User Characteristics and Reponses to a Shared-Use Station Car Program: An Analysis of ZEV•NET in Orange County, CA

UCI-ITS-WP-08-1

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2008

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Number of words: 5,658 (title page, abstract, and text) + 1,500 (4 tables and 2 figures) = 7,158.

Abstract
Growing concerns about petroleum dependence, greenhouse gas emissions, and traffic congestion make shared-use vehicle programs look increasingly attractive. They offer an alternative to car ownership that yields benefits to their members by lowering the cost of transportation and to society at-large by reducing per capita VMT and increasing the use of public transportation. While neighborhood carsharing programs have already received a lot of attention, station car programs, the other type of shared-use vehicle program, largely have not. In the station car approach, shared vehicles are based at public transportation terminals to "extend" the public transportation network. This paper analyzes responses to a survey of the users of UC-Irvine's ZEV•NET research program, which employs battery electric vehicles and is managed using information technologies. We find that ZEV•NET users participate in the program because they like the flexibility, the ease of use, and the reliability of ZEV•NET vehicles. ZEV•NET commuters are also more concerned about travel stress, cost, and environmental impacts than those who drive alone. By contrast, the latter place greater value in flexibility, reliability, and to a lesser degree, time. Moreover, the demographic characteristics of ZEV•NET users are not statistically different from those of non-users. As ZEV•NET users are not much more concerned about environmental issues than non-users, just advertising the environmental impacts of this program would not be sufficient to grow ZEV•NET; instead, potential cost advantages should be emphasized. These findings should be useful for designing more station car programs that rely on zero-emitting vehicles.

Keywords: Shared-Use Vehicles; Zero Emission Vehicles; Logistic Regression; Sustainable Transportation.

INTRODUCTION

With growing concerns about petroleum dependence, greenhouse gas emissions, and traffic congestion, alternative transportation strategies are getting another serious look. One approach that could address all of these concerns is a shared-use vehicle program, which offers an alternative to car ownership under which members may use vehicles on an hourly basis (*1*).

Indeed, car-sharing offers benefits to its users and to society-at-large. For the former, it reduces the cost of transportation by sharing the capital cost of owning a vehicle among multiple users who "gain the benefits of private vehicle use without the costs and responsibilities of ownership" (*2*). For society at-large, car-sharing has been shown to reduce per capita VMT for its users while increasing the use of public transportation and of environmentally friendly alternatives such as walking and bicycling (*3, 4*). Car-sharing also reduces the need for parking spaces, which encourages a more compact urban form. It is therefore not surprising that car-sharing is growing: in the United States, as of January 2008, an estimated 5,261 shared-use vehicles served approximately 234,000 members (*5*) – twice as many as in 2006 (*3*).

Car-sharing does not correspond to a single concept, however; instead, it refers to a continuum that goes from *neighborhood car-sharing* to *station cars* (*6*). In neighborhood carsharing, vehicles are stationed near selected locations throughout a city (e.g., in a parking lot at an apartment complex), where they are available for personal trips. These vehicles are generally not used for daily commutes as they are intended to provide access to destinations not conveniently served by transit. Most car-sharing organizations (CSOs) in the United States and in Europe are of the neighborhood car-sharing variety.

By contrast, in the station car approach, vehicles based at a public transportation terminal are intended to be "extensions" of the public transportation system to complete a commute to work, or for other transit-based trips. Because station cars extend the reach of public transportation, their potential for success may be greatest in locations where public transit exists but where urban density is insufficient to support high ridership. In such cases, station cars and public transit can mutually benefit from each other: the extended "reach" provided by a station car program increases the attractiveness of a transit system, while potential transit riders represent a market for station car programs (*7*).

Although much is known about neighborhood car sharing programs (*1-4*), the station car concept has hitherto received relatively little attention. To help bridge this gap, this paper analyzes responses to a survey of users and potential users of UC-Irvine's Zero-Emission Vehicle · Network-Enabled Transport (ZEV•NET) research program. The purpose of this program is to explore a clean and efficient alternative to conventional single-occupant commuting. This commuter-oriented car sharing program is especially attractive because it offers zero-emitting (hence the "Z"), battery electric vehicles (EVs) and relies on information technologies for managing vehicle reservations, vehicle locking/unlocking, and other system communications (its reliance on the internet is reflected by the "NET" in its name).

In the next section, we provide some background information about car sharing programs, introduce ZEV•NET, and briefly review some relevant papers. We then summarize our data and the administration of our survey, as well as our modeling methodology, before discussing our results. The last section presents our conclusions and policy recommendations.

BACKGROUND

An overview of carsharing

Although the car sharing concept is not new, it has only recently begun to enjoy commercial success, especially in the United States (*2*). The first carsharing programs emerged in Europe, beginning with a cooperative known as “Sefage” in Zurich, Switzerland in 1948. Other programs, including “Procotip” in France in 1971 and “Witkar” in Amsterdam in 1974 did not succeed. In the 1980s and early 1990s, a handful of other carsharing programs surfaced in Europe and in the United States, with mixed results. The most successful of these is Car Share Switzerland, which was established in 1987 and has since grown to become one of the largest CSOs in the world, with over 1,950 vehicles and 77,100 members throughout the country (*8*). In the United States, the Mobility Enterprise research program at Purdue University (1983-1986) operated with some success but struggled to achieve high vehicle utilization. Another U.S. program, the Short Term Auto Rental (STAR) demonstration program in San Francisco (1983-1985), failed for two reasons: 1) difficulties in collecting user fees; and 2) high repair costs associated with the program’s economy-class vehicles.

