Impacts of Carsharing on Passenger Vehicle Use and Greenhouse Gas Emissions

Technical Background Document

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Study Selection

Only a few empirical studies examine the effect of carshare membership on travel behavior, since carsharing is a relatively new phenomenon. (For descriptions of the growth and development of the carsharing industry, see Shaheen, Mallery, & Kingsley, 2012; Shaheen, Cohen, & Chung, 2009; Shaheen & Cohen, 2007.). We focused on those studies that were conducted in the United States and that were published after 1999, since earlier carsharing programs differed in many important logistical aspects (such as systems for key entry, payment, and locations of cars consolidated at transit stations rather than distributed throughout neighborhoods). Just two studies meet these criteria and also include a published description of the survey methodology with sufficient information that statistical significance could be evaluated. The first is a multiyear study by Cevero (reported in Cervero, 2003; Cervero & Tsai, 2004; Cervero, Golub, & Nee, 2006, 2007). The second is a study by Martin and Shaheen (2011), for which we conducted statistical tests using supplemental information by the authors. In addition to these two, several studies were conducted by consultants on behalf of public agencies (Price, DeMaio, & Hamilton, 2006; Lane, 2005; Katzev, 1999), and Zipcar conducted an internal study (Zipcar, 2005); findings and scope for these studies are summarized in Table 1.

All of these studies focus on traditional carsharing, and do not examine free-floating carsharing, peer-to-peer carsharing, or specialized-vehicle sharing. They focus on how carshare membership has affected the travel choices of participating households, and not on the broader question of carsharing's potential impact on regional VMT and GHG emissions, or on the efficacy of policies intended to promote carsharing.

Table 1. Impact of Carshare Membership on VMT among Carshare Members

Study	Study Location	Study Year(s)	Change	Difference in mean VMT for members	Sample size	
					Without carsharing	With carsharing
Martin & Shaheen, 2011	Multiple cities in the U.S. and Canada	2008	Join carsharing	-26.9%	6,281	6,281

Study	Study Location	Study Year(s)	Change	Difference in mean VMT for members	Sample size	
					Without carsharing	With carsharing
Cervero et al., 2006, 2007	San Francisco Bay area	2001-2003	Service launch	-2.2%	143	247
Cervero, 2003; Cervero et al., 2007	San Francisco Bay area	2001-2005	Service launch	-32.9%	143	363
Price et al., 2006	Washington DC area	Mixed-2006	Join carsharing	-43%	369	369
Lane, 2005	Philadelphia	2002-2003	Service launch	probable decrease	262	262
Katzev, 1999	Portland	1998-1999	Service launch	+25.1%	33	33
Zipcar, 2005	21 U.S. cities	Mixed-2005	Join carsharing	-79.8%	NA	NA

Effect Size, Methodology, and Applicability Issues

The available studies on the impact of carshare membership on individual travel behavior are too few and too limited for a precise estimate of its effect. Of the two studies meeting the specified criteria, only Cervero et al. (2007) used an experimental design, measuring behavior before and after carsharing was launched and comparing members to a nonmember control. However, the experimental and control groups were not randomly assigned, and so the causal role of carsharing, independent of the type of person who tends to join carsharing, was not established. A comparison of the would-be members and non-members in the baseline year prior to the launch of carsharing showed the would-be members already traveled 33.1% fewer miles and consumed 65.1% fewer gallons of gasoline daily, on average, before they started using carsharing (Cervero et al., 2007; our calculation).

Neither of the two studies meeting the specified criteria included tests for statistical significance for all of the differences in VMT and in emissions (or gasoline consumption). However, using the means, standard deviations, and sample sizes published in Cervero et al. (2007) and those provided from author Elliot Martin of Martin and Shaheen (2011), we conducted two-sample t-tests (for equivalence of means) to evaluate statistical significance of the differences reported (see Table 2). Some results that are only marginally significant with $p<0.200$ are included in our review since statistical significance is harder to establish with small sample sizes and so few studies are available.

