Methodology: Impact of Car Sharing Membership, Transit Passes and Bike Sharing Membership on Vehicle Miles Traveled

Purpose

Provided is a detailed accounting of the methods utilized to calculate the impact of car sharing membership, bike sharing membership and the provision of transit passes on household vehicle miles traveled (VMT). Additionally, references to some additional research examined are provided.

Car Sharing

Background

To determine impact of car sharing membership on household VMT, findings from *San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts*[i] were implemented. This 2006 study by Cervero et al was built on previous studies beginning in 2001, and examined the longer term impacts of the City CarShare program on travel demand and car ownership. The findings document significantly reduced daily VMT for carsharing members.

Cervero's study provides a best-fitting multiple regression equation predicting average daily VMT. All else being equal, City CarShare membership typically lowered daily travel by 7 vehicle miles. Residing in dense, transit-friendly San Francisco reduced the figure by another 3 vehicle miles. Owning a bicycle cut down on daily travel by nearly an additional 4 vehicle miles. Every additional car added per household member, however, raised daily VMT by 13. Four years into the City CarShare program, the combination of being a CarShare member, owning a bicycle, and reducing car ownership all serve to shrink the transportation sector's ecological footprint in the San Francisco Bay Area.ii .

The table below provides the variables and their coefficients, the standard error and probability, as well as the GreenTrip Connect data source where applicable. This model was applied to determine CarShare membership impact on household VMT. Using our modeled VMT, we then use this model to estimate the percent reduction on VMT by assuming no car sharing, then assuming the level of carsharing in the scenario, and calculate the percent reductions. Then the modeled VMT is scaled by this percentage.

Table
Regression Model for Predicting Respondents' Average Daily VMT;
Survey #5, All Trip Purposes, All Day Types

Variables	Coefficient Estimate	Standard Error	*Probability*	*GreenTrip Connect Data Source*
Member Status:				
City Car Share Member (1=yes;	-7.08	3.46	0.04	User Input

0=no)				
Socio-Economic Controls:				
No. of Vehicles Per Household Member	13.07	2.09	0	
Owns a bicycle (1=yes; 0=no)	-3.784	1.89	0.046	User Input
Age (years)	0.75	0.432	0.083	PUMS
Age squared	-0.008	0.005	0.077	
Personal income, annual (in $1000s)	-0.086	0.056	0.127	PUMS
Personal income, annual (in $1000s), squared	0.0004	0.00025	0.095	
Resides in San Francisco (0=no; 1=yes)	-3.064	2.03	0.132	User Input
Constant	4.206	10.232	0.681	
Summary Statistics				
Number of Cases			459	
R-Square			.148	
F Statistics (probability)			8.214 (.000)[iii]	

Given that this study was carried out on the first and longest running carsharing program in the US, is a longitudinal study beginning with the CarShare program's inception, on a California-based carsharing program, and provides a rigorous examination that includes a regression analysis and formula, this study was deemed appropriate to use in our analysis to understand carsharing membership's impact on household VMT.

We may do analysis of the California household survey data, but we need car sharing locations for 2012, and do not have that data.

Additional studies reviewed included *The Impact of Carsharing on Household Vehicle Ownership,* (Elliot Martin and Susan Shaheen 2011); *The Impact of Carsharing on Public Transit and Non-Motorized Travel: An Exploration of North American Carsharing Survey Data* (Elliot Martin * and Susan Shaheen 2011).

Implementation

The reduction in VMT is calculated using the following process. First the VMT is modeled using the inputs from the building definition including the affordable units and level of affordability. This VMT result is then scaled by the ratio of running the above equation to estimate VMT for the given household with no carsharing member ships over the same household but with the number of selected carsharing memberships each. This also assumes that the number of autos owned per unit is the same as the total units entered divided by the number units in the building. For the number of people in each unit the average size for all unit types weighted by the number of each type is used.

$$S = \frac{4.206 + 13.07 * Autos_{per\ person} + 0.75 * A - 0.008 * A^2 - 0.86 * I + 0.0004 * I^2}{4.206 - 7.09 * N_{cs} + 13.07 * Autos_{per\ person} + 0.75 * A - 0.008 * A^2 - 0.86 * I + 0.0004 * I^2}$$

Where S is the scale factor, N_{cs} is the number of carsharing memberships per unit, $Autos_{per\ person}$ is the average number of autos per person in the building, A is the age of the people in the building (30 years old is used), and I is the average income in the building in 1,000s (75 is used as a default). The VMT is the scaled by this factor S:

$$VMT_{carshare\ adjusted} = VMT_{modeled} * S$$

Transit Passes

Background

Findings from *Do Employee Commuter Benefits Reduce Vehicle Emissions and Fuel Consumption? Results of the fall 2004 Best Workplaces for Commuters* were the basis for determining the impact of transit passes on household VMT. This 2005 study by Herzog et al, utilized survey results to determine the difference between the commuting patterns of employees receiving employee commuter benefits and those who do not. It was found that where employers provide employees with incentives to commute by means other than driving alone, significant percentages of them take advantage of these benefits. Resulting savings in vehicle trips, VMT, emissions and fuel consumption were then calculated. VMT reductions of 4.16 to 4.79 percent were found.