More recently, a station car system employing EVs based at Bay Area Rapid Transit District (BART) stations was tested from 1996 to 1998. This program provided its users with EVs for station-based and work-based trips; home-based vehicle use was permitted, and vehicle use fees were generally paid by users. An analysis of this program (*9*) found that men were often drawn by high-tech aspects of this program whereas women typically had environmental motivations; passenger-miles-traveled in conventional vehicles decreased by 94 percent for participants (with commensurate reductions in air pollutants); and this program generated a positive response from its users and the public alike.

City CarShare is another car-sharing organization in the San Francisco Bay Area. After the first two years of operation, Cervero et al. (*10*) reported that its members’ VMT, gasoline consumption, and GHG emissions decreased relative to a control group due to reduced car ownership, decreased car use, use of efficient vehicles, and increased carpooling (*11*). A follow-up study after the program’s fourth year reported that declines in VMT and fuel consumption were greatest during the first years of the program and then leveled off with time, however.

Among recent station car research programs, the CarLink programs are of particular interest because just like the program we study in this paper, they operated as shared-use vehicle systems coupled to regional transit (*12*). Primarily managed by the Institute of Transportation Studies at UC-Davis and UC-Berkeley, CarLink was comprised of two pilot programs. The first CarLink program (January 1999 to November 1999), later known as CarLink I, involved fifty-four persons who shared 12 natural gas-powered Honda Civics based at the Dublin-Pleasanton BART station. It provided links for home-based users, work-based commuters, and shared vehicle access for Lawrence Livermore National Lab employees during the day. The second CarLink pilot program (CarLink II) lasted from July 2001 to June 2002, and included 107 participants. It involved a larger fleet of vehicles (2001 Ultra Low Emission Vehicle Honda Civics), provided commuter feeder and day use services to several companies (CarLink I served a single employer), fielded integrated carsharing technologies, and was located in the Palo Alto region. CarLink II led to a reduction in solo driving, a decrease in VMT, and an increase in transit use for non-commute trips (*13*).

Several studies have attempted to determine the demographic characteristics of the “typical” car-sharer. Several trends consistently emerge, and a meta-analysis (*1*) finds that the typical car-sharer is slightly more likely to be male, from a smaller household (1 or 2 people), in his mid-30s to mid-40s, with at least a Bachelor’s degree and an upper middle class income.

Identifying the demographics of “typical” car-sharers can be thought of as a demand-side market analysis, as a region’s demographics dictate some portion of the potential for car sharing in that region. On the supply side, the geographic layout of a region must be considered. A recent study identified the following neighborhood characteristics as conducive to car-sharing (*14*): parking pressure; transit availability; higher density neighborhoods; and a mix of uses.

An overview of ZEV•NET

Our focus in this paper is UC-Irvine's Zero-Emission Vehicle · Network-Enabled Transport (ZEV•NET) research program. This station car program, which was deployed in 2001, is managed by the UC-Irvine National Fuel Cell Research Center (NFCRC). By facilitating the use of commuter rail and employing zero-emission vehicles, ZEV•NET's purpose is to explore a clean and efficient alternative to conventional single-occupant commuting.

The ZEV•NET concept was developed to address concerns about urban air quality, petroleum dependence, and traffic congestion. California's ZEV mandate, promulgated by the California Air Resources Board (CARB), was also a key driver (*15*). The ZEV mandate requires automakers to produce a specified numbers of zero- or low-emitting vehicles each year and offers additional "transportation systems" credits for producing EVs that (1) are deployed in shared-use vehicle programs; (2) provide linkages to transit; and/or (3) use information technologies to facilitate system operation. The present ZEV•NET fleet consists of 16 Toyota RAV4 EVs, 12 of which are in regular service, and two Toyota Prius (mostly used for administrative support). ZEV•NET vehicles meet all three criteria above, so they give automakers a cost-effective way of complying with ZEV regulations. The motivating roles of the ZEV regulations and the supplemental transportation system credits can be expected to continue, as a recent CARB review recommended retaining these provisions (*16*).

The primary resource for program participants is the ZEV•NET website (www.zevnet.org), which can be used for making reservations. The website also assists ZEV•NET administrators with fleet management by facilitating vehicle re-assignments, remote vehicle locking/unlocking, and maintenance scheduling. Finally, the website maintains logs of reservations and vehicle use. From its inception in April 2003 through June 2008, the ZEV•NET website recorded 20,461 vehicle reservations from 133 unique users, for a total of 63,344 vehicle-hours and 116,220 vehicle-miles traveled.

ZEV•NET vehicles are based at the Irvine Transportation Center (ITC), a local commuter rail terminal located near the center of Orange County. Nearby destinations include the Irvine Spectrum (a popular shopping and entertainment destination), UC-Irvine, the Great Park, and a number of high tech firms. These destinations are served by local bus lines, but this service is often seen as inconvenient.