In contrast to Cervero et al.'s (2007) study, Martin and Shaheen's (2011) study was sufficiently large (n=6,281) for statistical precision, but relied on respondents' own estimates of their annual miles traveled over the course of a year, which may not be accurate. In addition, they did not use a true before-and-after survey, but rather relied on respondents to retrospectively recall their travel the year prior to joining carsharing, however long ago it was prior to the survey date. To the extent that respondents were equally accurate in appraising each period of time, this bias would not matter in measuring the change, but more distant recall has a higher risk of poor accuracy, as well as a tendency for reporting of reductions in miles traveled if respondents believe reductions to be socially desirable, as may be the case among early carsharing members. However, their study at least offers reasonable confidence of an average reduction in VMT as perceived by members retrospectively.

The additional studies offer a much wider range of results. Studies by Price et al. (2006) and Zipcar (2005) report larger reductions in VMT than the two studies that meet the selection criteria; the reduction in the Zipcar study is almost three times as large as the reduction in the Martin and Shaheen study (2011). Lane (2005) does not actually measure overall VMT before versus after joining carsharing, but does measure several other aspects of carshare participants' behavior that suggest a probable decrease in VMT. In particular, he measures car-owners' annual VMT before they joined carsharing, carshare vehicles' mileage, and members' report of how their use of various modes changed after joining carsharing, and concludes a reduction in VMT is likely. Finally, Katzev (1999) reported a statistically significant *increase* in VMT of 25.1% (p=0.058), with non-owners' increased VMT outweighing owners' decreases in VMT (which were not statistically significant), but the study had a very small sample. The other studies did not provide statistical tests of the significance of the effects reported.

Because carsharing's potential for reducing VMT relies on car-owners reducing (or foregoing) private vehicle use, trends in vehicle ownership among carshare members provide another perspective on its impact. The more car-owners (versus non-owners) who join, and perhaps get rid of a car, the greater the potential reductions in VMT. Martin, Shaheen, and Lidicker (2010) and Cervero et al. (2007) both find that about a quarter of members reduced the number of vehicles they owned since joining carsharing (see Table 3). Cervero et al. (2007) found that members and non-members were equally likely to get rid of a vehicle between 2001 and 2005, but that members were less likely to have acquired a first or additional vehicle. Martin et al. (2010) estimate that the average number of vehicles per household dropped from 0.47 to 0.24 among households who joined carsharing organizations, with most becoming carless. In addition to likely reductions of VMT, when people use carsharing in lieu of privately

owned cars, it improves fleet efficiency and utilization of parking places, since miles driven are done so with cleaner cars and using fewer parking spaces.

A variety of additional factors may affect the size of the effect of carsharing and the applicability of the past empirical results to future scenarios (Tal 2009). For instance, there may be a difference between short-term and longer-term effects. Existing studies have differed in the amount of time that elapsed between “before” and “after” measures, though all were relatively short-term. Shorter amounts of time might fail to capture longer-term changes relating to vehicle ownership, residential location, and other life-patterns potentially affecting VMT. In addition, the impact of membership on travel choices may differ depending on the prevalence and penetration of carsharing service within a given market. Greater availability of cars may mean more use, with an unknown effect on overall VMT. Both the quality of service and the type of service (e.g. traditional, peer-to-peer, free-floating, etc.) may affect not only how and how much it is used, but also who is inclined to join. The type of user who will participate in carsharing in the future may differ from early adopters in unknown ways, and changing attitudes and behaviors of future generations would also play a role, as would any synergistic effects of other policies affecting travel choices, such as gas prices, land use changes, transit service, parking policies.