Comprehensive benefit packages such as those enjoyed by commuters in the BWC group, with financial incentives, services (such as guaranteed ride home, carpool matching, etc.) and informational campaigns, appear to produce reductions of trips, VMT, pollutants, and fuel consumption of around 15 percent even under conservative assumptions. Benefits packages offering services and information, but not financial incentives, appear to produce reductions of around 7 percent under conservative assumptions.

While Herzog's study examines changes in driving patterns for an employer-based, not a resident-based program, no such evaluation of resident-based programs was found, so GreenTrip Connect uses the employer-based results of 4.16 to 4.79 percent VMT reduction range as a proxy.

Of interest is an ongoing program in Boulder, Colorado. Eco Pass currently gives employees of participating businesses and residents of participating neighborhoods unlimited rides on Regional Transportation District buses. Nearly 40,000 residents and workers participate in the program. However, a study of results on VMT reduction is not available. Furthermore, Boulder officials are looking at the feasibility of expanding the popular Eco Pass program to the entire community. Further information and detailed analysis is available in the *Countywide EcoPass Feasibility Study, Boulder County*, January 2014.

While there have been several studies of the effectiveness of employer-based trip reduction programs at reducing vehicle trips and/or increasing the share of alternative modes, only a few have estimated reductions in vehicle miles travelled (VMT) or GHG emissions[iv]. A good overview of employer-based studies programs is *Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions*, September 2014.

Implementation

Therefore to adjust the VMT for transit passes the VMT is adjusted down by 4.475 percent (the average of the range given above) for each transit pass (N_{tp}). Any additional fractional transit pass reduction is simply scaled by the fraction times (f_{tp}) 4.475%. The following formula is used:

$$VMT_{trasit\ pass\ adjusted} = \{VMT_{bike\ share\ adjusted} * (1 - 0.04475)^{N_{tp}}\} * (1 - 0.4475 * f_{tp})$$

Bike Sharing

Background

To determine impact of bike sharing membership on household VMT findings from the paper *"Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia (Fishman and Washington 2015)" were* implemented. The paper examines the degree to which car trips are replaced by bike share, through an examination of survey and trip data from bike share programs in Melbourne, Brisbane, Washington, D.C., London, and Minneapolis/St. Paul.

The following table shows the impact car substitution has on estimated car travel reduction. Car travel reduction has been estimated by multiplying the estimated distance traveled by the car substitution rate.

Table 1
Bike share size, usage and car travel reduction.

	Melbourne	Brisbane	Washington, D.C.	Minnesota	London[*]
Bikes[a]	600	1800	1800	1325	8000
Trips[b] (2012)	138,548	209,232	2,008,079	268,151	9,040,580
Trips per day per bike	0.6	0.3	3.0	0.9	3.1
Regional population[2]	3,999,980	2,065,998	5,860,342	3,759,978	7,170,000
Mean trip duration[b]	22.0	16.2	15.8	17.5	17.5
Est. travel speed (km/h)	12	12	12	12	12
Est. distance traveled per trip (KM)	4.4	3.2	3.1	3.5	3.5
Est. distance traveled per system 2012 (KM)	609,611	677,912	6,345,530	940,152	31,642,029
Car substitution	19%	21%	7%	19%	2%
Est. car travel reduction (KM)	115,826	142,361	444,187	182,390	632,841
Est. car travel reduction per bike (KM)	193	79	247	135	79
Annual members	921	1926	18,000	3500	76,283

Applying this methodology to data from Bay Area Bike Share household VMT reductions for bike share users were calculated as shown in the table below. The 19 percent car substitution rate utilized for GreenTrip Connect of was based on the Minneapolis substitution rate.

	Bay Area Bike Share
dist. (km) for system in year	61,7640
car substitution rate	19%
Est car travel reduction	117,351.60
Annual members	8,539
Km/day/member	13.74
miles per day per membership	0.0234

Additional references include Public Bikesharing in North American: early Operator and User Understanding (Susan A. Shaheen, PH.D., Elliot W. Martin, Ph.D., Adam P. Cohen, Rachel S. Finson, June 2012); Public Bikesharing in North America During a Period of Rapid Expansion: Understanding Business Models, Industry Trends and User Impacts (Susan A. Shaheen, Ph.D., Elliot W. Martin, Ph.D., Nelson D. Chan, Adam P. Cohen, Mike Pogodzinski, Ph.D., October 2014)

Implementation

For each bike share membership per unit the daily VMT is adjusted down by 0.0234 miles using the calculated VMT reduction from the Bay Area Bike Share data. The following formula is used:

$$VMT_{bike\ share\ adjusted} = VMT_{trasit\ pass\ adjusted} - 0.0234 * N_{bs}$$

Where N_{bs} is the number of bike share memberships per unit.

[i] Cervero. “San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts,” n.d.

[ii] Cervero. “San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts,” n.d., pg 38

[iii] Cervero. “San Francisco City CarShare: Longer-Term Travel-Demand and Car Ownership Impacts,” n.d., pg 38

[iv] Marlon G. Boarnet , University of Southern California, Hsin-Ping Hsu, University of California, Irvine, and Susan Handy, University of California, Davis. “Impacts of Employer-Based Trip Reduction Programs and Vanpools on Passenger Vehicle Use and Greenhouse Gas Emissions,” September 30, 2014., pg 3.