In its present form, ZEV•NET serves four companies as well as participating staff, faculty, and commuters at UC-Irvine. As primarily a station car program, the main role of ZEV•NET vehicles is to enhance mobility between the ITC and employment sites. To maximize the impacts of ZEV•NET, carpooling during trips to and from the ITC is encouraged (*17*). ZEV•NET also incorporates aspects of neighborhood carsharing. Indeed, ZEV•NET vehicles may be used for work-based daytime trips between the morning and evening commutes. This maximizes the use of ZEV•NET vehicles and their environmental benefits.

The corporations participating in ZEV•NET are each loaned two vehicles for a nominal annual fee. Because ZEV•NET is a research program, these fees only help defray the cost of managing and supporting the program. Were the program to transition to commercial operation, fees would likely incorporate both periodic and usage-based components.

Although ZEV•NET has been in operation for several years, no rigorous assessment of its performance from the user perspective has been performed. The purpose of this study is to understand whether and how ZEV•NET users differ from non-users in terms of socio-demographic characteristics and personal attitudes. The information gained will provide insight into the attractiveness of ZEV•NET from its users' perspective, allow system administrators to enhance system operation, and serve as a basis for exploring system expansion opportunities.

SURVEY ADMINISTRATION AND DATA

Our unique dataset was collected via an internet-based survey distributed to employees of the three corporate ZEV•NET participants (Thales Avionics, Inc., Orthodyne Electronics, and Canon Development Americas & Canon R&D) and student, staff and faculty commuters at UC-Irvine. The fourth corporate participant, iMonitorEnergy, joined after the distribution of the survey and therefore is not included in this study.

Two versions of the survey were developed and made available by the research team: one for frequent ZEV•NET users and another for infrequent or non-users. Five sections of the survey were common to both groups: (1) inquiries about household size and commuting patterns; (2) a question about the factors that influence commute mode choice; (3) perceptions of ZEV•NET; (4) "opinion" questions about various social concerns; and (5) requests for demographic characteristics. Questions for ZEV•NET users only asked about (1) carpooling with ZEV•NET; (2) perception of EV range; (3) specific aspects of ZEV•NET vehicles; and (4) personal beliefs. Non-ZEV•NET users were asked (1) why they don't use the commuter-rail-plus-ZEV•NET combination and (2) why they don't use ZEV•NET for daytime work-based trips. Several questions included in this survey were based on questions in the CarLink study survey (*13*). Both forms of the survey used in the present study are available from the authors upon request.

The survey was hosted on the UC-Irvine Electronic Educational Environment (EEE) website. This resource permits UC-Irvine staff, faculty, and students to develop, conduct, and securely store results of surveys for academic use.

The survey was administered over approximately two weeks. To protect privacy and to minimize possible work disruptions, potential survey participants were contacted by survey coordinators designated by each ZEV•NET corporate participant and UCI. We asked survey coordinators to invite all ZEV•NET users and as many non-users as possible via an invitation email crafted by the research team; this invitation email included a link to the survey. A reminder email was sent approximately one week after the initial invitation to encourage participation.

The survey was completed by 118 respondents. Because the invitation to participate was distributed via corporate email lists and other means, it is difficult to calculate a precise response rate. We estimate that it is between 25% and 30%, based on data from Orthodyne Electronics 17 out of 67) and Canon R&D (48 out of 160). A comparison of the demographic characteristics of our respondents with those of Orange County residents reveal that our respondents are more likely to be of working age (between 25 and 60), female (57.2%), and better educated. They are also more likely to have annual household incomes between $60,000 and $200,000 and to come from households with 2 to 4 individuals.

For reference, there were 65 unique ZEV•NET users between January and June 2008 (13 of which used ZEV•NET only once in 2008), so our survey elicited responses from at least 40% of "frequent" ZEV•NET users in 2008. Of the 26 "frequent" ZEV•NET users, 11 reported commuting via commuter rail and ZEV•NET. In addition, ZEV•NET users reported an average of two daytime work-based trips each per week.

METHODOLOGY

To examine our respondents' assessment of ZEV•NET, we adopted several approaches. First, since our sample is small, we performed a Principal Components Analysis (PCA) to analyze how various answers (especially perceptions) cluster together to create summary variables (*18*). From this analysis, we created two new variables (see Table 1). This non-parametric approach is robust and widely used for pattern analysis in psychology and marketing. We did not rely on factor analysis (*19*) because our sample size and the structure of the factors we found does not meet the empirical criteria proposed by Guadagnoli and Velicer's (*20*) Monte Carlo simulation study for obtaining reliable factors. Other survey responses did not cluster.

TABLE 1 CLUSTERING OF OPINIONS & ATTITUDES

Survey Items and Principal Components[2]	**Weight**
PC1 – Climate change, pollution and driving[1]	
1. "I'm concerned about climate change."	0.03997
2. "I'm concerned about air pollution."	0.04079
3. "I'm concerned about traffic congestion."	0.03280
4. "My actions impact climate change."	0.03833
5. "We need to change now to improve the environment"	0.04048
6. "Rising gas prices have impacted how much I drive"	0.02544
7. "Rising gas prices make it more likely my next car will be a high-MGH type"	0.03219
PC2 – Perception of ZEV•NET[1]	
1. "ZEV•NET vehicles are environmentally benign."	0.04693
2. "ZEV•NET vehicles are reliable."	0.06912
3. "ZEV•NET vehicles are fun to drive."	0.06675
4. "Charging ZEV•NET vehicles is easy."	0.06719

Notes.