Table 2. Calculation of the Statistical Significance of the Impact of Carshare Membership on Household VMT, Gas Consumption, and GHG emissions

After vs. before joining carsharing										
			After			***Before***				
Study	***Study year(s)***	***Measure***	***Mean***	***Std. dev.***	***N***	***Mean***	***Std. dev.***	***N***	***Mean difference***	***Percent difference***	***t-statistic* (p-value)***
Martin & Shaheen, 2011	Mixed-2008	Annual VKT	4,728.6	8,492.3	6,281	6,468.2	11,355.1	6,281	-1,739.6	-26.9%	9.72 (0.000)
Cervero 2003; Cervero, et al., 2006, 2007	2001-2003	Daily VMT	4.40	13.31	247	4.50	11.32	143	-0.10	-2.2%	0.08 (0.940)
	2001-2005	Daily VMT	3.02	5.68	363	4.50	11.32	143	-1.48	-32.9%	1.95 (0.052)
Martin & Shaheen, 2011	Mixed-2008	Annual tons GHG	1.10	2.20	6,281	1.68	3.03	6,281	-0.58	-34.5%	12.28 (0.000)
Cervero, 2003; Cervero et al., 2006, 2007	2001-2003	Daily gallons gas	0.05	0.17	247	0.07	0.23	143	-0.03	-36.5%	1.33 (0.184)
	2001-2005	Daily gallons gas	0.03	0.12	363	0.07	0.23	143	-0.04	-59.5%	2.84 (0.005)
Carsharing members (or pre-members) vs. non-members										
			Members			***Non-members***				
Study	***Study year(s)***	***Measure***	***Mean***	***Std. dev.***	***N***	***Mean***	***Std. dev.***	***N***	***Mean difference***	***Percent difference***	***t-statistic (p-value)***
Cervero, 2003; Cervero, et al., 2006, 2007	2001 (pre-launch)	Daily VMT	4.50	11.32	143	6.73	15.49	155	-2.23	-33.1%	1.41 (0.160)
	2003	Daily VMT	4.40	13.31	247	13.10	28.30	157	-8.70	-66.4%	4.16 (0.000)
	2005	Daily VMT	3.02	5.68	363	9.51	26.44	36	-6.49	-68.2%	3.89 (0.000)
	2001 (pre-launch)	Daily gallons gas	0.07	0.23	143	0.21	0.60	155	-0.14	-65.1%	2.59 (0.010)
	2003	Daily gallons gas	0.05	0.17	247	0.46	1.29	157	-0.42	-89.9%	5.02 (0.000)
	2005	Daily gallons gas	0.03	0.12	363	0.31	0.71	36	-0.28	-90.3%	6.71 (0.000)

***t*-statistic is for test for difference in means, before versus after and for members versus non-members.**

Table 3. Impact of Carshare Membership on Household Vehicle Ownership

Study	Study Location	Study Year	Elapsed time	% of members with			% foregoing purchase	Average change in number	Sample size
				Increase in number	No change	Decrease in number			
Martin et al., 2010	Multiple cities	2008	Mixed (up to 10 yrs)	3.6%	71.1%	25.3%	25%[a]	-0.233 cars	6,281
Cervero & Tsai, 2004	San Francisco Bay area	2001, 2003	2 yrs	7.6%	63.2%	29.1%	NA	NA	462
Cervero et al., 2007	San Francisco Bay area	2001, 2005	4 yrs	27.4%	58.4%	24.2%	NA	NA	363
Price et al., 2006	Washington DC area	2006	Mixed (up to 2 yrs)	36%[b]		29%[c]	71%[d]	NA	NA
Zipcar, 2005	Multiple cities	2005	Mixed (up to 5 yrs)	61%		39%[e]		NA	NA
Lane, 2005	Philadelphia	2002, 2003	1 yr	0.0%	N/A[f]	24.5%	29.1%[f]	-1.07 cars	262

[a] maybe, probably, or definitely would buy a car in the absence of carsharing

[b] disagree or strongly disagree was able to sell (suggesting an *increase* or *no change* in the number of vehicles they own)

[c] strongly agree or agree was able to sell (suggesting a *decrease* in number of vehicles they own)

[d] strongly agree or agree that they have postponed buying

[e] shed or forewent buying

[f] 29.1% decided not to acquire one ("no change" was not offered as an option in a multiple-choice selection)

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