TDM Methodology: Impact of Carsharing Membership, Transit Passes, Bikesharing Membership, Unbundled Parking, and Parking Supply Reductions on Driving

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Purpose

This paper describes in detail the methods used in GreenTRIP Connect to calculate the impact of carsharing memberships, bike sharing memberships and the provision of transit passes on household vehicle miles traveled (VMT). This paper also explains reductions in driving based on parking policies such as a reduction of supply and charging for parking. Additionally, we provide references to some additional research.

Carsharing

Background

To determine the impact of carsharing memberships 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 contribute to reduced driving 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.

Given that this study was carried out on the first and longest running carsharing program in the US, the study is a longitudinal study beginning with the Carshare program's inception, is 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.

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 affordable units and level of affordability. This VMT result is then scaled by the ratio of the change in VMT from the regression above for only the car share membership and the calculated VMT, as shown in the equations below.

$$S \equiv 1 - \frac{7.08}{VMT_{modeled}}$$

Then this number is raised to the power of the number of memberships per household ($N_{memberships}$,) which is obtained from the user. However, if the user has chosen two memberships per unit and the number of adults in the average unit is less than two, an adjustment is made. In this case, if the building composition is such that the average number of people over 18 is less than two, then the number of memberships is reduced to that number. Likewise if the user selects "One for every driver" the number of memberships is set to the average number of people over 18 per unit. Thus the final calculation uses the following equation.

$$VMT_{carshare\ adjusted} = VMT_{modeled} * S^{N_{memberships}}$$

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 per transit pass provided.

Comprehensive benefit packages such as those enjoyed by commuters in the Best Workplaces for Commuters 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, GreenTrip Connect uses the employer-based results of 4.16 to 4.79 percent VMT reduction range as a somewhat conservative proxy.

Of interest is an ongoing program in Boulder, Colorado. EcoPass 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 EcoPass 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 for resident transit passes the VMT is adjusted down by 4.475 percent (the average of the range given above) for each transit pass (N_{tp} which is limited by the average number of people 18 and older in the units, or people above 5 years old if that is the user's choice). Any additional fractional transit pass reduction is included by adding the fraction (f_{tp}) to the overall number; this assumes the uptake in transit passes will reflect the amount of the chosen discount. The following formula is used:

$$VMT_{trasit\ pass\ adjusted} = VMT_{carshare\ adjusted} * (1 - 0.04475)^{(N_{tp}+f_{tp})}$$

Bikesharing

Background

To determine impact of bikesharing membership on household VMT findings from the paper *"Bikeshare'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	617,640
car substitution rate	19%
Est car travel reduction (annual km)	117,351.60
Annual members	8,539
Km/year/member	13.74
miles per day per member	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:

$$VMT_{bikeshare\ adjusted} = VMT_{transit\ pass\ adjusted} * (1 - 0.0234)^{N_{bs}}$$

N_{bs} is the number of bike share memberships per unit chosen by the user, up to a maximum of the number of people 18 years old and over per unit in the building.

Parking Limitations

Background

The 2010 *"CAPCOA Quantifying Greenhouse Gas Mitigation Measures"*[iv] provided direct guidance for quantifying VMT reductions on parking strategies. See the CAPCOA document for full explanation of the methodology.

For VMT reductions associated with unbundled parking, the CAPCOA document recommends that the VMT reduction is a function in the increase in vehicle cost (as a result of the monthly parking charge) multiplied by the elasticity (change in driving as a result of total vehicle costs) with an adjustment from vehicle ownership to VMT.[vi] See the equation below to demonstrate that calculation.

% Reduction in VMT = Change in vehicle cost * elasticity * A

Where:

- Change in vehicle cost = monthly parking cost * (12/$4,000), with $4,000 representing the annual vehicle cost per Victoria Transportation Policy Institute - VTPI
- -0.4 = elasticity of vehicle ownership with respect to total vehicle costs (lower end per VTPI)
- A: 85% = adjustment from vehicle ownership to VMT (see Appendix B for detail)

To estimate the VMT reductions from reduced parking supply, the CAPCOA guidance considers a reduction in VMT if the parking supply is below the Institute of Transportation Engineers (ITE) recommended spaces per unit of 1.2 for apartments. [vii]

$$\%\ \text{VMT Reduction} = \frac{\text{Actual parkingprovision} - 1.2}{1.2} \times 0.5$$

Finally, the overall VMT reduction both unbundling and parking supply limitation combined cannot be greater than 20%.[viii]

Implementation

For parking price reduction the following formula is used:

$$S_{pricing} \equiv 1 - \frac{P_{parking} \times 12}{\$4000} \times 0.85 \times 0.4$$

$P_{parking}$ is the monthly cost of parking entered by the user.

And for supply considerations the following formula is used if the supply is less than 1.2 spaces per unit:

$$S_{parking\ supply} \equiv 1 - \left\{\frac{1.2 - PS}{1.2} \times 0.5\right\}$$

"PS" is the parking supply given by the user in Connect. The product of these is applied to the "bike sharing adjusted VMT," after it is first checked to make sure that the reduction is no more than 20%.

$$S \equiv S_{pricing} \times S_{parking\ supply} \mid if\,(S < 0.8)\ then(S = 0.8)$$

The final value for VMT is:

$$VMT_{Parking\ Adjusted} = S \times VMT_{bike\ share\ adjusted}.$$

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[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

[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.

[v] Barbara Lee, NSCAPCD. "Quantifying Greenhouse Gas Mitigation Measures, A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures," August, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf

[vi] Barbara Lee, NSCAPCD. "Quantifying Greenhouse Gas Mitigation Measures, A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures," August, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf. pgs. 211-212.

[vii] Barbara Lee, NSCAPCD. "Quantifying Greenhouse Gas Mitigation Measures, A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures," August, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf. pgs. 207-209.

[viii] Barbara Lee, NSCAPCD. "Quantifying Greenhouse Gas Mitigation Measures, A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures," August, 2010. http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf. pg. 55.

Appendix A:

Carshare membership impact table

Regression Model for Predicting Residents' Average Daily VMT; All Trip Purposes, All Day Types

Variables	Coefficient Estimate	Standard Error	*Probability*	*GreenTrip Connect Data Source*
Member Status:				

City Car Share Member (1=yes; 0=no)	-7.08	3.46	0.04	User Input
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)[viii]	

Appendix B

CAPCOA's Appendix C "Unbundle parking cost" from Table C-1, Transportation Calculations:

Strategy	T#	Equation	Variable	Value	Source/Notes
Unbundle Parking Cost from Property Cost (Parking Pricing/Policy)	C3	A = Adjustment from Vehicle Ownership to VMT = average trips per 2 vehicles * 1 vehicle per average trips =(9.8 trips/ 2 vehicles) * (1 vehicle / 5.7 trips) = 0.85	Average trips per X vehicles	Households with 2 vehicles take 9.8 trips while households with 1 vehicle take 5.7 trips per day	i.e. A reduction of 1 vehicle leads to an 0.85 reduction in vehicle trips http://www.dot.ca.gov/hq /tsip/tab/documents/travel surveys/2000_Household _Survey.pdf, table 8.7