1. Questions above are based on the following scale: 0 = Disagree strongly; 1 = Disagree; 2 = Neutral/No opinion; 3 = Agree; and 4 = Strongly agree. To find a respondent's PC1 or PC2 score, take the weighted score of her answers, using the weights above; these weights are normalized so that PC1 and PC2 are between 0 and 1. A higher value of PC1 indicates more concerns for the environment and a higher awareness of the links between driving, congestion, air pollution, and climate change. A higher value of PC2 indicates a better opinion of ZEV•NET vehicles (environmental impacts, reliability, and ease of use).
2. To assess the adequacy of PC1 and PC2, we relied on standard statistics (Cronbach's alpha and KMO) and Bartlett's test. Cronbach's alpha indicates how well a set of variables measures a single underlying construct; it is high when inter-item correlations are high and should exceed 0.6; we obtained $\alpha=0.864$ for PC1 and $\alpha=0.693$ for PC2. KMO tests whether partial correlations between variables are small; it should exceed 0.6; we found 0.858 and 0.734 for PC1 and PC2 respectively. Finally, Bartlett's test checks whether the correlation matrix of the variables differs significantly from the identity matrix, which we find here ($p<0.001$); otherwise, the factor model is inappropriate.

Next, we analyzed the frequency of responses to various questions and we conducted some simple tests. We also summarized graphically responses to key questions. We then applied the Wilcoxon-Mann-Whitney (WMW) test to explore differences in the responses of ZEV•NET users and non-users. The WMW test is a non-parametric test for assessing whether two samples come from the same distribution. The null hypothesis is that the two samples are drawn from a single population, and therefore that their probability distributions are equal.

Finally, to elicit the key reasons that motivate people to become ZEV•NET users, we built a logistic regression model where the explanatory variables are socio-economic as well as perception and opinion variables (partly summarized by the principal components created above). Our model was estimated using Stata 9.2 on a PC. In order to obtain robust results, we checked for influential observations but more importantly, we strived to build a model that would fit well our respondents' desire to use ZEV•NET or not.

RESULTS

Survey summary

One of our goals was to compare various characteristics of two groups of people eligible to use ZEV•NET: participants and non-participants. This required excluding two respondents younger than 25 (the minimum age for participating in ZEV•NET) and respondents very unfamiliar with ZEV•NET, which left 95 respondents. Of these, 26 completed the survey for "frequent ZEV•NET users" (Group I) and the other 69 respondents were assigned to Group II; they completed the survey for "infrequent or non-ZEV•NET users."

Results of our WMW tests are summarized in Table 2. A difference between responses of two groups is considered significant when the p-value is below 0.05 and highly significant when it is below 0.01; this is indicated by one and two stars respectively. The p-value measure the probability that the difference between the two groups happened by chance if the null hypothesis that there is no difference is true. For the WMW test statistic, we report a positive value when the responses of the ZEV•NET-using group are higher than those of the non-ZEV•NET-using group, and a negative value otherwise. In most cases, ZEV•NET users were compared to non-users (indicated by an "A" in the second column of Table 2); for questions related strictly to commuting, we compared respondents who use commuter rail and ZEV•NET with respondents who commute by driving alone (indicated by a "B" in the second column of Table 2).

We found no statistically significant differences between the demographic characteristics of ZEV•NET users and non-users, although the mean age and the education level of ZEV•NET users are slightly lower. The "typical" ZEV•NET user is a male in his early 40s, with a Bachelor's degree, who lives in a household of two people. He is politically moderate and his household income is approximately $100,000 per year. These characteristics are consistent with the carsharing literature.

However, ZEV•NET users and non-users differ on their spatial and temporal commuting indicators. First, ZEV•NET commuters are more likely than drive-alone commuters to begin their commutes earlier and to live further away from their work site. Second, factors affecting commute mode choice vary significantly between these two groups: respondents who use commuter rail and ZEV•NET weigh more heavily travel stress, environmental impacts, and cost than those who drive alone. By contrast, those who drive alone place greater value in flexibility, reliability, and to a lesser degree, time. Note that travel time, flexibility, and cost are considered among the three most important factors by 77%, 58%, and 56% of all respondents respectively.

