, taxis, buses, and rail transit. Relative to just cars and taxis (ignoring public transit), City CarShare comprised 30.7 percent of vehicle miles traveled.

[11] Shares for non-members were: BART – 55.3 percent; Muni – 41.2 percent; and CalTrain – 3.5 percent. These results differ from Survey #2 wherein the largest share of trips among members were by BART.

[12] The cities of Berkeley and Oakland also inaugurated City CarShare programs in late 2001, however our surveys were conducted only among members of the San Francisco program.

[13] Statistics presented in this sub-section are drawn from all three surveys: surveys #1, #2, and #3. These materials largely draw profiles of members and non-members for year 2001.

[14] Katzev, R. January 2001. CarSharing Portland: An Analysis of Its First Year. Paper presented at the Annual Meeting of the Transportation Research Board, Washington, D.C.

[15] Standard deviations for annual household incomes were $45,715 for non-members and $27,520 for members.

[16] Katzev, R., 2001, *op cit*.

[17] Among non-member surveyees, 54.7 percent of household cars were owned by the respondents, 19.5 percent were not owned but were available, and 25.8 percent were not available.

[18] One non-member household also reduced car ownership levels.

[19] Nelson\Nygaard Consulting Associates. April 2002. "City CarShare Vehicle Ownership Survey Results and Analysis." San Francisco: prepared for City CarShare.

[20] Katzev, R., 2001, *op cit*.

[21] In cases where respondents provided two days of travel diary information, a single 24-hour estimate was derived by averaging over the two days. If respondents completed a survey for just one day, that single-day recorded was used in the analysis.

[22] Steininger, K.; Vogl, C.; and Zettl, R. Car-Sharing Organizations: The Size of the Market Segment and Revealed Change in Mobility Behavior. *Transport Policy*, Vol. 3, No. 4, 1996, pp. 177–185.

[23] Separation by day type was not considered necessary as long as purposes were stratified since, for example, there is no reason to believe that factors influencing medical trips differ between weekdays and weekends.

[24] Between Survey #2 and Survey #3, the difference of difference results were: **(1) work:** car (19.2 percent), transit (-1.3 percent), walk (-4.8 percent), bike (-8.2 percent); **(2) return home:** car (12.2 percent), transit (-3.8 percent), walk (4.3 percent), bike (4.4 percent); **(3) school:** car (10.7 percent) transit (2.4 percent), walk (-17.1 percent), bike (-16.8 percent); **(4) shopping:** car (32.8 percent), transit (7.9 percent), walk (-53.6 percent), bike (-53.6 percent); **(5) personal business:** car (19.2 percent), transit (-3.8 percent), walk (5.4 percent), bike (5.5 percent); **(6) medical:** car (25.6 percent), transit (7.6 percent), walk (-38.3 percent), bike (-29.2 percent); **(7) social:** car (-12.0 percent), transit (6.8 percent), walk (-3.2 percent), bike (12.0 percent); **(8) recreation-other:** car (2.4 percent), transit (0.6 percent), walk (-3.5 percent), bike (-9.4 percent); **(9) all purposes:** car (14.3 percent), transit (-1.4 percent), walk (-6.4 percent), bike (-8.3 percent).

[25] In the aggregate analysis, the unit of analysis is the person, and the metric is the daily sum of mode-adjusted VMT for all purposes, averaged over the two-day travel-diary period. In the trip-level analysis, the unit of analysis is the individual trip, and the metric is the mode-adjusted VMT for each trip, again averaged over the two-day travel-diary period.

[26] Moran's I was estimated using the TransCAD GIS software package. The statistic was calculated as:

$$I = \frac{n \sum_i \sum_j w_{ij} (y_i - y') (y_j - y')}{[ \sum_i (y_i - y')^2 ] ( \sum \sum_{i?j} w_{ij})}$$

where $y_i$ is the variable of interest, y' is the global mean, i and j subscripts index traffic zones, and $w_{ij}$ is a spatial weight. The weight, $w_{ij}$, was based on the degree of "shared-boundary" adjacency of super-districts, ranging in value from zero (non-adjacency) to one (only when one super-district totally envelops another, which is not the case with Bay Area super-districts). Like a Pearson-Product moment correlation, Moran's I ranges in values between –1 and +1, with a high positive value indicating spatial clustering and agglomerations, a high negative value revealing a "patchy," alternating spatial pattern, and a zero value suggesting pure spatial randomness.

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