TABLE 2 WILCOXON-MANN-WHITLEY (WMW) TESTS

Survey Items	Groups Compared[1]	WMW statistic[2]	p-value[3]
Demographic characteristics			
Number of people in household	A	1.932*	0.022
Straight-line distance from centroid of home zip to work location [miles]	B	4.673**	<0.001
Hour of departure for work in morning [AM]	B	-4.120**	<0.001
Hour of departure for home in evening [PM]	B	-2.916**	0.004
Respondent-estimated distance from home to nearest commuter rail station [miles]	B	0.805	0.421
Age [25-29, 30-39, 40-49, 50-59, ≥60]	A	-1.714	0.087
Sex [male = 1, female = 0]	A	-0.469	0.639
Educational attainment [1 = High school, 2 = Associates degree, 3 = Bachelor's degree, 4 = Advanced degree]	A	-1.638	0.101
Political orientation [0 = very liberal, 1 = liberal, 2 = moderate, 3 = conservative, 4 = very conservative]	A	0.112	0.911
Household income [$0-20K, $20-40K, $40-60K, $60-80K, $80-100K, $100-120K, $120-150K, $150-200K, >$200K]	A	-0.162	0.871
Factors that influence commute mode choice (up to three) [1 if chosen, 0 otherwise]			
Cost	B	0.251*	0.013
Flexibility	B	-0.564**	<0.001
Reliability	B	-0.354*	0.028
Stress	B	0.644**	<0.001
Time	B	-0.173	0.201
Environmental impact	B	0.419**	0.001
Perceptions of ZEV•NET program [from 1 = "Strongly disagree" to 5 = "Strongly agree"]			
"ZEV•NET vehicles are environmentally benign."	A	2.527*	0.012
"Reserving the vehicles is inconvenient."	A	-2.075**	0.038
"The ZEV•NET vehicles are reliable."	A	4.851**	<0.001
"The ZEV•NET vehicles are fun to drive."	A	3.544**	<0.001
"Charging the vehicles is easy."	A	5.981**	<0.001
Impact on work-based travel frequency			
Average weekly work-based bicycle/walking trips	A	-2.119*	0.034
Average weekly work-based vehicle trips (including trips using ZEV•NET vehicles)	A	1.977*	0.046
Broad opinions [from 1 = "Strongly disagree" to 5 = "Strongly agree"]			
"I am concerned about climate change."	A	0.989	0.323
"I am concerned about air pollution."	A	0.749	0.454
"I am concerned about petroleum dependence."	A	1.273	0.203
"My commute is stressful."	B	-1.399	0.162

"Rising gas prices have caused me to reduce the amount that I drive/travel."	B	1.498	0.134
"Rising gas prices make it likely that my next vehicle will be a hybrid or other high-'mpg' vehicle."	B	2.235*	0.025
"My automobile sends a message about who I am."	A	2.301*	0.021
Most pressing southern California issues (up to three) [1 if chosen, 0 otherwise]			
Traffic congestion	A	-0.190	0.849
Air pollution	A	0.177	0.859
Oil prices/dependence	A	1.283	0.199
Climate change	A	0.638	0.528

Notes:

1. In column 2, "A" indicates a comparison between ZEV•NET users and eligible non-ZEV•NET users (N = 26 vs. N = 69); "B" indicates a comparison between rail + ZEV•NET commuters and eligible drive-alone commuters (N = 11 vs. N = 63).
2. A positive value indicates that the responses of the ZEV•NET-using group are higher on average than those of the non-ZEV•NET-using group; a negative value indicates the opposite. * and ** indicate that the difference is significant at 5% and 1% levels, respectively
3. The p-value (or probability value) measures the probability that the difference between the two groups happened by chance, if the null hypothesis that there is no difference is true.

ZEV•NET users and non-users also have different perceptions of ZEV•NET vehicles: compared to the latter, ZEV•NET users perceive ZEV•NET vehicles as more environmentally benign, less inconvenient, more reliable, more fun to drive, and easier to charge. This result may be partly due to self-selection, although greater familiarity with the program may lead to more favorable opinions about ZEV•NET.

Our survey also yielded several unexpected results. First, WMW test results (Table 2) suggest that participating in ZEV•NET leads to a decrease in work-based bicycling and walking and to an increase in vehicle-based trips (combining personal and ZEV•NET vehicles). Two factors may explain these findings: the flexibility provided by the daytime availability of ZEV•NET vehicles, and the urban form of Orange County, which is typically not conducive to bicycling or walking. In fact, this daytime flexibility may be the reason why some respondents switched to commuting via train and ZEV•NET, thereby reducing VMT when it is most useful.

Second, ZEV•NET participants appear to be no more concerned about air pollution or climate change than non-participants, which was unexpected since the ZEV•NET "brand" emphasizes the environmental benefits of the program (*21*). We might also have expected car-sharers to be more environmentally aware than the general population.

By contrast, ZEV•NET users appear to value their image while driving EVs. In fact, out of all 15 opinion questions, the most significant difference was that ZEV•NET users were significantly more likely than non-users to agree that "My automobile sends a message about who I am." In addition, out of eight questions about ZEV•NET, the statement "I am proud to drive an electric vehicle" generated the second-highest proportion of "strongly agree" responses (see Figure 1 for a summary of responses to this survey section).

However, ZEV•NET users seem primarily concerned by the bottom line. Indeed, over 60% of them strongly agree that they like using ZEV•NET vehicles because they don't have to pay for gas, which garnered the most support in this section (Figure 1); other "perks" such as preferred parking are also valued. In addition to saving money, the driver gets the "bonus" satisfaction of knowing that his behavior is environmentally benign—at no cost to him.

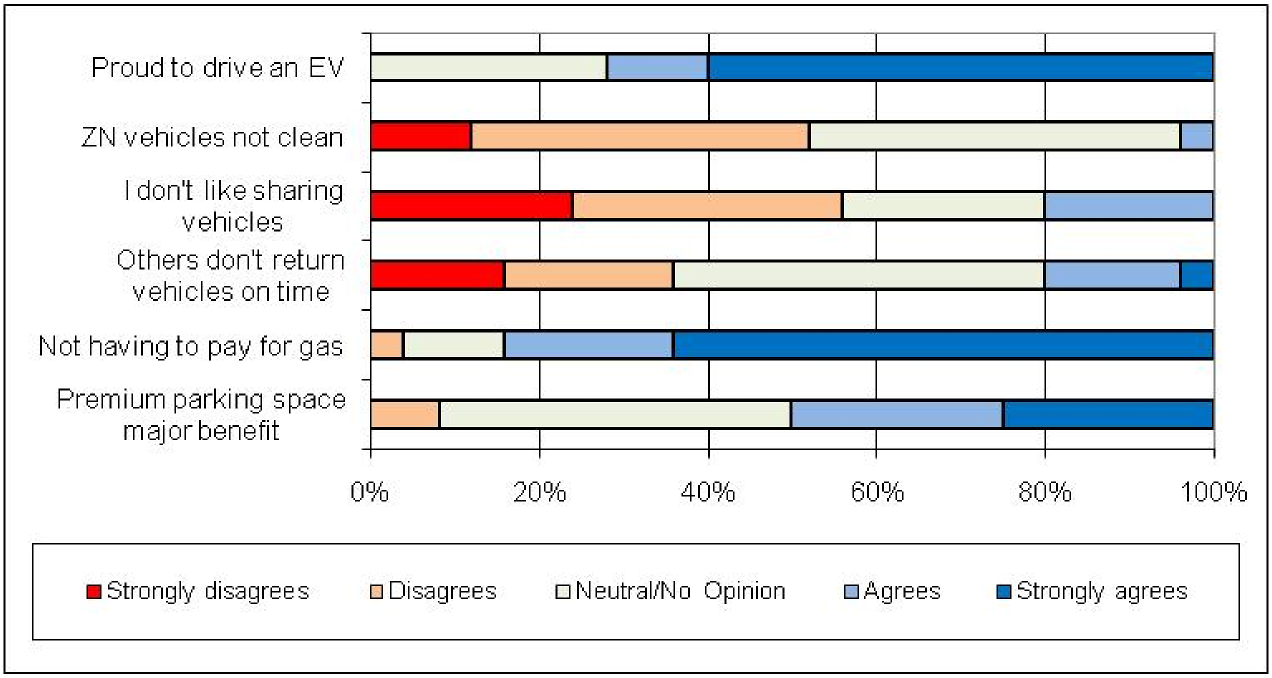

Figure 1 Perceptions of ZEV•NET (ZEV•NET users only).

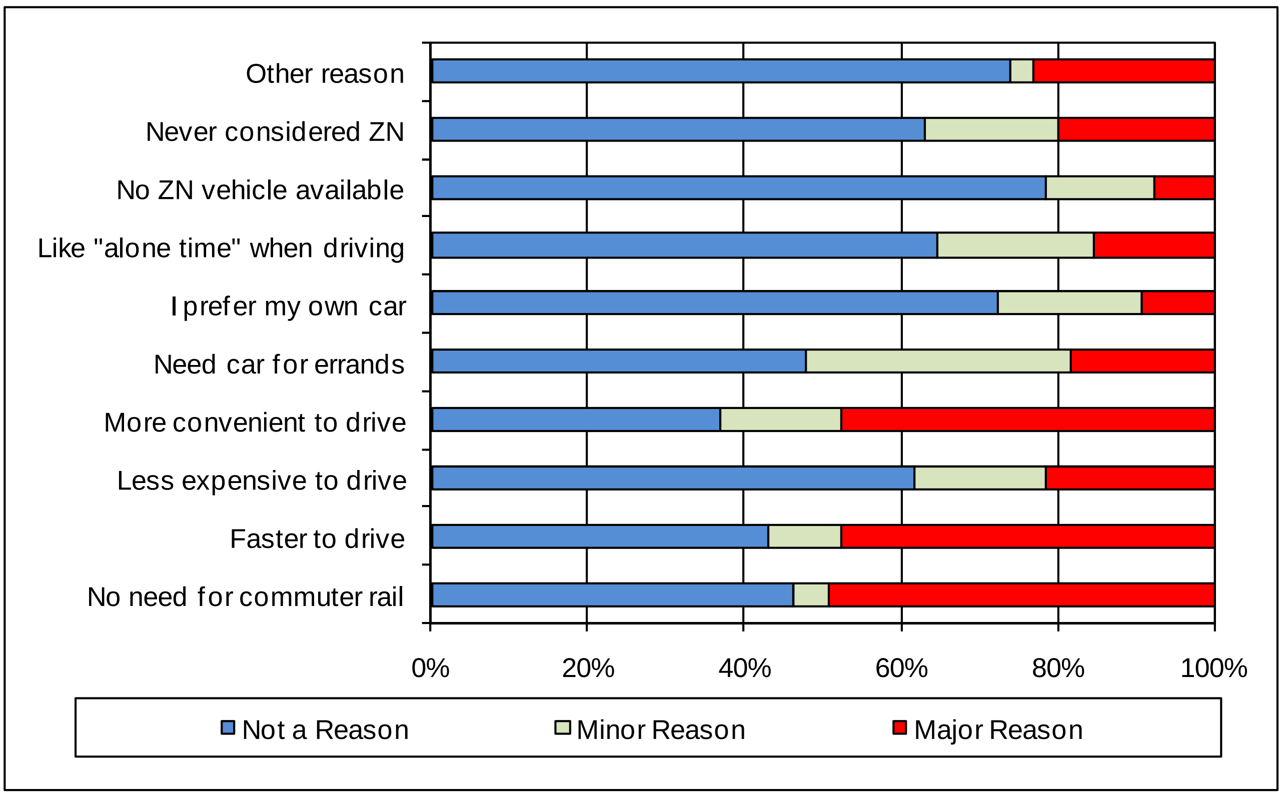

Figure 2 Reasons for not using commuter rail & ZEV•NET (non-ZEV•NET users only)

Figure 2 summarizes the reasons why non-ZEV•NET users do not commute using commuter rail and ZEV•NET. First, since approximately 20% of respondents had "never thought about using commuter rail and ZEV•NET" as an option, simply increasing the visibility of ZEV•NET may boost overall interest. On the other hand, approximately 50% of respondents are too close to their workplace to use commuter rail, so for them ZEV•NET is not very attractive. Likewise, it may be tough to attract respondents who are very proud of their vehicle and enjoy driving it, or those who like their time alone while driving.

On the other hand, marketing efforts that challenge quantifiable perceptions about commuting may be successful. For example, the statements "It is faster to drive" and "It is less expensive to drive" received significant support (Figure 2). This suggests that ZEV•NET may be more attractive if it can be shown that using ZEV•NET with commuter rail is almost as fast as driving alone during rush hour. Similarly, the low cost of commuter rail and ZEV•NET could be emphasized especially given the current gasoline prices.

A few other questions shed light on broader issues relevant to car-sharing (results not shown). Foremost is the apparently low preoccupation with environmental and energy-related issues in relation to other social concerns. For example, in a list of 10 potential social concerns (including "the economy," "housing," "immigration," "health care," and others), air pollution, petroleum dependence, and climate change were rated a top-three problem by only 18%, 29%, and 5% of respondents, respectively. Climate change, in fact, received the fewest number of votes of all options excluding "other." On the other hand, "traffic congestion" was a top-three problem for nearly 75% of all respondents. This suggests again that strategies for marketing programs like ZEV•NET should focus on individual benefits (reduced stress, time savings, or the ability to be productive while traveling by train), and potential cost advantages, over "do-good" messages targeting social responsibility.

Our survey also asked about the best way to address traffic congestion, petroleum dependence, climate change and air pollution in southern California using transportation-related strategies. Again, there were no significant differences between ZEV•NET users and non-users. The top three suggestions to address traffic congestion were to: increase the frequency of transit (74%); reduce fares (57%); and increase roadway capacity (40%). Increasing the gas tax (6%) and implementing congestion pricing (8%) were the least popular options. To reduce transportation-related emissions, 75% favored improving transit, 66% supported promoting alternative fuel vehicles (AFVs), and 53% preferred tightening auto emissions standards, but less than 10% favored increasing the gasoline tax. Suggestions for addressing petroleum dependence were similar: there was strong support for enhancing public transit (66%), promoting AFVS (66%), and increasing the CAFE standards (53%), but no support for increasing the gas tax (7%). Finally, only 30% of respondents supported increasing the domestic production of oil.

Logistic regression

Only 81 respondents provided all of the information required for our logistic regression; their characteristics are summarized in Table 3. Results from the logistic regression are reported in Table 4. To simplify our discussion, we kept only statistically significant variables or groups of variables (such as income variables) with at least one statistically significant variable.

Let us start with demographic characteristics. Unsurprisingly, respondents with larger families are more likely to be ZEV•NET users, probably because their other vehicle(s) are more in-demand. Also, the "early-in", "early-out" schedule characteristic of rail commuting fits well with family life, making commuter rail plus ZEV•NET inherently more attractive for this population. Female and younger respondents are also more likely to use ZEV•NET; we conjecture that the former may be more attracted to its green image while the latter are more open to experimenting with new technologies.

TABLE 3 DESCRIPTIVE STATISTICS OF LOGISTIC REGRESSION VARIABLES

Variable	Min	Mean	Standard Deviation	Max
Dependent Variable				
ZEV•NET user (1=Yes)	0.000	0.259	0.441	1.000
Demographic Characteristics				
Number of people in household	1.000	2.642	1.288	6.000
Gender (male=1)	0.000	0.556	0.500	1.000
Age: 31 to 40 years old (Yes=1)	0.000	0.259	0.441	1.000
Age: 41 to 50 years old (Yes=1)	0.000	0.333	0.474	1.000
Age: 51 years old or more (Yes=1)	0.000	0.321	0.470	1.000
Education: Highest degree is an Associate Degree (Yes=1)	0.000	0.198	0.401	1.000
Education: Highest degree is Bachelor Degree (Yes=1)	0.000	0.481	0.503	1.000
Education: Highest degree is Masters Degree or higher (Yes=1)	0.000	0.259	0.441	1.000
Household Income: Not specified	0.000	0.062	0.242	1.000
Household Income: $60,000 to $100,000 per year	0.000	0.321	0.470	1.000
Household Income: $100,001 to $150,000 per year	0.000	0.210	0.410	1.000
Household Income: $150,001 per year or more	0.000	0.247	0.434	1.000
Geographic Variables				
Distance between home zip code and work zip code centroids (in miles)	1.300	20.306	19.854	155.500
Attitudes and Beliefs				
PC1 – Climate change, pollution and driving	0.250	0.661	0.179	1.000
Dummy variable for missing value of PC2	0.000	0.628	0.226	1.000
PC2 - Perception of ZEV•NET	0.000	0.049	0.218	1.000

Note: Sample size = 81.

Likewise, having a higher income increases the likelihood of using ZEV•NET, whereas a higher level of education, somewhat surprisingly, decreases it. This result is not as puzzling, however, if we jointly consider the impacts of income and education, which tend to increase together: our results may simply reflect some form of compensation between these two variables.

A few other variables were also significant. An approximate measure of the distance between home and work (based on zip code centroids) is significant but not very influential: as this distance increases, ZEV•NET becomes attractive to our respondents. By contrast, the index that summarizes perceptions of ZEV•NET is statistically significant and, based on odds ratios, influential. It suggests that ZEV•NET users are motivated by a mix of convenience, ease of use, and reliability. However, PC1, which summarizes opinions about climate change, pollution, and driving, is not statistically significant (it does not appear in Table 4). This suggests that environmental beliefs alone are not sufficient to change people's commuting habits.

TABLE 4 LOGISTIC REGRESSION RESULTS

Variable	**Coefficient**	**Robust Standard Error**	**Odds Ratio**
Constant term	-8.327**	(3.167)	- -
Demographic Characteristics			
Number of people in household	2.531**	(0.797)	12.567
Gender (Male=1)	-4.583*	(2.184)	0.010
Age: 31 to 40 years old (Yes=1)	-5.849*	(2.420)	0.003
Age: 41 to 50 years old (Yes=1)	-8.925**	(3.147)	0.0001
Age: 51 years old or more (Yes=1)	-5.592*	(2.393)	0.004
Education: Highest degree is an Associate Degree (Yes=1)	-5.758*	(2.588)	0.003
Education: Highest degree is Bachelor Degree (Yes=1)	-8.364*	(3.362)	0.0002
Education: Highest degree is Masters Degree or higher (Yes=1)	-7.066*	(3.089)	0.001
Household Income: Not specified	9.324**	(3.453)	11201.530
Household Income: $60,000 to $100,000 per year	7.789**	(2.626)	2412.765
Household Income: $100,001 to $150,000 per year	8.524*	(3.473)	5036.608
Household Income: ≥$150,001 per year	3.229	(2.328)	25.260
Geographic Variables			
Distance between home zip code and work zip code centroids (in miles)	0.045**	(0.017)	1.046
Program Characteristics			
Dummy variable for missing value of PC2	10.237**	(3.695)	27924.720
PC2 (Perception of ZEV•NET)	8.981*	(3.707)	7952.079

Notes:
1. * and ** indicate that significance at the 5%, and 1% levels, respectively.
2. The Count R^2 is the proportion of correct model predictions; here, it equals 0.926 so this model correctly predicts 92.6% of ZEV•NET users among our respondents. The Adjusted Count R^2 is the proportion of correct guesses beyond the number that would be correctly guessed by choosing the outcome category with the largest percentage of observed; here, its value is 0.714.

Diagnostic tests suggest that this model is well specified: the Stata link test fails to rejects the null hypothesis that the model is well specified, and this model successfully predicts ZEV•NET users 92.6% of the time. We are therefore reasonably confident in the validity and the robustness of the results, although they are based on a small sample.

POLICY IMPLICATIONS AND CONCLUSIONS

Our results show that despite of ZEV•NET's green care image, the primary reasons for choosing a commute mode are flexibility, reliability, and cost. Daytime users indicated that the "free" fuel strongly motivated their use of ZEV•NET vehicles. Not much is known about participants' willingness to pay for accessing the vehicles, but it is hypothesized that if individual user rates were set high enough to justify commercial operation, the costs would only be acceptable if participants were able to shed the cost of their own car—something that would be particularly difficult in southern California. Thus, for society to realize the positive impacts of commuter rail combined with zero-emission vehicles for local transportation, it will be necessary to pursue policies that "level the playing field" between single-occupant automobile commuting and alternatives such as this one. Although not favored by survey respondents, congestion pricing or taxes on gasoline consumption or greenhouse gas emissions would increase the relative attractiveness of non-automobile modes.

As gasoline prices continue to rise, commuter rail and public transit will likely continue to grow in popularity. This could naturally increase the appeal of ZEV•NET. To promote this program to individuals, we recommend focusing on factors deemed important by our respondents (i.e., flexibility, reliability, and cost). To promote ZEV•NET to potential corporate participants, one can contrast the membership cost and convenience to that of private station-to-workplace shuttle services, which tend to be extremely expensive (often thousands of dollars per month). In addition to potential cost savings, participating corporations would also benefit from a greener public image.

Our results could also be used to identify other regions that may be well suited for a shared-use station car program. The "typical" station car user was described above although, of course, significant variation exists; nevertheless, regions with greater proportions of people that match that profile may tend to be more receptive to car-sharing programs. Other prerequisites for programs such as ZEV•NET to flourish are the availability of parking at rail stations serving a busy commuter rail line, a high concentration of employment sites nearby, and limited local public transportation.

Finally, it is important to remember that these results are based on a small sample (simply because ZEV•NET is not a very large program at this point), so care is warranted when trying to generalize these results to other station car programs.

ACKNOWLEDGMENTS

We wish to acknowledge the support of Lorin Humphries, the Operations Manager for ZEV*NET, for helping our data collection effort. We are grateful to Toyota for supporting our research and we are indebted to the vision of Bill Reinert, National Manager for Advanced Technology. We also thank Professor Will Recker and Doctor James Marca for helpful comments. As usual, we are responsible for all remaining errors.

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